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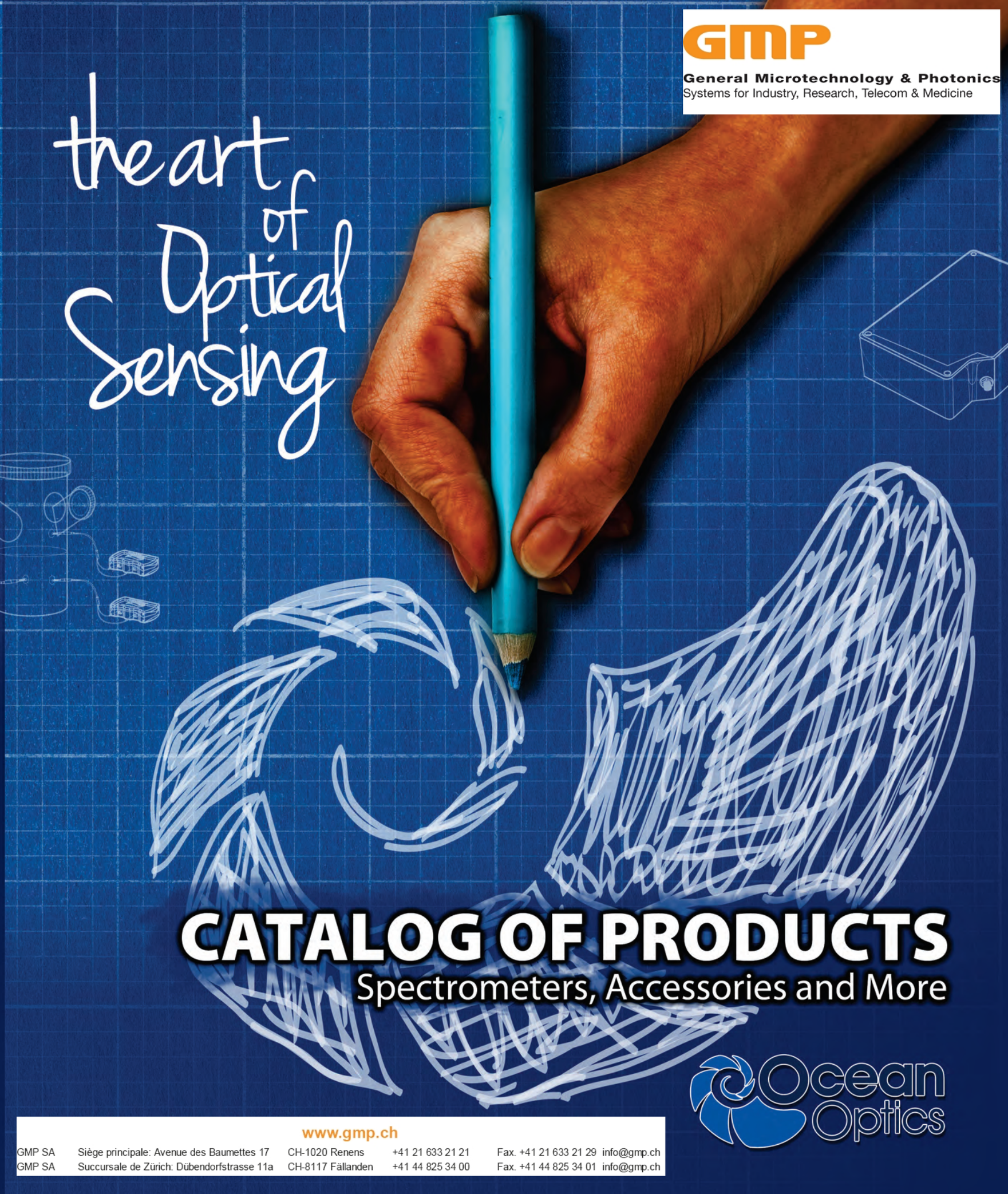
the art of Optical Sensing



CATALOG OF PRODUCTS

Spectrometers, Accessories and More

Ocean Optics

www.gmp.ch

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Ocean Optics at Work
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Measuring hue, saturation and brightness of a male Northern Cardinal's breast plumage

Jay Kalous and Duke Pauli
Reflectance measurement of light off crop canopies

John Giddings
Measuring the sunrise over Mount Fuji

Ordering Information

Pricing

- For the latest pricing information, visit our website at www.oceanoptics.com or contact an Applications Scientist in your region. Published pricing does not include taxes, duties and other charges that may apply in some circumstances. Pricing is by component and typically does not reflect the overall system price.
- We honor pricing cited in our quotations for 30 days from the date of the quote.
- You can purchase Ocean Optics products from any of our four locations or from one of our fine distributors. Some items are also available online at www.oceanoptics.com.
- Ocean Optics prices are subject to change without notice.

Credit Cards

We accept American Express, MasterCard and VISA.

Terms

Net 30 with prior credit approval.

Sales Tax

Prior approval is required for tax exempt status. Please fax resale certificates to our Accounting Department at +1 727-733-3962 for approval or contact receivables@oceanoptics.com.

Shipping

Our Next Day Shipping guarantee applies to more than 500 Ocean Optics products, including custom-configured spectrometers. All qualifying orders received before 4 p.m. (ET) Monday thru Friday will be shipped by the next business day from Ocean Optics USA directly to customers anywhere in the world. International shipping rates and fees apply. Contact your regional Ocean Optics office for details on local shipping commitments.

This pledge refers to Ocean Optics' commitment to ship next day and not to the shipping method itself. Orders are shipped UPS Ground unless otherwise specified. Customers may reverse shipping charges to the carrier of their choice.

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Staying Friends with Ocean Optics

We hope you'll take the time to look us up on your favorite social networking site.

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Spectrometers

Ocean Optics pioneered the concept of modular, miniature spectroscopy to offer more flexibility in your optical sensing applications. Our line of spectrometer models ranges from the world's most popular general-purpose miniature spectrometers to compact, scientific-grade units that perform as well as most high-priced laboratory-grade systems.

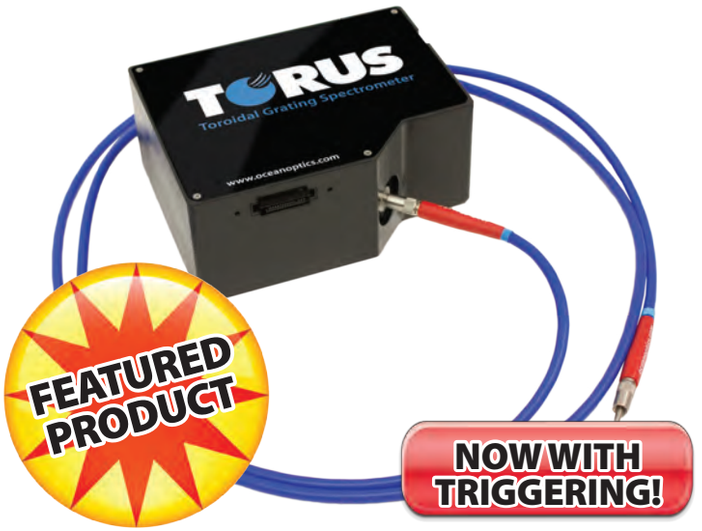
Our spectrometers address the needs of users across a wide range of industries and disciplines involved in basic research and science discovery, OEM development and industrial process control. Our expertise comes from assisting you in designing the optimum spectroscopy system for your needs, a service we've provided for more than 150,000 applications.

Fact

If you placed every spectrometer we've sold atop each other, the stack would reach nearly 20,000 feet – about the height of Alaska's Mt. Denali, the tallest mountain in North America.

Torus Concave Grating Spectrometers

Compact Spectrometer Delivers Low Stray Light and High Throughput



Torus is a family of aberration-corrected holographic concave diffraction grating spectrometers that delivers low stray light, high throughput and excellent thermal stability for a wide range of research and OEM applications.

Our initial Torus model is a Visible range spectrometer (360-825 nm) whose spectral range and low stray light make it especially useful for measuring color. Its high throughput and great thermal stability make it ideal for demanding applications.

Like most Ocean Optics spectrometers, Torus interfaces with a computer via the USB port and couples to our line of SMA 905-terminated optical fibers, light sources and accessories. Spectrometer operation is as simple as installing SpectraSuite spectroscopy software and then connecting the USB cable from the spectrometer to the computer. Wavelength calibration coefficients – unique to each spectrometer – are programmed into a memory chip right on the unit and the software reads these values from the spectrometer.

Key Features

Concave Grating-based Spectrometer

Toroidal diffraction grating ensures low stray light and high throughput

Robust Performance in a Small Footprint

Ideal for applications requiring color or radiometric accuracy, low stray light and absorbance measurements up to 3.0 OD

Low Stray Light with Excellent Throughput

Provides viable alternative to standard miniature spectrometers for applications such as color and high-concentration absorbance measurements and precision light metrology

Physical	
Dimensions:	149.9 mm x 119.4 mm x 63.5 mm (5.9 in. x 4.7 in. x 2.5 in.)
Weight:	954 g (2.1 lb.)
Operating temp.:	0 to 50 °C, non-condensing
Detector	
Detector type:	Sony ILX511B
Detector range:	200-1100 nm
Pixels:	2048
Pixel well depth:	~62,500 e-
Optical Bench	
Design:	Flat field
Focal length:	85 mm
Entrance aperture:	5, 10, 25, 50 or 100 µm wide slit or fiber with user-selectable aperture (tested at F3 and F4)
Gratings:	Toroidal concave holographic (blazed @ 400 nm)
Mechanical interface:	8-32 threaded holes at base (3 places)
Optical input interface:	SMA 905 fiber connector and C-mount lens adapter
Spectroscopic	
Wavelength range:	360-825 nm
Optical resolution:	≤1.6 nm FWHM over the spectral range
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	16 bits
Dark noise:	50 RMS counts, 300 counts peak to peak
Dynamic range:	8.5×10^7 (system); 1300:1 (single acquisition)
Integration time:	1 ms-65 s
Stray light:	0.015% @ 400 nm
Thermal stability:	<0.0056 nm/ °C (wavelength stability)
Electronics	
Power consumption:	250 mA @ 5 VDC
Power options:	USB or GPIO port
Data transfer speed:	Full spectrum every 1 ms with USB 2.0 port, 15 ms with USB 1.1 port, 200 ms with serial port
Connector:	USB or GPIO port
Inputs/Outputs:	Yes, 8 onboard digital user-programmable GPIOs
Analog channels:	0
Breakout box:	Supported
Trigger modes:	4 modes
Strobe functions:	Yes
Computer Requirements	
Computer interface:	USB 2.0, RS-232
Operating systems:	Any supported by OmniDriver/SeaBreeze or RS-232
Compliance	
CE mark:	Yes
RoHS:	Yes
Software	
Operating software:	SpectraSuite support (extra), Overture
Dev. software:	OmniDriver/SeaBreeze driver (extra)

Torus Concave Grating Spectrometers

Low Stray Light, High Throughput

Holographic Concave Grating Design

Reflective concave gratings are concave mirrors that disperse light; the concavity of the grating reflects and focuses the light and the grating groove pattern disperses the light. These aberration-corrected concave gratings are known for their low stray light and high efficiency. The toroidal (the radius of curvature in the focusing and dispersion directions are different) grating used in Torus further enhances the aberration correction and efficiency.

For our Visible Torus spectrometer, we use a variable line spacing grating with 550 (+/-2) grooves/mm groove density at center and a blaze wavelength of 400 nm. Blaze wavelength is the wavelength of maximum diffraction efficiency and depends on bench design and other considerations.

Next Generation of High-Value Miniature Spectrometers

Torus is the first of a new line of Ocean Optics spectrometers distinguished by scientific-grade spectral performance in the compact, flexible bench design that is our hallmark.

Like our flagship USB2000+ Spectrometer, Torus uses a Sony ILX511B linear CCD-array detector. However, the Torus debuts a unique flat field optical bench design. The Torus has the same robust, high-speed electronics made popular by our USB2000+, but with improved throughput and less stray light due to the aberration-corrected toroidal grating. What's more, Torus has good thermal stability. Its wavelength drift is mitigated and peak shape stays the same over a wide temperature range. As a result, Torus makes possible precision metrology, fluorescence and absorbance applications with demanding stray light and thermal stability requirements.

Torus Options

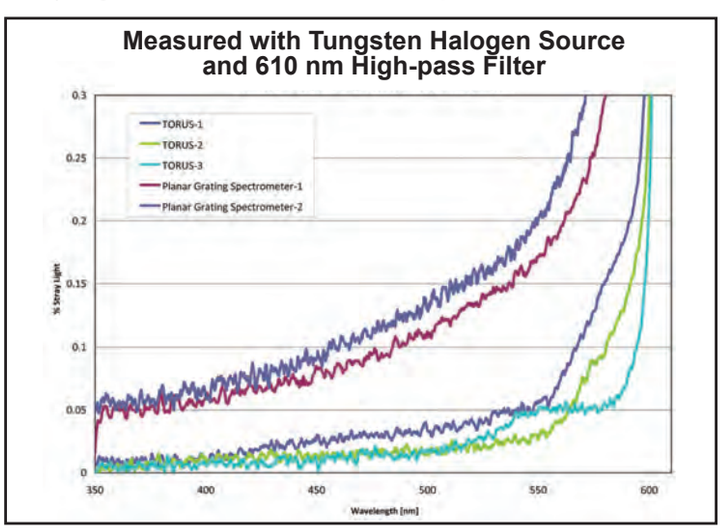
Torus is responsive from 360-825 nm and is available with the same optical bench accessories – slits, order-sorting filters and more – as our USB2000+ Spectrometer. The Torus accommodates SMA 905-terminated optical fibers, light sources and accessories. Free-space optical coupling is accommodated with standard C-mount adapters. Torus is fully operational in SpectraSuite software and is compatible with our OmniDriver and SeaBreeze software development platforms. Software is priced separately.

Typical Applications

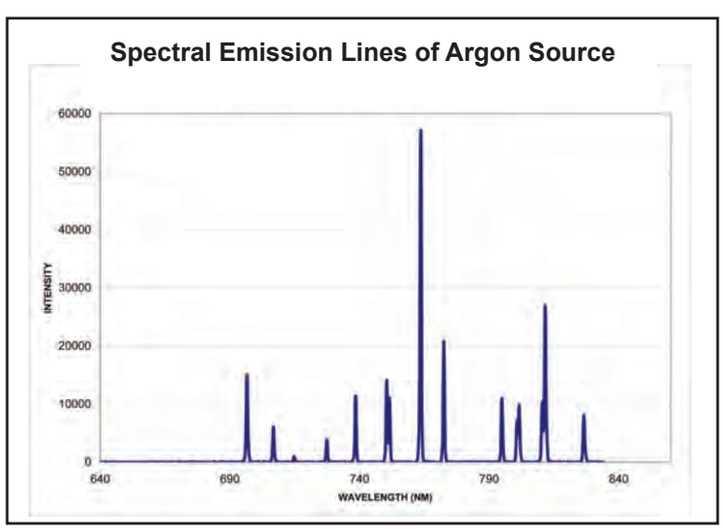
Torus works well for applications where low stray light, high throughput and great thermal stability are necessary. Here are some examples:

- Absorbance of optically dense solutions (the smaller the amount of stray light present, the higher the absorbance values that can be measured)
- Precision measurement of LEDs, lasers and other light sources
- Medical dosimetry in tissue and biological media
- Trace gas amounts in the atmosphere

Stray Light Performance of Torus Spectrometer



Sample Results with Torus Spectrometer



Understanding Ocean Optics Spectrometers

Helpful Hints in Choosing the Optimum Spectrometer Model

Spectroscopy is a technique in which the design criteria exist as a set of trade-offs. The optimal spectrometer for you depends entirely upon the application – and your budget. The design process begins by asking a series of questions: What are you trying to measure? How fast do you need the measurement? Where is the sample? Who will be operating the instrument? Then, there's the most important question of all: Why are you making the measurements?

Armed with the answers to those questions, Ocean Optics can help guide you to the best spectrometer, at the best value, for your application. Here's a quick guide to your primary choices:

Spectrometer Models at a Glance

Spectrometer Family	Most Popular	Detector Type	Typical Use
USB	USB2000+, USB4000, CHEMUSB and Jaz	Linear CCD arrays	General-purpose and educational; applications include absorbance, emission and color
HR	HR2000+, HR4000	Linear CCD arrays	Characterization of lasers and atomic emission lines
QE65000	QE65000	Back-thinned, TE-cooled CCD array	High-sensitivity, low light-level applications such as fluorescence and Raman
Maya	Maya2000 Pro	Back-thinned CCD array	High-sensitivity applications; also, deep UV
Holographic Concave Grating	Torus models	Linear CCD arrays	Low stray light, high-sensitivity applications
NIR	NIRQuest512, NIRQuest256-2.5	TE- cooled InGaAs linear array	Wide range of NIR applications from 900-2500 nm
Mid-IR	SIR models	InGaAs, InAs	Transient-event applications from 900-3400 nm; especially suited for laser applications
STS	STS-VIS, STS-NIR	CMOS	OEM applications

Spectrometer Configuration Types

Throughout this catalog, we describe the majority of our spectrometer models in one of three ways:

- **User-configured** describes spectrometers for which you select the optimum combination of optical bench components, including gratings, slits, filters and more. These built-to-suit spectrometers offer maximum flexibility.

- **Preconfigured** spectrometers have all the optical bench components already selected. We offer these "preset" spectrometers for general UV-VIS and VIS-NIR applications, extended-range (UV-NIR) use, fluorescence and irradiance.

- The term **Spectrometer Systems** most often applies to an application-specific, spectroscopy-based instrument that often includes sampling accessories, software and the like. Our primary system models are in Raman, LIBS and metrology and are covered elsewhere in this catalog.

All spectrometers are available with an extensive selection of complementary accessories and are covered by our exclusive 3-year warranty (excluding OEM models).

USB Series Spectrometers Overview

Choosing the Best USB2000+ or USB4000 Option for Your Application

Ocean Optics USB-Series spectrometers are versatile performers for a wide array of applications. Although our flagship USB2000+ and USB4000 spectrometers have comparable electronics and architecture, they do have one very important difference: their linear CCD array detectors. In addition, USB2000+ and USB4000 spectrometers are available in application-ready (preconfigured for specific application types) and build-your-own (user-configured for maximum flexibility) versions.

Comparing the USB2000+ and USB4000 Spectrometers

The USB2000+ has a 2048-element Sony ILX511B detector and the USB4000 has the 3648-element Toshiba TCD1304AP detector. Both are linear silicon CCD arrays with an effective range of 200-1100 nm and are available with the same optical bench accessory options (quartz window for UV performance, order-sorting filters and so on).

Advantages of the USB2000+

- Its Sony ILX511B detector is coated with a phosphor for better response in the UV – making it especially useful for applications below 350 nm.
- It has a faster minimum integration time – 1 ms (compared with 3.8 ms for the USB4000). That's an advantage for applications involving transient events such as measuring a pulsed light source.
- In applications where you have a considerable amount of light, its faster integration time helps you avoid saturating the detector.
- It has better optical resolution performance – an advantage when resolving fine spectral features is necessary.

Advantages of the USB4000

- It has better response at wavelengths beyond 400 nm – making it a good choice for VIS-Shortwave NIR applications.
- Its signal to noise ratio (300:1) is slightly better than that for the USB2000+. This is important in low-light level applications.
- It's slightly less expensive than the USB2000+. Both systems offer great value at a reasonable price.

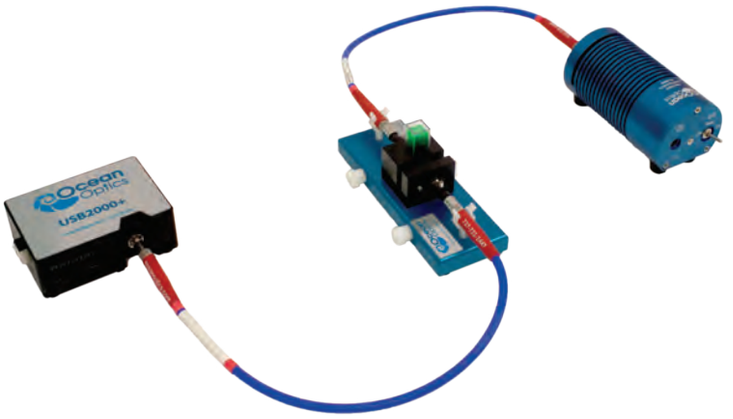
USB Series Spectrometer Models at a Glance

You can configure a USB2000+ or USB4000 with gratings and optical bench accessories for a variety of applications. Or, over the next several pages, investigate one of the many application-ready USB2000+/USB4000 systems described in the table below:

Best for	USB2000+ Series	USB4000 Series
General Use	USB2000+UV-VIS USB2000+VIS-NIR	USB4000-UV-VIS USB4000-VIS-NIR
General Use with Enhanced Sensitivity	USB2000+UV-VIS-ES USB2000+VIS-NIR-ES	USB4000-UV-VIS-ES USB4000-VIS-NIR-ES
Extended Range (200-1025 nm)	USB2000+XR1	USB4000-XR1
Extended Range (200-1025 nm) with Enhanced Sensitivity	USB2000+XR1-ES	USB4000-XR1-ES
Fluorescence	No preconfigured models	USB4000-FL (several excitation wavelength options)
Irradiance	USB2000+RAD	No preconfigured models

USB2000+UV-VIS and USB2000+VIS-NIR

Application-ready Spectrometers for the UV-VIS and VIS-NIR



Solutions absorbance is a common application for a USB2000+-VIS-NIR. A typical setup could include a 1 cm cuvette holder with optical fibers and a visible light source.

We offer general-purpose UV-VIS and VIS-NIR spectrometers – where all of the optical bench accessories are already selected – for basic spectroscopy applications such as measuring absorbance in solutions and reflectance of solids. Here are some key features:

- Each of the four models has an order-sorting filter and 25 µm slit for optical resolution of ~1.5 nm (FWHM)
- The USB2000+UV-VIS covers the 200-850 nm range and the USB2000+VIS-NIR covers 350-1000 nm
- Enhanced sensitivity models (ES) have an installed detector collection lens for increased light collection efficiency
- Software is priced separately and operates on Windows, OS X and Linux operating systems

Specifications	USB2000+UV-VIS	USB2000+VIS-NIR	USB2000+UV-VIS-ES	USB2000+VIS-NIR-ES
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm	89.1 mm x 63.3 mm x 34.4 mm	89.1 mm x 63.3 mm x 34.4 mm	89.1 mm x 63.3 mm x 34.4 mm
Weight:	190 g	190 g	190 g	190 g
Detector:	2048-element linear silicon CCD array	2048-element linear silicon CCD array	2048-element linear silicon CCD array	2048-element linear silicon CCD array
Integration time:	1 ms - 65 seconds	1 ms - 65 seconds	1 ms - 65 seconds	1 ms - 65 seconds
Dynamic range:	8.5 x 10^7 (system), 1300:1 (single acquisition)	8.5 x 10^7 (system), 1300:1 (single acquisition)	8.5 x 10^7 (system), 1300:1 (single acquisition)	8.5 x 10^7 (system), 1300:1 (single acquisition)
Sensitivity:	75 photons/count; also, 2.9 x 10^{-17} joule/count 2.9 x 10^{-17} watts/count (for 1-second integration)	75 photons/count; also, 2.9 x 10^{-17} joule/count 2.9 x 10^{-17} watts/count (for 1-second integration)	75 photons/count; also, 2.9 x 10^{-17} joule/count 2.9 x 10^{-17} watts/count (for 1-second integration)	75 photons/count; also, 2.9 x 10^{-17} joule/count 2.9 x 10^{-17} watts/count (for 1-second integration)
Signal-to-noise ratio:	250:1 (at full signal)	250:1 (at full signal)	250:1 (at full signal)	250:1 (at full signal)
Dark noise:	50 (RMS)	50 (RMS)	50 (RMS)	50 (RMS)
Grating:	600 lines/mm, set to 200-850 nm (blazed at 300 nm)	600 lines/mm, set to 350-1000 nm (blazed at 500 nm)	600 lines/mm, set to 200-850 nm (blazed at 300 nm)	600 lines/mm, set to 350-1000 nm (blazed at 500 nm)
Slit:	25 µm width (height is 1000 µm)	25 µm width (height is 1000 µm)	25 µm width (height is 1000 µm)	25 µm width (height is 1000 µm)
Detector collection lens:	No	No	Yes	Yes
Focal length:	42 mm (input); 68 mm (output)	42 mm (input); 68 mm (output)	42 mm (input); 68 mm (output)	42 mm (input); 68 mm (output)
Order-sorting:	Single-piece, multi-bandpass detector coating to eliminate second-order effects from 200-850 nm	Single-piece, multi-bandpass detector coating to eliminate second-order effects from 350-1000 nm	Single-piece, multi-bandpass detector coating to eliminate second-order effects from 200-850 nm	Single-piece, multi-bandpass detector coating to eliminate second-order effects from 350-1000 nm
Resolution:	1.5 nm (FWHM)	1.5 nm (FWHM)	1.5 nm (FWHM)	1.5 nm (FWHM)
Stray light:	< 0.05% at 600 nm < 0.10% at 435 nm < 0.10% at 250 nm	< 0.05% at 600 nm < 0.10% at 435 nm	< 0.05% at 600 nm < 0.10% at 435 nm < 0.10% at 250 nm	< 0.05% at 600 nm < 0.10% at 435 nm
Fiber optic connector:	SMA 905 to single-strand optical fiber (0.22 NA)	SMA 905 to single-strand optical fiber (0.22 NA)	SMA 905 to single-strand optical fiber (0.22 NA)	SMA 905 to single-strand optical fiber (0.22 NA)

USB4000-UV-VIS and USB4000-VIS-NIR

Application-ready Spectrometers for the UV-VIS and VIS-NIR

The USB4000-UV-VIS and USB4000-VIS-NIR are reliable, robust spectrometers that have a 3648-element linear CCD array detector for good signal-to-noise performance as well as enhanced electronics for controlling the spectrometer and accessories.

Each spectrometer has a 3648-element Toshiba TCD1304AP detector with a multibandpass order-sorting filter and 25 µm slit for optical resolution to ~1.5 nm (FWHM). We also offer enhanced-sensitivity (ES) models – distinguished by more efficient light collection optics. The USB4000-UV-VIS covers the 200-850 nm wavelength range and the USB4000-VIS-NIR covers 350-1000 nm. Software is priced separately and operates on Windows, OS X and Linux.

Although the USB4000-UV-VIS and USB4000-VIS-NIR have a preconfigured optical bench, there's still flexibility built in. That's because these spectrometers are compatible with our entire range of SMA 905-terminated fiber optic accessories. UB4000-UV-VIS and USB4000-VIS-NIR spectrometers make great choices for a variety of basic absorbance, reflectance and emission applications.

Specifications	USB4000-UV-VIS	USB4000-VIS-NIR	USB4000-UV-VIS-ES	USB4000-VIS-NIR-ES
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm	89.1 mm x 63.3 mm x 34.4 mm	89.1 mm x 63.3 mm x 34.4 mm	89.1 mm x 63.3 mm x 34.4 mm
Weight:	190 g	190 g	190 g	190 g
Detector:	Toshiba TCD1304AP Linear CCD array	Toshiba TCD1304AP Linear CCD array	Toshiba TCD1304AP Linear CCD array	Toshiba TCD1304AP Linear CCD array
Integration time:	3.8 ms-10 seconds	3.8 ms-10 seconds	3.8 ms-10 seconds	3.8 ms-10 seconds
Dynamic range:	3.4 x 10^6 (system), 1300:1 for a single acquisition	3.4 x 10^6 (system), 1300:1 for a single acquisition	3.4 x 10^6 (system), 1300:1 for a single acquisition	3.4 x 10^6 (system), 1300:1 for a single acquisition
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm	130 photons/count at 400 nm; 60 photons/count at 600 nm	130 photons/count at 400 nm; 60 photons/count at 600 nm	130 photons/count at 400 nm; 60 photons/count at 600 nm
Signal-to-noise ratio:	300:1 (at full signal)	300:1 (at full signal)	300:1 (at full signal)	300:1 (at full signal)
Dark noise:	50 (RMS)	50 (RMS)	50 (RMS)	50 (RMS)
Grating:	600 l/mm, set to 200-850 mm (blazed at 300 nm)	600 l/mm, set to 350-1000 nm (blazed at 500 nm)	600 l/mm, set to 200-850 mm (blazed at 300 nm)	600 l/mm, set to 350-1000 nm (blazed at 500 nm)
Slit:	1000 µm x 25 µm	1000 µm x 25 µm	1000 µm x 25 µm	1000 µm x 25 µm
Detector collection lens:	No	No	Yes	Yes
Focal length:	42 mm (input); 68 mm (output)	42 mm (input); 68 mm (output)	42 mm (input); 68 mm (output)	42 mm (input); 68 mm (output)
Order-sorting:	Single-piece, multi-bandpass detector coating to eliminate second-order effects from 200-850 nm	Single-piece, multi-bandpass detector coating to eliminate second-order effects from 350-1000 nm	Single-piece, multi-bandpass detector coating to eliminate second-order effects from 200-850 nm	Single-piece, multi-bandpass detector coating to eliminate second-order effects from 350-1000 nm
Optical resolution:	1.5-2.3 nm (FWHM)	1.5-2.3 nm (FWHM)	1.5-2.3 nm (FWHM)	1.5-2.3 nm (FWHM)
Stray light:	<0.05% at 600 nm; 0.10% at 435 nm	<0.05% at 600 nm; 0.10% at 435 nm	<0.05% at 600 nm; 0.10% at 435 nm	<0.05% at 600 nm; 0.10% at 435 nm
Fiber optic connector:	SMA 905 to single-strand optical fiber (0.22 NA)	SMA 905 to single-strand optical fiber (0.22 NA)	SMA 905 to single-strand optical fiber (0.22 NA)	SMA 905 to single-strand optical fiber (0.22 NA)

USB Series Spectrometers

Extended Range XR Spectrometers

Our XR-Series USB Spectrometers are responsive across a wide spectral range and provide you optical resolution of ~2.0 nm (FWHM) with the convenience of a single, monolithic unit that covers wavelengths from ~200-1025 nm.

The XR option is now available for our USB2000+ (USB2000+XR1) and USB4000 (USB4000-XR1) Spectrometers and can be configured into custom systems (specify GRATING_#XR1). The extended-range grating is also available in a portable Jaz Spectrometer configuration (see JAZ-EL200-XR1 in the Jaz section). And for enhanced sensitivity, select the USB2000+XR1-ES or USB4000-XR1-ES.

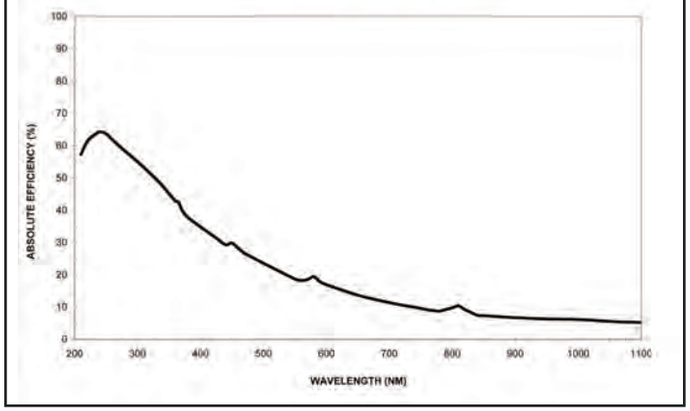
With the XR Series, there's no need to daisy-chain multiple spectrometers to enable UV-NIR coverage. Thanks to the XR's 500 lines/mm groove density grating, you have the advantages of broader spectral coverage as well as good optical resolution.

This grating delivers 825 nm of spectral range and is blazed at 250 nm. And, because their optical bench designs are not affected, the USB2000+ and USB4000 experience no trade-off in performance with the new grating.

Specifications	USB2000+XR1	USB4000-XR1	USB2000+XR1-ES	USB4000-XR1-ES
Spectrometer type:	USB2000+ advanced electronics spectrometer	USB4000 general-purpose spectrometer	USB2000+ enhanced-sensitivity spectrometer	USB4000 enhanced-sensitivity spectrometer
Grating:	Grating #31, 500 l/mm, blazed at 250 nm	Grating #31, 500 l/mm, blazed at 250 nm	Grating #31, 500 l/mm, blazed at 250 nm	Grating #31, 500 l/mm, blazed at 250 nm
Spectral range:	200-1025 nm	200-1025 nm	200-1025 nm	200-1025 nm
Entrance slit:	25 µm	25 µm	25 µm	25 µm
Detector collection lens:	No	No	Yes	Yes
Optical resolution (FWHM):	~1.7-2.1 nm	~1.7-2.0 nm	~1.7-2.1 nm	~1.7-2.0 nm
Order-sorting filter:	Yes	Yes	Yes	Yes

Note: Dimensions, detector and electronics specifications are comparable to the specifications for the USB2000+ and USB4000 Spectrometers and their application-ready versions.

XR Extended Range Grating Efficiency



Technical Tip: XR-Series Applications

XR-series spectrometers are especially useful for solar irradiance measurements, atomic emission line analysis, plasma monitoring, process applications and more.

Those applications benefit from the XR's unique optical characteristics. The diffraction grating provides coverage from 200-1025 nm, but that's only part of the story. The broad range doesn't do you much good if you are unable to manage higher-order spectral sorting. So we developed a proprietary order-sorting filter that is applied directly to the detector to eliminate second- and third-order effects.

USB4000-FL Fluorescence Spectrometers

Preconfigured Spectrometers for Fluorescence

The USB4000-FL, USB4000-FL-450 and USB4000-FL-395 Spectrometers are preconfigured for fluorescence measurements from 360-1100 nm. Each spectrometer comes with a 200 µm slit and detector collection lens for increased light throughput and features plug-and-play operation, a high-performance 3648-element CCD-array detector and fast USB 2.0 connectivity.

There are three USB4000-FL options:

- **USB4000-FL**
  Our basic fluorescence spectrometer can be combined with various excitation sources and accessories for probe- and cuvette-based setups. We offer an extensive range of separate LEDs for excitation.

- **USB4000-FL-450 and USB4000-FL-395**
  These models offer all the advantages of our USB4000-FL, but with a direct-attach 470 nm LED (pictured) or 395 nm LED for excitation. The LED connects to the spectrometer via a 10-pin connector. The spectrometer powers and controls (through software) the LED. The direct-attach LED option provides you with a convenient, small-footprint package for your single-wavelength excitation needs.

Filtering Options

USB4000-FLs can be used with our LVF-series Linear Variable Filters for simple yet effective separation of excitation and fluorescence energy. Use our LVF-L Linear Variable Low-pass Filter to fine-tune your excitation source for maximum signal with minimum overlap. Our LVF-H Linear Variable High-pass Filter can be effective on the detection side. Additional blocking filter options are also available.

Physical	
Dimensions:	89.1 mm x 63.3 mm x 34. 4 mm (spectrometer only); 89.1 mm x 120.3 mm x 34.4 mm (spectrometer w/LED)
Weight:	190 g (spectrometer only); 310 g (spectrometer w/LED)
Detector Specifications	
Detector:	Toshiba TCD1304AP Linear CCD array
Detector range:	200-1100 nm
Pixels:	3648 pixels
Pixel size:	8 µm x 200 µm
Pixel well depth:	100,000 electrons
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm
Optical Bench	
Design:	f/4, Asymmetrical crossed Czerny-Turner
Focal length:	42 mm (input); 68 mm (output)
Entrance aperture:	200 µm wide slit
Grating:	Grating #3 -- groove density 600 l/mm, set to 360-1000 nm, 500 nm blaze
Detector collection lens:	Yes, L4
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Spectroscopic	
Wavelength range:	360-1000 nm
Optical resolution:	~10.0 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	50 RMS counts
Dynamic range:	3.4 x 10^6 (system), 1300:1 for a single acquisition
Integration time:	3.8 ms-10 seconds
Stray light:	<0.05% at 600 nm; 0.10% at 435 nm
Corrected linearity:	>99%
LED Specifications for USB4000-FL-450 and USB4000-FL-395	
Wavelength:	460-490 nm (USB4000-FL-450) and 380-410 nm (USB4000-FL-395)
Power consumption:	60 mA @ 5 VDC
Power output:	60 µW (minimum) into a 600 µm fiber
Stability:	+/-1.0% drift after 2-minute warm-up period
Electronics	
Power consumption:	250 mA @ 5 VDC
Data transfer speed:	Full scans to memory every 5 ms with USB 2.0 port
Inputs/Outputs:	Yes, 8 onboard digital user-programmable GPIOs
Analog channels:	No
Auto nulling:	Yes
Trigger modes:	4 modes
Strobe functions:	Yes
Connector:	22-pin connector

USB2000+RAD Spectrometer

Preconfigured for Irradiance Measurements

The USB2000+RAD Spectroradiometer is a preconfigured combination of a powerful 2-MHz analog-to-digital (A/D) converter, programmable electronics, a 2048-element CCD-array detector, a high-speed USB 2.0 port and cosine corrector. This innovative combination produces our fastest spectrometer yet and provides resolution to 0.35 nm (FWHM). The USB2000+RAD allows you to capture and store a full spectrum into memory up to once per millisecond when the spectrometer is interfaced to a computer via a USB 2.0 port.

This spectroradiometer system features a USB2000+ Spectrometer and attached CC-3-DA cosine corrector. It does not require in-field NIST-traceable UV-VIS calibration as it is precalibrated by Ocean Optics with our SPEC-CAL-UV radiometric calibration service for UV spectrometers. The USB2000+RAD is preconfigured and ready for measurement "out of the box" so that installation and measurement is fast, accurate and convenient.

Features

- Programmable microcontroller
- Up to 1,000 full spectra per second
- Modular design
- Automatically reads wavelength calibration coefficients of the spectrometer and configures operating software
- RoHS and CE compliant

Physical	
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm
Weight:	190 g
Detector	
Detector:	Sony ILX511B linear silicon CCD array
Detector range:	200-1100 nm
Pixels:	2048 pixels
Pixel size:	14 µm x 200 µm
Pixel well depth:	~62,500 electrons
Sensitivity:	75 photons/count at 400 nm; 41 photons/count at 600 nm
Optical Bench	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output
Entrance aperture:	50 µm wide slit
Grating:	Grating # 2 groove density 600 l/mm, set to 250-800 nm (400 nm blaze)
Detector collection lens:	Yes, L2
Collimating and focusing mirror:	Standard
UV enhanced window:	UV2 quartz window
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Spectroscopic	
Wavelength range:	200-850 nm
Optical resolution:	~2.0 FWHM
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	50 RMS counts
Dynamic range:	8.5 x 10^7 (system); 1300:1 for a single acquisition
Integration time:	1 ms to 65 seconds (20 s typical)
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Corrected linearity:	>99%
Electronics	
Power consumption:	250 mA @ 5 VDC
Data transfer speed:	Full scans to memory every 1 ms with USB 2.0 or 1.1 port, 300 ms with serial port
Trigger modes:	4 modes
Strobe functions:	Yes
Gated delay feature:	Yes
Connector:	22-pin connector

Turn your USB2000+RAD into a spectroradiometric system for calculating Photosynthetically Active Radiation (PAR). SpectraSuite-PAR is a plug-in for our SpectraSuite spectroscopy software that uses absolute irradiance of the light incident on plants and other samples and converts the irradiance values from µW/cm^2 (microwatts per square centimeter) to µmol/m^2/s (micromoles per square meter per second) -- the measurement unit more commonly used for PAR analysis.

USB User-Configured Spectrometers Overview

Optimizing the USB2000+ and USB4000 Spectrometers for Your Application

With standard USB2000+ and USB4000 Spectrometers, you select the ultimate combination of optical bench options -- gratings, slits, filters, mirrors and more – to optimize the system for your application. Hundreds of different setups can be configured for each model.

With the exception of the detector, the USB2000+ and USB4000 use identical optical bench accessories.

USB2000+/USB4000 Optical Bench Options

Maximum flexibility is available with USB2000+ and USB4000 Spectrometers. Here are the optical bench accessories available for your spectrometer:

1 **SMA 905 Connector**
Light from a fiber enters the optical bench through the SMA 905 Connector. The SMA 905 bulkhead provides a precise locus for the end of the optical fiber, fixed slit, absorbing filter and fiber clad mode aperture.

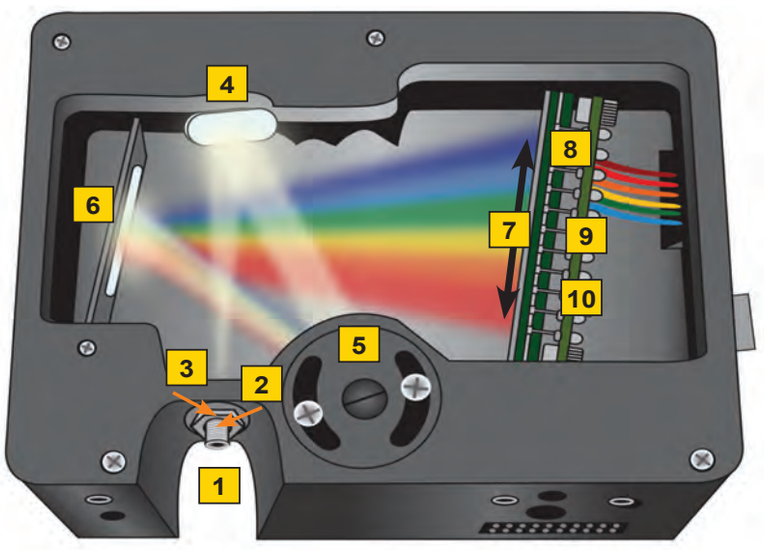
2 **Fixed Entrance Slit: specify slit size**
Light passes through the installed slit, which acts as the entrance aperture. Slits come in various widths from 5 µm to 200 µm. The slit is fixed in the SMA 905 bulkhead to sit against the end of a fiber.

3 **Longpass Absorbing Filter: optional**
If selected, an absorbing filter is installed between the slit and the clad mode aperture in the SMA 905 bulkhead. The filter is used to limit bandwidth of light entering spectrometer or to balance color.

4 **Collimating Mirror: specify standard or SAG+**
The collimating mirror is matched to the 0.22 numerical aperture of our optical fiber. Light reflects from this mirror, as a collimated beam, toward the grating. You can opt to install a standard mirror or a UV absorbing SAG+ mirror.

5 **Grating and Wavelength Range: specify grating and starting wavelength**
We install the grating on a platform that we then rotate to select the starting wavelength you've specified. Then we permanently fix the grating in place to eliminate mechanical shifts or drift.

6 **Focusing Mirror: specify standard or SAG+**
This mirror focuses first-order spectra on the detector plane. Both the collimating and focusing mirrors are made in-house to guarantee the highest reflectance and the lowest stray light possible. You can opt to install a standard or SAG+ mirror.



7 **L2/L4 Detector Collection Lens: optional**
This cylindrical lens, made in-house to ensure aberration-free performance, is fixed to the detector to focus the light from the tall slit onto the shorter detector elements. It increases light-collection efficiency.

8 **Detector**
We offer a 2048-element Sony ILX511B and 3648-element Toshiba TCD1304AP linear CCD array detector. Each pixel responds to the wavelength of light that strikes it. Electronics bring the complete spectrum to the software.

9 **OFLV Variable Longpass Order-sorting Filter: optional**
Our proprietary filters precisely block second- and third-order light from reaching specific detector elements.

10 **UV2/UV4 Detector Upgrade: optional**
When selected, the detector's standard BK7 window is replaced with a quartz window to enhance the performance of the spectrometer for applications <340 nm.

USB2000+ Spectrometer

User-configured for Maximum Flexibility

The USB2000+ Spectrometer is a clever combination of technologies: a powerful 2-MHz A/D converter, programmable electronics, a 2048-element CCD-array detector and a high-speed USB 2.0 port.

This innovative design produces our fastest spectrometer and provides resolution to 0.35 nm (FWHM). The USB2000+ allows you to capture and store a full spectrum into memory up to once per millisecond (nearly 1,000 full spectra every second) when the spectrometer is interfaced to a computer via a USB 2.0 port (performance may vary depending on computer and process loading). The USB2000+ is perfect for chemical, biochemical and other applications where fast reactions need to be monitored.

Features

- Up to 1,000 full spectra/second
- Programmable microcontroller
- Modular design – hundreds of configurations possible
- Built-to-suit wavelength range and resolution
- Automatically reads the wavelength calibration coefficients of the spectrometer and configures operating software
- USB-to-PC interface; no external power requirements
- RoHS and CE compliance

Programmable Microcontroller

The USB2000+ has an onboard programmable microcontroller that provides flexibility in controlling the spectrometer and accessories. Through a 22-pin connector, you can implement all operating parameters in the software, such as controlling external light sources, creating processes and routines and retrieving data from external devices.

Physical	
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm
Weight:	190 g
Detector	
Detector:	Sony ILX511B linear silicon CCD array
Detector range:	200-1100 nm
Pixels:	2048 pixels
Pixel size:	14 µm x 200 µm
Pixel well depth:	~62,500 electrons
Sensitivity:	75 photons/count at 400 nm; 41 photons/count at 600 nm
Optical Bench	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits or fiber (no slit)
Grating options:	14 different gratings, UV through Shortwave NIR
XR grating option:	Yes
Detector collection lens option:	Yes, L2
OFLV filter options:	OFLV-200-850; OFLV-350-1000
Other bench filter options:	Longpass OF-1 filters
Collimating and focusing mirrors:	Standard or SAG+
UV enhanced window:	Yes, UV2 quartz window
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Spectroscopic	
Wavelength range:	Grating-dependent
Optical resolution:	~0.3-10.0 nm FWHM
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	50 RMS counts
Dynamic range:	8.5 x 10^7 (system); 1300:1 for a single acquisition
Integration time:	1 ms to 65 seconds (20 seconds typical)
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Corrected linearity:	>99%
Electronics	
Power consumption:	250 mA @ 5 VDC
Data transfer speed:	Full scans to memory every 1 ms with USB 2.0 or 1.1 port, 300 ms with serial port
Inputs/Outputs:	Yes, onboard digital user-progammable GPIOs
Analog channels:	No
Auto nulling:	No
Breakout box compatibility:	No
Trigger modes:	4 modes
Strobe functions:	Yes
Gated delay feature:	Yes
Connector:	22-pin connector

USB4000 Spectrometer

User-Configured to be Flexible

If you're looking for an economical, versatile spectrometer, you'll find the USB4000 to be an exceptional solution. This compact, modular unit packs a 3648-element Toshiba linear CCD-array detector to provide increased signal-to-noise and enhanced electronics for control of the spectrometer as well as its accessories.

The USB4000 Spectrometer is distinguished by its enhanced electronics: 16-bit A/D resolution with auto nulling feature (an enhanced electrical dark-signal correction); EEPROM storage of calibration coefficients for simple spectrometer start-up; 8 programmable GPIO signals for controlling peripheral devices; and an electronic shutter – a handy feature to prevent detector saturation.

The USB4000 couples easily via an SMA 905 connector to our line of spectroscopic accessories. Direct-attach accessories are available as well as discrete light sources, optical fibers, sampling devices such as cuvette holders and flow cells and many more. In most instances, changing the sampling system from one experiment setup to another is as easy as unscrewing a connector and swapping out accessories.

Features

- Programmable microcontroller
- Modular design
- Automatically reads wavelength calibration coefficients of the spectrometer and configures operating software
- RoHS and CE compliant

Physical	
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm
Weight:	190 g
Detector	
Detector:	Toshiba TCD1304AP linear CCD array
Detector range:	200-1100 nm
Pixels:	3648 pixels
Pixel size:	8 µm x 200 µm
Pixel well depth:	100,000 electrons
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm
Optical Bench	
Design:	f/4, Asymmetrical crossed Czerny-Turner
Focal length:	42 mm (input); 68 mm (output)
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits or fiber (no slit)
Grating:	Multiple gratings, UV through Shortwave NIR
OFLV filter:	OFLV-200-850, OFLV-350-1000
UV enhanced window:	Yes, UV4 quartz window
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Spectroscopic	
Wavelength range:	Grating dependent
Optical resolution:	~0.1-10 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	50 RMS counts
Integration time:	3.8 ms-10 seconds
Dynamic range:	3.4×10^6 (system), 1300:1 for a single acquisition
Stray light:	<0.05% at 600 nm; 0.10% at 435 nm
Corrected linearity:	>99%
Electronics	
Power consumption:	250 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 5 ms with USB 2.0 port
Inputs/Outputs:	Yes, 8 onboard digital user-programmable GPIOs
Breakout box compatible:	Yes, with the USB-ADP-BB adapter
Trigger modes:	4 modes
Strobe functions:	Yes
Connector:	22-pin connector

Fun Fact: Our USB Spectrometers are among the most popular selling miniature spectrometers on the market and can trace their lineage to the S1000 – the world's first miniature spectrometer -- which we introduced in 1992. The first miniature spectrometer we sold went to a researcher at Los Alamos National Laboratories, whose work involved plutonium. Years later we tracked down that first spectrometer and now display it at company headquarters.

USB User-configured Spectrometers

Bench Accessories for USB2000+/USB4000 Spectrometers

The magic behind our USB2000+ and USB4000 miniature spectrometers is the range of options you can select to configure your optical bench to perfectly suit your unique application needs. By consulting with an Ocean Optics Applications Scientist, you can choose the optimum combination of aperture size, detector accessories, filters, gratings and more.

SMA 905 Connectors

This precision connector aligns to the spectrometer's entrance slit and ensures concentricity of the fiber. While SMA 905 is standard, connector adapters are available for mating to ST or FC connectors.

Fixed Entrance Slits

Our entrance slits are rectangular apertures that are 1 mm tall and come in varying widths from 5 µm to 200 µm. Smaller slit sizes achieve the best optical resolution.

Slit	Description	USB2000+ Pixel Resolution	USB4000 Pixel Resolution
SLIT-5	5-µm wide x 1-mm high	~3.0 pixels	~5.3 pixels
SLIT-10	10-µm wide x 1-mm high	~3.2 pixels	~5.7 pixels
SLIT-25	25-µm wide x 1-mm high	~4.2 pixels	~7.5 pixels
SLIT-50	50-µm wide x 1-mm high	~6.5 pixels	~11.6 pixels
SLIT-100	100-µm wide x 1-mm high	~12 pixels	~21 pixels
SLIT-200	200-µm wide x 1-mm high	~24 pixels	~42 pixels

Note: Torus uses INTSMA-Series slits. See Jaz section for options.

Longpass Absorbing Filters

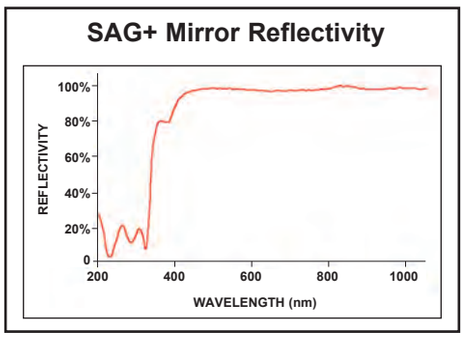
Whether you select a Longpass Absorbing or Blocking Filter, each has a transmission band and a blocking band to restrict radiation to a certain wavelength region. This helps eliminate second- and third-order effects. Filters are installed permanently.

Item	Description
OF1-WG305	Longpass filter; transmits light >305 nm
OF1-GG375	Longpass filter; transmits light >375 nm
OF1-GG395	Longpass filter; installed, transmits light >395 nm
OF1-GG475	Longpass filter; transmits light >475 nm
OF1-OG515	Longpass filter; transmits light >515 nm
OF1-OG550	Longpass filter; transmits light >550 nm
OF1-OG590	Longpass filter; transmits light >590 nm

Collimating and Focusing Mirrors

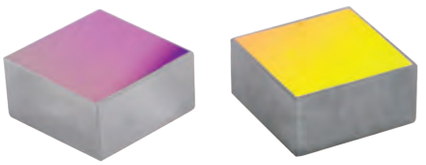
You can replace our standard aluminum-coated reflective mirrors with our proprietary UV-absorbing SAG+ Mirrors. These increase reflectance in the VIS-NIR range while increasing your spectrometer's sensitivity. They also absorb nearly all UV light – reducing the effects of excitation scattering in fluorescence measurements.

Item Code: SAG+UPG



Grating and Wavelength Range

With a choice of multiple gratings, you can easily customize the spectral range and most efficient region of your USB Series Spectrometer. Our gratings are permanently fixed in place at the time of manufacture and are available in both ruled and holographic versions. See pages 20-21 for grating options and efficiency curves and consult an Ocean Optics Applications Scientist for details.

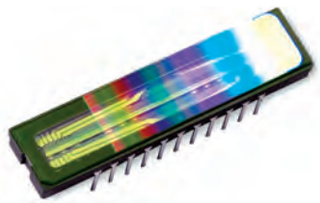


USB User-Configured Spectrometers

Detectors and Accessories for USB2000+/USB4000 Spectrometers

Detectors

The USB2000+ has a 2048-element Sony ILX511B detector and the USB4000 has a 3648-element Toshiba TCD1304AP detector. Both are linear silicon CCD arrays with an effective range of 200-1100 nm. Detectors come with BK7 or quartz windows. Order-sorting filters and collection lenses are optional.



Detector Collection Lenses

These cylindrical lenses ensure aberration-free performance and are fixed to the detector's window to focus light from the tall slit onto the shorter detector elements. The L2 (for the USB2000+) and L4 (USB4000) increase light collection efficiency and help reduce stray light. They also are useful for low-light level applications where a large-diameter fiber is being used.

Detectors with OFLV Filters

OFLV Variable Longpass Order-sorting Filters are applied to the detector's window to eliminate second- and third-order effects. We use a patented coating technology to apply the filter to the substrate.

UV2 and UV4 Detector Window Upgrades

For any application <350 nm, we replace the detector's standard BK7 glass window with a quartz window. Quartz transmits in the UV and provides better UV performance.

Detector	Description	Spectrometer
DET2B-200-850	Sony ILX511B detector, installed, w/200-850 nm variable longpass filter and UV2 quartz window; best for UV-VIS systems configured with Grating #1 or #2	USB2000+
DET2B-200-1100	Sony ILX511B detector, installed, w/200-850 nm variable longpass filter and UV2 quartz window; best for UV-VIS systems configured with XR-1 Grating	USB2000+
DET2B-350-1000	Sony ILX511B detector, installed, with 350-1000 nm variable longpass filter; best for VIS system configured with Grating #2 or #3	USB2000+
DET2B-UV	Sony ILX511B detector, installed, with UV2 quartz window; best for systems configured for <360 nm	USB2000+
DET2B-VIS	Sony ILX511B detector, installed, with VIS BK7 window; best for systems configured for >400 nm	USB2000+, Torus
DET2B-TORUS-OSF	Sony ILX511B detector, installed, with Torus Order-Sorting Filter	Torus
DET4-200-850	Toshiba TCD1304AP detector, installed, w/200-850 nm variable longpass filter and UV2 quartz window; best for UV-VIS systems configured with Grating #1 or #2	USB4000
DET4-200-1100	Toshiba TCD1304AP detector, installed, with 200-850 nm variable longpass filter and UV4 quartz window; best for systems configured with XR-1 grating	USB4000
DET4-350-1000	Toshiba TCD1304AP detector, installed, with 350-1000 nm variable longpass filter; best for VIS systems configured with Grating #2 or #3	USB4000
DET4-UV	Toshiba TCD1304AP detector, installed, with UV4 quartz window; best for systems configured for <360 nm	USB4000
DET4-VIS	Toshiba TCD1304AP detector, installed, with VIS BK7 window; best for systems configured for >400 nm	USB4000

Additional detector configurations – including a no-window option – are available. Please consult an Application Scientist for details.

Technical Tip: Optimizing Your Spectrometer

Our spectrometers can be optimized for parameters such as spectral range, optical resolution (FWHM) and sensitivity by selecting gratings, entrance apertures (slits) and other optical bench accessories appropriate to your application. Customers frequently ask if they can change the system's spectral range and optical resolution in the field. For spectral range, the short answer is: no. Spectral range is a function of the detector and grating, both of which are fixed in place. To change a grating requires returning the spectrometer to Ocean Optics for reconfiguration. For optical resolution, you have a little more leeway. For example, if your spectrometer has no slit installed, you can affect optical resolution by using optical fibers of different diameters. Also, our Jaz spectrometer has replaceable slits. Otherwise, slit changes require returning the spectrometer to us.

USB Series Spectrometers

USB Direct-Attach Accessories

We offer a variety of compact, modular Direct-Attach Accessories that enable you to make your USB Series Spectrometer a custom-tailored solution for your unique application needs. Each accessory is designed and manufactured to be robust and provide years of reliable service.

USB-ISS-UV-VIS
Sampling System

This clever, integrated sampling system is a direct-attach sample holder and deuterium tungsten light source for 200-1100 nm. You can control the USB-ISS-UV-VIS's shutter through software. A separate 5V power supply is included.

Item Code: USB-ISS-UV-VIS

USB-ISS-VIS
Sampling System

The USB-ISS-VIS is a snap-on cuvette holder and visible light source combination that holds a 1-cm square cuvette and features a range of 390-900 nm. The system's light source features a long-life tungsten bulb and multiple violet light emitting diodes. Powered via USB.

Item Code: USB-ISS-VIS

USB-LS Series
Integrated LEDs

Turn your USB2000+ or USB4000 into a spectrofluorometer by adding an integrated LED module. Standard versions are available with 395 nm and 470 nm excitation wavelengths; the 470 nm LED module is also available with a 4-20 mA output.

Item Code: USB-LS-395, USB-LS-450, USB-LS-450-4-20

USB-FHS
Snap-On Filter Holder

The USB-FHS is a combination light source-filter holder that is optimized for 390-900 nm measurements. It can be used for fast, convenient absorbance and transmission measurements of square and round filters up to 2". The USB-FHS features long-life tungsten bulbs and multiple violet light emitting diodes. Powered via USB.

Item Code: USB-FHS

USB-BP
Portable Battery Pack

The USB-BP is a portable Lithium Ion battery pack that gives you up to eight hours of continuous power to your USB Spectrometer and any additional direct-attach accessories. This battery pack delivers 2 amp-hours at 5 volts through its two lithium cells. The USB-BP charges in three hours with its included charger.

Item Code: USB-BP

USB User-Configured Spectrometers

Choosing the Right Grating

Groove Density

The groove density (mm^{-1}) of a grating determines its dispersion, while the angle of the groove determines the most efficient region of the spectrum. The greater the groove density, the better the optical resolution possible, but the more truncated the spectral range.

Spectral Range

Spectral range (bandwidth) is the dispersion of the grating across the linear array and is a function of the groove density. When you choose a starting wavelength for a spectrometer, you add its spectral range to the starting wavelength to determine the wavelength range. For several gratings, the Spectral Range of a grating varies according to the starting wavelength range. The rule of thumb is this: the higher the starting wavelength, the more truncated the spectral range.

Blaze Wavelength

For ruled gratings, blaze wavelength is the peak wavelength in an efficiency curve. For holographic gratings, it is the most efficient wavelength region.

Best Efficiency (>30%)

All ruled or holographically etched gratings optimize first-order spectra at certain wavelength regions; the "best" or most efficient region is the range where efficiency is >30%. In some cases, gratings have a greater spectral range than is efficiently diffracted. For example, Grating 1 has about a 650 nm spectral range, but is most efficient from 200-575 nm. In this case, wavelengths >575 nm will have lower intensity due to the grating's reduced efficiency.

Note: Although the spectral range of a spectrometer with Grating 13 is broad, the detector will respond to light only from 300-1100 nm. Also, because the grating has broad spectral range, optical resolution <3.0 nm FWHM is not possible. More important, second-order effects are much more difficult to eliminate or mitigate through order-sorting filters. Our XR grating (#31) is a better choice for broad-range applications.

We offer multiple gratings for our USB2000+/USB4000 Spectrometers.

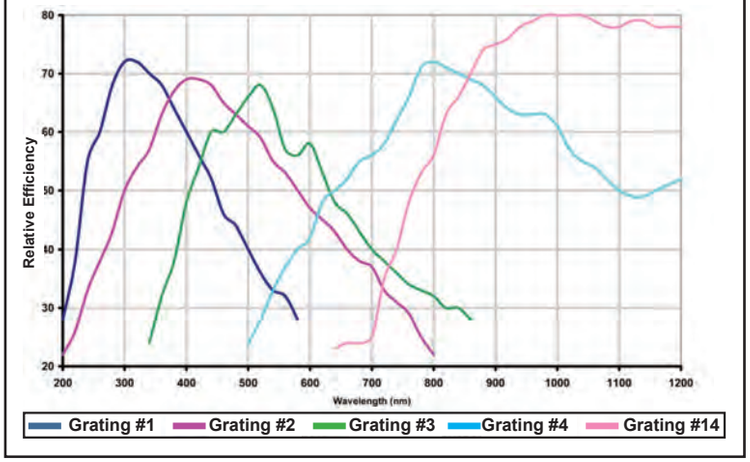
Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
1	UV	600	650 nm	300 nm	200-575 nm
2	UV-VIS	600	650 nm	400 nm	250-800 nm
3	VIS-Color	600	650 nm	500 nm	350-850 nm
4	NIR	600	625 nm	750 nm	530-1100 nm
5	UV-VIS	1200	300 nm	Holographic UV	200-400 nm
6	NIR	1200	200-270 nm	750 nm	500-1100 nm
7	UV-VIS	2400	100-140 nm	Holographic UV	200-500 nm
8	UV	3600	50-75 nm	Holographic UV	290-340 nm
9	VIS-NIR	1200	200-270 nm	Holographic VIS	400-800 nm
10	UV-VIS	1800	100-190 nm	Holographic UV	200-635 nm
11	UV-VIS	1800	120-160 nm	Holographic VIS	320-720 nm
12	UV-VIS	2400	50-120 nm	Holographic VIS	260-780 nm
13	UV-VIS-NIR	300	1700 nm	500 nm	300-1100 nm
14	NIR	600	625 nm	1000 nm	650-1100 nm
31	UV-NIR	500	200-1025 nm	250 nm	200-450 nm

USB User-Configured Spectrometers

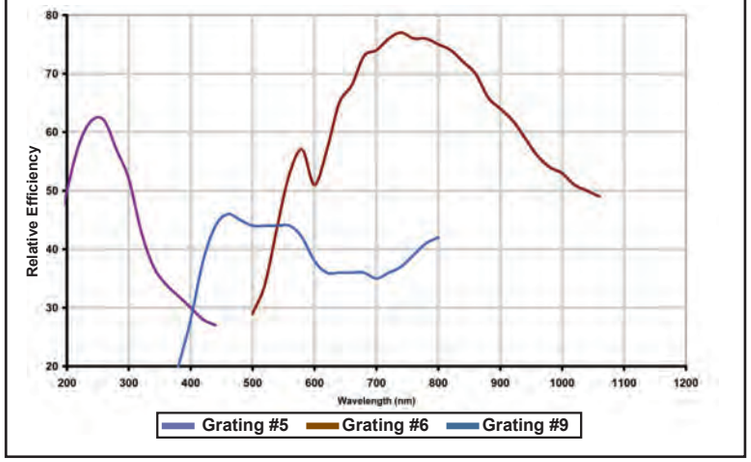
Gratings for USB2000+/USB4000 Spectrometers

The graphs below are grating efficiency curves for gratings with groove densities of 500, 600, 1200, 1800 and 2400 mm^{-1}. Additional information is available at www.oceanoptics.com/Products/bench_grating_usb.asp.

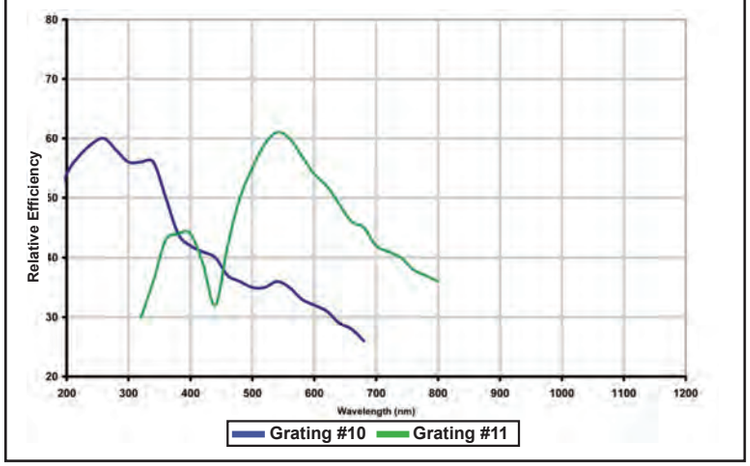
Groove Density of 600 mm^{-1}



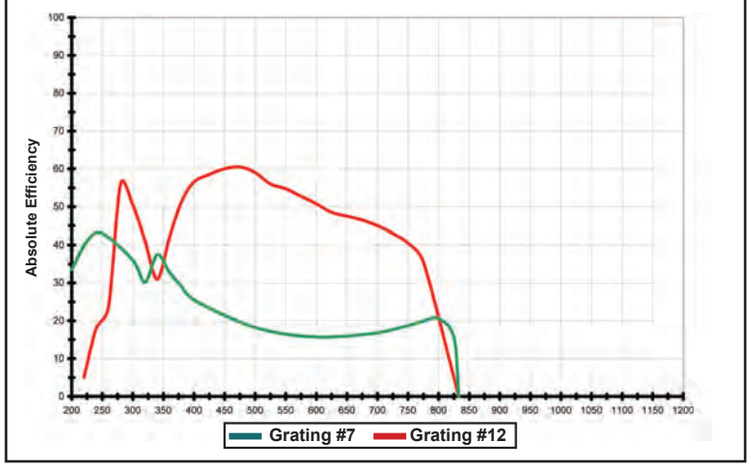
Groove Density of 1200 mm^{-1}



Groove Density of 1800 mm^{-1}



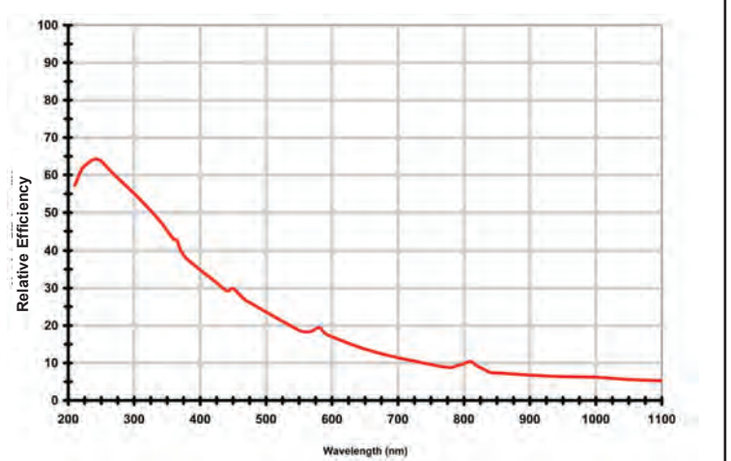
Groove Density of 2400 mm^{-1}



Grating Selection Tips:

- These efficiency curves relate only to the grating. System response is affected by a number of variables, including detector response.
- Grating selection often involves trade-offs. For example, gratings with very high groove density (lines/mm^{-1}) allow greater optical resolution but at the expense of a truncated spectral range. If the user is characterizing two or three closely aligned laser wavelengths, such a trade-off of resolution for range might be acceptable. For other applications, a wider range with good resolution would make better sense.
- The XR grating (#31) is a good option for broad spectral coverage (200-1025 nm) without sacrificing optical resolution (~2.0 nm FWHM with a 25 µm slit). For efficiency of Grating #8 (3600 mm^{-1}), visit our website.

Groove Density of 500 mm^{-1}

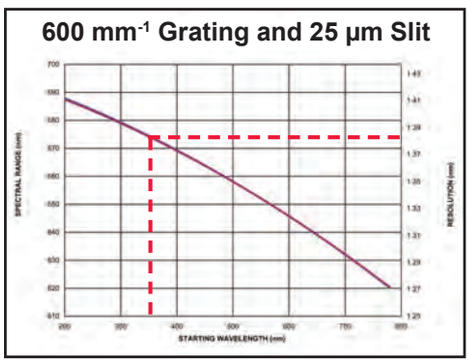


USB Series Spectrometers
Predicted Ranges and Resolution

Predicted Ranges and Resolution
These graphs demonstrate the range and resolution of your "USB" Bench Spectrometer with a 25 µm slit.

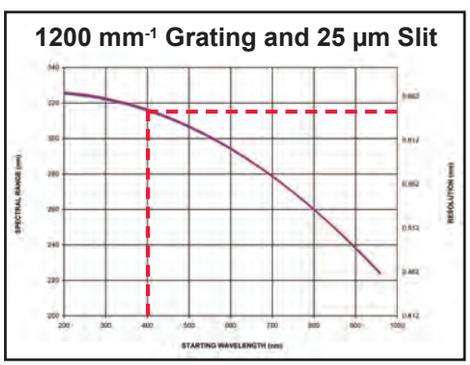
"USB" Bench with Sony Detector: USB2000+

600 mm^{-1} Grating and 25 µm Slit



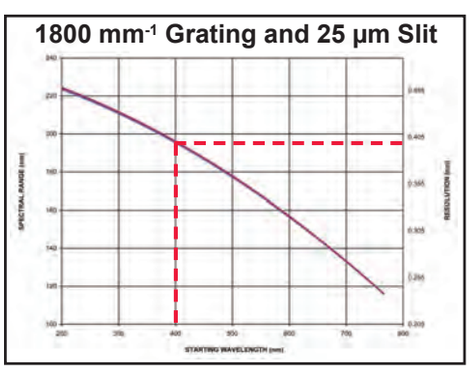
Example:
If the starting wavelength is 350 nm, then the range is ~674 nm, providing a 350-1024 nm wavelength range and 1.38 nm resolution.

1200 mm^{-1} Grating and 25 µm Slit



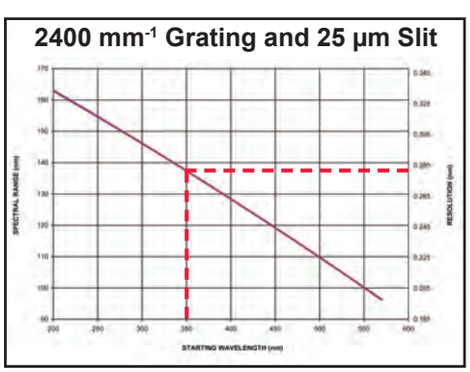
Example:
If the starting wavelength is 400 nm, then the range is ~316 nm, providing a 400-716 nm wavelength range and 0.65 nm resolution.

1800 mm^{-1} Grating and 25 µm Slit



Example:
If the starting wavelength is 400 nm, then the range is ~195 nm, providing a 400-595 nm wavelength range and 0.40 nm resolution.

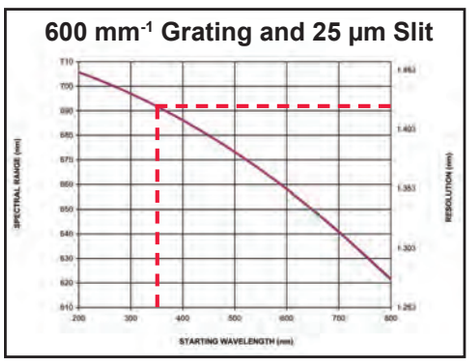
2400 mm^{-1} Grating and 25 µm Slit



Example:
If the starting wavelength is 350 nm, then the range is ~137 nm, providing a 350-487 nm wavelength range and 0.28 nm resolution.

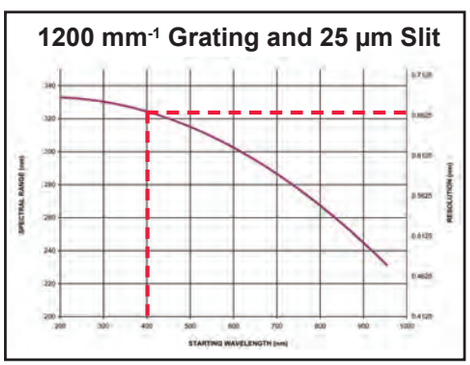
"USB" Bench with Toshiba Detector: USB4000

600 mm^{-1} Grating and 25 µm Slit



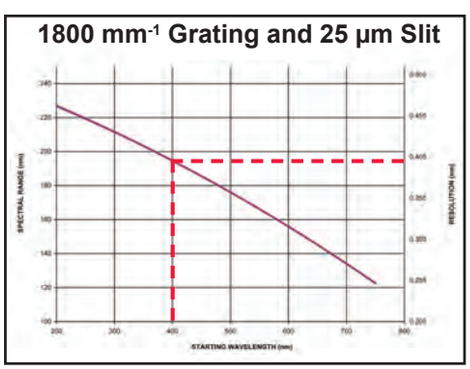
Example:
If the starting wavelength is 350 nm, then the range is ~692 nm, providing a 350-1042 nm wavelength range and 1.40 nm resolution.

1200 mm^{-1} Grating and 25 µm Slit



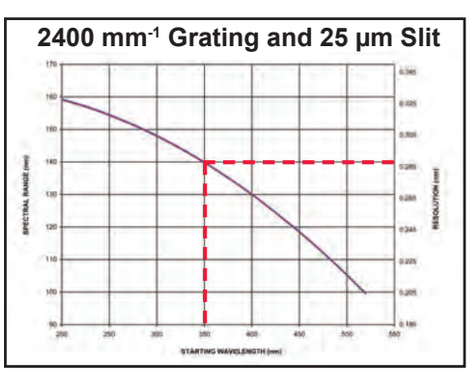
Example:
If the starting wavelength is 400 nm, then the range is ~325 nm, providing a 400-725 nm wavelength range and 0.67 nm resolution.

1800 mm^{-1} Grating and 25 µm Slit



Example:
If the starting wavelength is 400 nm, then the range is ~195 nm, providing a 400-595 nm wavelength range and 0.40 nm resolution.

2400 mm^{-1} Grating and 25 µm Slit



Example:
If the starting wavelength is 350 nm, then the range is ~140 nm, providing a 350-490 nm wavelength range and 0.29 nm resolution.

USB Series Spectrometers

Adapters, Cables and Other Accessories

Adapters, Cables and Device Control

Item Code	Description
ACC-CON-US4	Spectrometer accessory connector for external triggering on USB4000s
USB-ADP-BB	Adapter to connect USB4000 to HR4000 Breakout Box
USB-ADP-PC	Cable and adapter block to connect from serial port on spectrometer to serial port on computer; included with USB-CBL-PS power supply
USB-ADP-PC-E	European version of USB-ADP-PC
USB-ADP-PX2	Adapter block and cable to connect PX-2 Pulsed Xenon Lamp to USB2000+/USB4000
USB-AOUT	4-20 mA Analog Output Module for USB4000, USB2000+ Spectrometers
USB-CBL-0.5M	USB cable, 0.5 m length, for spectrometer-to-PC interface
USB-CBL-1	USB cable, 1 m length, for spectrometer-to-PC interface
USB-CBL-MINI	Mini USB cable for spectrometer-to-PC interface

Power Supplies

Item Code	Description
USB-CBL-PS	5 V universal power supply for spectrometers in serial mode
USB-BP	Direct-attach Lithium Ion battery pack for USB2000+/USB4000 Spectrometers
WT-12V	Regulated 12 V universal power supply (1.5A, 110/220 VAC)
WT-12V-R	Regulated 12 VDC power supply (2.5 A, 110 V)
WT-12V-R-E	Regulated 12 VDC power supply 2.5 A, with European-version cord for connecting power supply to wall outlet
WT-24V	24 VDC power supply (110 V)

Note: Most Ocean Optics power supplies are universal power supplies. Please contact an Applications Scientist for details.

Miscellaneous Spectrometer Accessories

Item Code	Description
SPEC-CADDY0350	Rugged, water-tight Pelican case for spectrometers and accessories; dimensions are 20” x 20” x 20” (50.8 x 50.8 x 50.8 cm)
SPEC-CADDY1500	Rugged, water-tight Pelican case for spectrometers and accessories; dimensions are 16.75" x 11.18" x 6.12" (42.5 x 28.4 x 15.5 cm)
SPEC-CADDY1520	Rugged, water-tight Pelican case for spectrometers and accessories; dimensions are 18.06" x 12.89" x 6.72" (45.9 x 32.7 x 17.1 cm)
SPEC-CADDY1560	Rugged, water-tight Pelican case for spectrometers and accessories; dimensions are 20.37" x 15.43" x 9.00" (51.7 x 39.2 x 22.9 cm)
USB-CUT	Demonstration USB Spectrometer with cutaway open optical bench; non-functioning spectrometer that's ideal as a teaching tool
STEADIQ-UV	Cooler-like, environmentally controlled enclosure compatible with USB2000+/USB4000 and other spectrometers; covers 200-1100 nm wavelength range
STEADIQ-VIS	Cooler-like, environmentally controlled enclosure compatible with USB2000+/USB4000 and other spectrometers; covers 400-2500 nm wavelength range

Note: Accessories specific to the Jaz Spectrometer are available in the Jaz section. Also, additional information on SteadiQ is available at the end of the Spectrometers section.

USB-TC

Increase Thermal Wavelength Stability

The new USB Temperature Controller (USB-TC) is an attachable heating device for our USB4000 and USB2000+ Miniature Spectrometers that greatly improves the thermal stability of your measurements. The USB-TC attaches directly to the spectrometer and maintains wavelength thermal stability to within +/-0.025 pixels/ ºC, making it ideal for industrial and other settings where temperature variations can affect spectral performance.

The USB-TC is available with pre-selected setpoint temperatures between 25-55 ºC and comes with a 12 VDC, 3A power supply. With constant ambient temperature, the USB-TC stabilizes to within 0.1 ºC of the final temperature within 30 minutes of power-up. The system will operate in temperatures ranging from 5-40 ºC below the setpoint temperature.

The USB-TC and is available with new spectrometer purchases or as a retrofit option for existing owners of USB2000+ and USB4000 spectrometers. Contact an Applications Scientist for details.

USB-TC Specifications

USB-TC w/USB2000+ or USB4000	
Size (cm):	6.35 x 8.9 x 3.18
Weight:	227 g (8 oz.)
Wavelength thermal stability:	+/-0.1 ºC of setpoint temperature +/-0.025 pixels/ ºC
Setpoint temperature:	Factory-adjustable between 25-55 ºC
Time to stabilize:	With constant ambient temperature, stabilizes to within 0.1 ºC of the final temperature within 30 minutes of power-up
Operating range:	5 ºC to 40 ºC below setpoint (Δ over which stability is maintained to +/-0.1 ºC)
Ambient temperature range:	Controls spectrometer to selected temperature when ambient temperature is between 5 ºC and 40 ºC below selected temperature
Environmental conditions:	0 ºC to 50 ºC
Temperature accuracy:	Selected temperature+/-2 ºC
Over-temperature threshold:	65 ºC +/-2 ºC
Humidity:	0-95% non-condensing

Tech Tip

Thermal Wavelength Stability in Spectrometers

Stability is a broad term that encompasses various elements of the spectrometer system, including the optical bench, electronics and light source. More specifically, thermal wavelength stability in spectrometers is a measure of the change in specifications (performance) at various temperatures; thermal stability is typically expressed in pixels per ºC for a passive device or as +/- ºC per setpoint temperature with an active device.

Ocean Optics provides three primary options for maintaining thermal stability in spectrometers:

- **Temperature Controllers** are active devices for controlling temperature. Examples are the USB-TC, which regulates device temperature; our SteadiQ spectrometer chamber, which regulates the environment temperature; and the thermoelectric coolers that typically regulate detector temperature in the QE65000, NIRQuest and other spectrometers.

- In **Passive Temperature Stabilization,** the spectrometer's athermal design promotes stability. For example, Torus has an optical bench design that minimizes temperature-related instability.

- The **Procedural Approach** uses experiment controls to mitigate the effects of temperature variation. Examples include taking frequent reference and dark measurements, integrating reference monitoring into the procedure and using electrical dark correction.

See individual product pages for thermal wavelength stability specifications.

Application Notes

Extended-range Measurement of a Deuterium-Halogen Light Source

Broad UV-NIR spectral coverage can be achieved in a miniature spectrometer configured with our XR-1 Extended Range grating, which is responsive from 200-1025 nm. Our USB2000+ Spectrometer with an XR-1 grating maintains good optical resolution over the UV-NIR range, making it useful for applications such as measuring the relative output of a combination deuterium-halogen light source.

Introduction

The ability to provide UV-NIR coverage in a single miniature spectrometer has always been a challenge. Trade-offs inherent to most diffraction gratings – most noticeably, the effect of blaze angle on the efficiency of the diffraction – can pose challenges for certain applications. While gratings were available that diffracted over a wide range, this came at the expense of decreased optical resolution and increased problems associated with second- and third-order overlap.

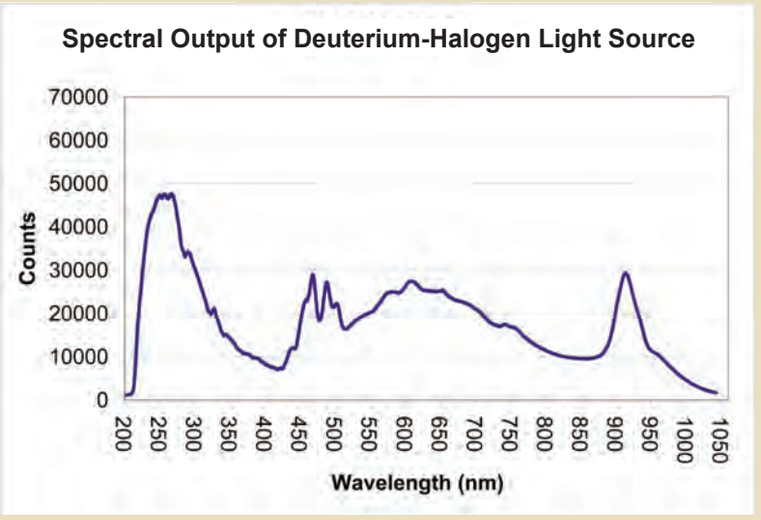
Newer gratings such as the XR-1 provide good efficiency over a wider wavelength range (200-1025 nm) than is otherwise possible with standard gratings. What's more, good optical resolution (<2.0 nm FWHM for most setups) can be maintained, and second- and third-order effects are eliminated by applying proprietary filtering technology to the CCD-array detector window. Transmission efficiency is affected only marginally by this filtering.

Broad spectral response in a single spectrometer offers convenience for those who regularly make measurements in both the UV-VIS and VIS-NIR, yet it also offers a solution for applications where samples are responsive across that same broad range. Examples include certain plasmas, solar irradiance, atomic emission lines and broadband light sources.

Experimental Conditions

To test the response of the XR-1 grating, we installed the 500 lines/mm groove density grating in the optical bench of our USB2000+. The spectrometer's optical bench also included a 25 µm slit and order-sorting detector filter. The grating provides 825 nm of spectral range and is blazed at 250 nm.

The test sample for the experiment was our DH-2000-BAL Deuterium Tungsten Halogen Light Source. The DH-2000-BAL combines the continuous spectrum of deuterium and tungsten halogen light sources in a single optical path to produce a powerful, stable output from 215-2000 nm (we observed only the region from 200-1025 nm). A UV-VIS optical fiber collected the signal from the light source. We recommend our QP450-2-XSR



optical fiber, which is a 455 µm core diameter fiber with excellent solarization resistance properties. Integration time of 10 milliseconds is typically sufficient for measuring a light source such as the DH-2000-BAL.

Results

The emission spectrum of the UV-NIR light source measured with the USB2000+XR matched the anticipated spectral output. The XR-1 grating showed good efficiency across the 200-1025 nm spectral range, with the best efficiency in the UV. Optical resolution was ~1.7 nm (FWHM) with a 25 µm slit (the standard slit option for the USB2000+XR1) and at ~1.2 nm (FWHM) with a 5 µm slit. Other expected spectrometer performance characteristics were unaffected by the presence of the grating.

Conclusions

Results demonstrate that an Ocean Optics spectrometer configured with the XR-1 extended-range grating will provide spectral coverage across the 200-1025 nm spectral range without sacrificing optical resolution performance or being subject to second- and third-order diffraction effects. The XR-1 is available in the application-ready USB2000+XR1, USB4000-XR1 and JAZ-EL200-XR1 Spectrometers (each has a 25 µm slit and order-sorting filter) or as a custom option in one of our other spectrometers. For applications requiring broad range and sub-nanometer optical resolution (FWHM), our HR2000+CG and HR4000CG-UV-NIR composite-grating spectrometers are recommended.

HR Series Spectrometers

High Resolution Miniature Spectrometers

Our HR Series Spectrometers combine optics and electronics that are ideal for applications demanding high resolution and fast measurements. Popular for laser characterization, gas absorbance and emission line analysis, our HR Series Spectrometers are especially useful where rapid reactions need to be monitored.

We offer two HR Series models, HR2000+ and HR4000, in both application-ready (preconfigured for specific application types) and build-your-own (user-configured for maximum flexibility) versions. Also, the HR2000+ and HR4000 have comparable electronics and architecture, but different linear CCD array detectors.

HR Optical Bench

Our HR Optical Bench is responsive from 200-1100 nm and can be configured to address your application needs through customization of gratings, mirror coatings, detector window and aperture size. Its onboard A/D converter allows you to capture and transfer up to one full spectrum into memory every millisecond when interfaced via USB to your computer.

The HR2000+ has a 2048-element Sony ILX511B detector and the HR4000 has the 3648-element Toshiba TCD1304AP detector. Both are linear silicon CCD arrays, with an effective range of 200-1100 nm, and are available with the same optical bench accessory options (quartz window for UV performance, order-sorting filters and so on). The HR2000+ has slightly better response in the UV and faster integration time; the HR4000 has an electronic shutter feature.

Onboard Microcontroller

The HR Series feature an onboard microcontroller that provides you considerable flexibility in controlling your spectrometer and accessories. Through its 30-pin connector, you can control the HR's operating parameters and light sources, create processes and retrieve information on external objects. Ten user-programmable digital inputs/outputs allow you to interface with other equipment or a triggering device.

Plug and Play USB Operation

The HR Series Spectrometers interface easily to a PC, PLC or other embedded controller via USB 2.0 or RS-232 serial port. Data unique to your spectrometer is programmed into a memory chip inside that is read by our spectrometer operating software – enabling hot-swapping between computers.

Electronic Shutter

HR4000 Spectrometers come with an electronic shutter for control of integration time from 10 µs-3.8 ms – an especially useful option for measuring transient events such as laser pulses.

HR Series Spectrometer Models at a Glance

You can configure an HR2000+ or HR4000 with gratings and optical bench accessories for a wide range of applications, or you can select from one of several application-ready HR2000+/HR4000s described in the table below:

Best for	HR2000+ Series	HR4000 Series
High resolution over extended range (200-1050 nm)	HR2000+CG	HR4000CG-UV-NIR
High resolution and enhanced sensitivity over extended range (200-1050 nm)	HR2000+ES	NA

HR2000+CG Application-Ready Spectrometer

Preconfigured for High Resolution over Extended Range

HR2000+CG

The HR2000+CG Composite Grating Spectrometer is preconfigured with our HC-1 Grating. This proprietary variable-blazed grating was specifically designed to provide full spectral output throughout the 200-1050 nm range.

Also, the HR2000+CG optical bench is preconfigured with a 5 µm slit for excellent optical resolution and our OFLV-200-1100 Variable Longpass Order-sorting Filter to eliminate second- and third-order effects.

The HR2000+CG is ideal for biological and chemical applications where fast measurements and high resolution are needed.

Features

- Broad UV-NIR response
- High resolution (1.0 nm FWHM) over entire available range
- Captures up to 1,000 full scans per second
- Programmable microcontroller

Physical	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
Detector	
Detector:	Sony ILX511B linear silicon CCD array
Detector range:	200-1100 nm
Pixels:	2048 pixels
Pixel size:	14 µm x 200 µm
Pixel well depth:	~62,500 electrons
Sensitivity:	75 photons/count at 400 nm; 41 photons/count at 600 nm
Optical Bench	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input and output
Entrance aperture:	5 µm wide slit
Grating:	HC-1
OFLV filter:	OFLV-200-1100
UV enhanced window:	Yes, UV2 quartz window
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
Spectroscopic	
Wavelength range:	200-1100 nm (best response 200-1050 nm)
Optical resolution:	<1.0 nm FWHM
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	14 bit
Dark noise:	12 RMS counts
Dynamic range:	8.5×10^7 (system); 1300:1 for a single acquisition
Integration time:	1 ms to 65 seconds
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Corrected linearity:	>99%
Electronics	
Power consumption:	220 mA @ 5 VDC
Data transfer speed:	Full scans into memory every 2 ms with USB 2.0 port; every 15 ms with USB 1.1 port
Inputs/outputs:	10 onboard digital user-programmable GPIOs
Analog channels:	One 13-bit analog input and one 9-bit analog output
Trigger modes:	4 modes
Strobe functions:	Yes
Connector:	30-pin connector

Technical Tip

The HC-1 Grating is a variable blazed grating that provides our HR Spectrometers with broad wavelength coverage (200-1050 nm). That extended range can be illuminated with a combination deuterium-tungsten halogen source like our DH2000-BAL, but an optical fiber for your system is a different matter. Because no single fiber covers the entire UV-NIR range, we suggest using a "mixed" bifurcated fiber assembly. A bifurcated assembly has two fibers, each of which can be configured for a different range – UV-VIS for one leg and VIS-NIR for the other leg.

Also of note, the HC-1 grating's native response at longer wavelengths is not as good as it is at shorter wavelengths. But you can take steps to mitigate the grating's response characteristics. For example, for relative mode measurements, increasing the number of signal averages may be a useful technique for optimizing response at longer wavelengths. Ensuring your light source and optical fiber are suited to longer wavelengths also is helpful. To ensure best results, we recommend consulting an Applications Scientist for assistance.

HR2000+ES Application-Ready Spectrometer

Preconfigured for High Resolution and Sensitivity

HR2000+ES

The HR2000+ES Spectrometer is a preconfigured system for enhanced sensitivity. This system integrates a high-resolution optical bench with a powerful 2-MHz A/D converter, programmable electronics and a 2048-element CCD-array detector for optical resolution to ~1.33 nm (FWHM).

The HR2000+ES has a slightly larger entrance slit (10 µm) and an L2 detector collection lens for additional sensitivity in extended-range applications. We also include a UV2 quartz window for UV transmission and the OFLV-200-1100 Variable Longpass Order-sorting Filter to eliminate second- and third-order effects.

Features

- Up to 1,000 full spectra per second
- Programmable microcontroller
- High-resolution bench
- Plug and play operation

Sample Applications for HR2000+CG/HR2000+ES

- Thin film measurements of various substrates
- Plasma monitoring
- Reflectance of nanoparticles
- Analysis of phosphors
- Characterization of lasers
- Solar irradiance
- Spectral output of light sources

Physical	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
Detector	
Detector:	Sony ILX511B linear silicon CCD-array
Detector range:	200-1100 nm
Pixels:	2048 pixels
Pixel size:	14 µm x 200 µm
Pixel well depth:	~62,500 electrons
Sensitivity:	75 photons/count at 400 nm; 41 photons/count at 600 nm
Optical Bench	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input and output
Entrance aperture:	10 µm wide slit
Grating:	HC-1 provides 200-1100 nm range
Detector collection lens:	Yes, L2
OFLV filter:	OFLV 200-1100 nm
UV enhanced window:	Yes, UV2 quartz window
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Spectroscopic	
Wavelength range:	200-1100 nm (best response 200-1050 nm)
Optical resolution:	~1.33 nm FWHM
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	14 bit
Dark noise:	12 RMS counts
Dynamic range:	8.5 x 10^7 (system); 1300:1 for a single acquisition
Integration time:	1 ms-65 seconds (20 s typical)
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Corrected linearity:	>99%
Electronics	
Power consumption:	220 mA @ 5 VDC
Data transfer speed:	Full scans to memory every 1 ms with USB 2.0 port, 15 ms with USB 1.1 port
Inputs/Outputs:	Yes, 10 onboard digital user-programmable GPIOs
Analog channels:	One 13-bit analog input; one 9-bit analog output
Auto nulling:	No
Breakout box compatibility:	Yes, HR4-BREAKOUT
Trigger modes:	4 modes
Strobe functions:	Yes
Gated delay feature:	No
Connector:	30-pin connector

What puts the "Extra Sensitivity" into the HR2000+ES? In large part, it's the addition of a detector collection lens. We fix a cylindrical, aberration-free lens to the detector to focus the image from the tall slit (entrance aperture) of the spectrometer bench onto the shorter detector elements. Depending on the optical bench configuration, this helps increase light-collection efficiency considerably. In fact, the lens collects light so efficiently that in many HR2000+/HR4000 applications – especially laser characterization – adding the lens would cause detector saturation.

HR4000CG-UV-NIR Spectrometer

Preconfigured for High Resolution and Extended Range

HR4000CG-UV-NIR

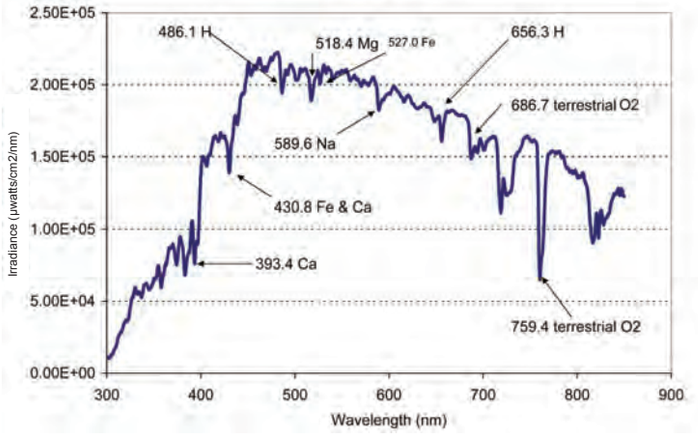
Our HR4000CG-UV-NIR Composite Grating Spectrometer uses our HC-1 Grating and provides full spectral output from 200-1100 nm with best efficiency at 200-1050 nm.

This preconfigured system has an OFLV variable Longpass Order-sorting filter that eliminates second- and third-order effects and utilizes a 5 µm entrance slit for improved optical resolution performance.

Features

- Broad UV-NIR response
- High resolution (0.75 nm FWHM)
- Installed HC-1 composite grating and order-sorting filter

Solar Irradiance Spectrum



Physical	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
Detector	
Detector:	Toshiba TCD1304AP linear CCD array
Detector range:	200-1100 nm
Pixels:	3648 pixels
Pixel size:	8 µm x 200 µm
Pixel well depth:	~100,000 electrons
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm
Optical Bench	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input and output
Entrance aperture:	5 µm wide slit
Grating:	HC-1
Detector collection lens:	Yes, L4
OFLV filter:	OFLV 200-1100 nm
UV enhanced window:	Yes, UV4 quartz window
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Spectroscopic	
Wavelength range:	200-1100 nm (best response 200-1050 nm)
Optical resolution:	<0.75 nm FWHM
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	14 bit
Dark noise:	12 RMS counts
Dynamic range:	3.4 x 10^6 (system); 1300:1 for a single acquisition
Integration time:	3.8 ms-10 seconds
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Corrected linearity:	>99%
Electronics	
Power consumption:	450 mA @ 5 VDC
Data transfer speed:	Full scans to memory every 4 ms with USB 2.0 port, 15 ms with USB 1.1 port
Inputs/Outputs:	Yes, 10 onboard digital user-programmable GPIOs
Analog channels:	One 13-bit analog input; one 9-bit analog output
Auto nulling:	No
Breakout box compatibility:	Yes, HR4-BREAKOUT
Trigger modes:	4 modes
Strobe functions:	Yes
Gated delay feature:	No
Connector:	30-pin connector

A cosine corrector is a useful tool for measuring solar irradiance. The cosine corrector consists of a screw-on stainless steel barrel with a thin disk of diffusing material inside and is designed to collect radiation from 180º field of view. (By comparison, an optical fiber will collect light from approximately 25 º field of view.) Cosine correctors can be attached directly to the spectrometer or to an optical fiber.

HR User-Configured Spectrometers Overview

Optimizing the HR2000+ and HR4000 Spectrometers for Your Application

All components within the HR Series Spectrometers are fixed in place at the time of manufacture and designed to give you years of reliable performance. Select the optical bench options to configure a system to perfectly suit your unique application needs.

With the exception of the detector, the HR2000+ and HR4000 use identical optical bench accessories. By consulting with an Ocean Optics Applications Scientist, you can choose the optimum combination of aperture size, detector accessories, filters, gratings and more.

HR Optical Bench Options

Maximum flexibility is available with HR2000+ and HR4000 Spectrometers. Here are the optical bench accessories available for your spectrometer:

1 **SMA 905 Connector**
Light from a fiber enters the optical bench through the SMA 905 Connector. The SMA 905 bulkhead provides a precise locus for the end of the optical fiber, fixed slit, absorbing filter and fiber clad mode aperture.

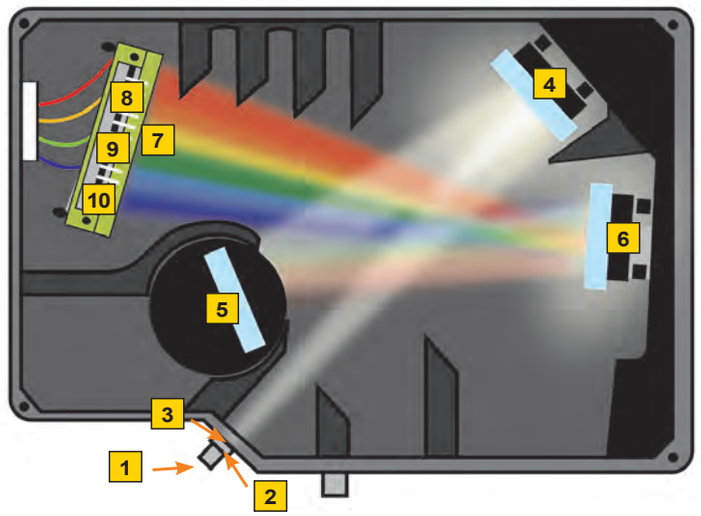
2 **Fixed Entrance Slit: specify slit size**
Light passes through the installed slit, which acts as the entrance aperture. Slits come in various widths from 5 µm to 200 µm. The slit is fixed in the SMA 905 bulkhead to sit against the end of a fiber.

3 **Longpass Absorbing Filter: optional**
If selected, an absorbing filter is installed between the slit and the clad mode aperture in the SMA 905 bulkhead. The filter is used to limit the bandwidth of light entering the spectrometer or to balance color.

4 **Collimating Mirror: specify standard or SAG+**
The collimating mirror is matched to the 0.22 numerical aperture of our optical fiber. Light reflects from this mirror, as a collimated beam, toward the grating. You can opt to install a standard mirror or a UV absorbing SAG+ mirror.

5 **Grating and Wavelength Range: specify grating and starting wavelength**
We install the grating on a platform that we then rotate to select the starting wavelength you've specified. Then we permanently fix the grating in place to eliminate mechanical shifts or drift.

6 **Focusing Mirror: specify standard or SAG+**
This mirror focuses first-order spectra on the detector plane. Both the collimating and focusing mirrors are made in-house to guarantee the highest reflectance and the lowest stray light possible. You can opt to install a standard or SAG+ mirror.



7 **L2/L4 Detector Collection Lens: optional**
One of these cylindrical lenses, made in-house to ensure aberration-free performance, is fixed to the detector to focus the light from the tall slit onto the shorter detector elements. This increases light-collection efficiency. The L2 is for the HR2000+; the L4 is for the HR4000.

8 **Detector**
We offer a 2048-element Sony ILX511B and 3648-element Toshiba TCD1304AP linear CCD array detector. Each pixel responds to the wavelength of light that strikes it. Electronics bring the complete spectrum to the software.

9 **OFLV Variable Longpass Order-sorting Filter: optional**
Our proprietary filters precisely block second- and third-order light from reaching specific detector elements.

10 **UV2/UV4 Detector Upgrade: optional**
When selected, the detector's standard BK7 window is replaced with a quartz window to enhance the performance of the spectrometer for applications <340 nm.

HR2000+ Spectrometer

User-Configured for Flexibility

HR2000+

One of our most popular items, the HR2000+ Spectrometer features a high-resolution optical bench, a powerful 2-MHz analog-to-digital (A/D) converter, programmable electronics, a 2048-element CCD-array detector and a high-speed USB 2.0 port.

This innovative combination produces an extremely fast spectrometer and provides resolution to 0.035 nm (FWHM).

The HR2000+ allows you to capture and store a full spectrum into memory nearly every millisecond (that's up to 1,000 full spectra every second) when the spectrometer is interfaced to a computer via a USB 2.0 port. The HR2000+ is perfect for chemical, biochemical and other applications where fast reactions need to be monitored and fine spectral features need to be resolved.

The HR2000+ interfaces to a computer via USB 2.0 or RS-232 serial port. When using the serial port, the HR2000+ requires a single 5-volt power supply (not included).

Data unique to each spectrometer are programmed into a memory chip on the HR2000+; SpectraSuite software reads these values for easy setup.

Features

- Up to 1,000 full spectra per second
- Programmable microcontroller
- High-resolution performance
- Multiple bench and interface options

Physical	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
Detector	
Detector:	Sony ILX511B linear silicon CCD-array
Detector range:	200-1100 nm
Pixels:	2048 pixels
Pixel size:	14 µm x 200 µm
Pixel well depth:	~62,500 electrons
Sensitivity:	75 photons/count at 400 nm; 41 photons/count at 600 nm
Optical Bench	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input and output
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits or fiber (no slit)
Grating options:	Multiple gratings, UV through Shortwave NIR
HC-1 grating option:	Provides 200-1050 nm range
Detector collection lens option:	Yes, L2
OFLV filter options:	OFLV 200-1100 nm
Other bench filter options:	Longpass OF-1 filters
Collimating and focusing mirrors:	Standard or SAG+UPG-HR
UV enhanced window:	Yes, UV2 quartz window
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Spectroscopic	
Wavelength range:	Grating dependent
Optical resolution:	~0.035-6.8 nm FWHM
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	14 bit
Dark noise:	12 RMS counts
Dynamic range:	8.5×10^7 (system); 1300:1 for a single acquisition
Integration time:	1 ms-65 seconds (20 s typical)
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Corrected linearity:	>99%
Electronics	
Power consumption:	220 mA @ 5 VDC
Data transfer speed:	Full scans to memory every 2 ms with USB 2.0 port, 15 ms with USB 1.1 port
Inputs/Outputs:	Yes, 10 onboard digital user-programmable GPIOs
Analog channels:	One 13-bit analog input; one 9-bit analog output
Auto nulling:	No
Breakout box compatibility:	Yes, HR4-BREAKOUT
Trigger modes:	4 modes
Strobe functions:	Yes
Gated delay feature:	No
Connector:	30-pin connector

HR4000 Spectrometer

User-Configured for Flexibility

HR4000

Inside the HR4000 Spectrometer is a 3648-element CCD-array Toshiba detector that enables optical resolution as precise as 0.02 nm (FWHM). Responsive from 200-1100 nm, the HR4000 can be customized for your setup needs through a choice of gratings, slits and other optical bench options.

The HR4000 gives you the freedom to set integration time and features an electronic shutter that helps minimize saturation – even with 3.8 ms integration.

The HR4000 interfaces easily with your computer or PLC through USB 2.0 or RS-232 ports. And, with its 10 user-programmable digital inputs/outputs, the HR4000 offers unparalleled connectivity with external equipment.

Features

- Onboard microcontroller and electronic shutter
- 0.02 nm optical resolution (FWHM) possible
- Choice of configurations and accessories

Technical Tip

The dynamic range of a system is the full scale signal divided by the minimum resolvable signal. For our spectrometers, the minimum resolvable signal is the standard deviation of the dark signal. A common misunderstanding is to interchange dynamic range and A/D resolution. However, a dynamic range measurement includes the system's minimum noise level (e.g., detector readout noise and electronic noise). It's most applicable to low light level applications because it defines minimum detectable signal.

Physical	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
Detector	
Detector:	Toshiba TCD1304AP linear CCD array
Detector range:	200-1100 nm
Pixels:	3648 pixels
Pixel size:	8 µm x 200 µm
Pixel well depth:	~100,000 electrons
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm
Optical Bench	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input and output
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits or fiber (no slit)
Grating options:	Multiple gratings, UV through Shortwave NIR
HC-1 grating option:	Provides 200-1050 nm range (best efficiency)
Detector collection lens option:	Yes, L4
OFLV filter options:	OFLV-200-1100
Other bench filter options:	Longpass OF-1 filters
Collimating and focusing mirrors:	Standard or SAG+UPG-HR
UV enhanced window:	Yes, UV4 quartz window
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Spectroscopic	
Wavelength range:	Grating dependent
Optical resolution:	~0.02-8.4 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)
A/D resolution:	14 bit
Dark noise:	12 RMS counts
Dynamic range:	3.4 x 10^6 (system); 1300:1 for a single acquisition
Integration time:	3.8 ms-10 seconds
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Corrected linearity:	>99%
Electronics	
Power consumption:	450 mA @ 5 VDC
Data transfer speed:	Full scans to memory every 4 ms with USB 2.0 port
Inputs/Outputs:	Yes, 10 onboard digital user-programmable GPIOs
Analog channels:	One 13-bit analog input; one 9-bit analog output
Auto nulling:	No
Breakout box compatibility:	Yes, HR4-BREAKOUT
Trigger modes:	4 modes
Strobe functions:	Yes
Gated delay feature:	No
Connector:	30-pin connector

HR User-Configured Spectrometers

Bench Accessories for HR2000+/HR4000 Spectrometers

The magic behind our HR2000+ and HR4000 miniature spectrometers is the range of options you can select to configure your optical bench to perfectly suit your unique application needs. By consulting with an Ocean Optics Applications Scientist, you can choose the optimum combination of aperture size, detector accessories, filters, gratings and more.

SMA 905 Connector

This precision connector aligns to the spectrometer's entrance slit and ensures concentricity of the fiber. While SMA 905 is standard, connector adapters are available for mating to ST or FC connectors.

Fixed Entrance Slits

Our entrance slits are rectangular apertures that are 1 mm tall and come in varying widths from 5 µm to 200 µm. Smaller slit sizes achieve the best optical resolution.

Slit	Description	HR2000+ Pixel Resolution	HR4000 Pixel Resolution
SLIT-5	5-µm wide x 1-mm high	~1.5 pixels	~2.0 pixels
SLIT-10	10-µm wide x 1-mm high	~2.0 pixels	~3.7 pixels
SLIT-25	25-µm wide x 1-mm high	~2.5 pixels	~4.4 pixels
SLIT-50	50-µm wide x 1-mm high	~4.2 pixels	~7.4 pixels
SLIT-100	100-µm wide x 1-mm high	~8.0 pixels	~14.0 pixels
SLIT-200	200-µm wide x 1-mm high	~15.3 pixels	~26.8 pixels

Longpass Absorbing Filter

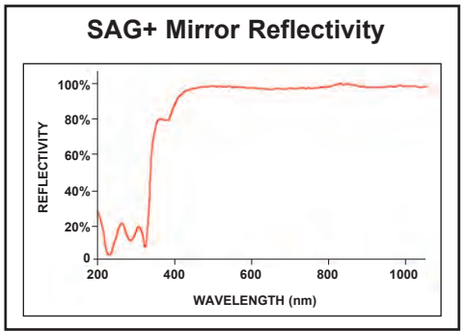
Whether you select a Longpass Absorbing or Blocking Filter, each has a transmission band and a blocking band to restrict radiation to a certain wavelength region. This helps eliminate second- and third-order effects. Filters are installed permanently.

Item	Description
OF1-WG305	Longpass filter; transmits light >305 nm
OF1-GG375	Longpass filter; transmits light >375 nm
OF1-GG395	Longpass filter; transmits light >395 nm
OF1-GG475	Longpass filter; transmits light >475 nm
OF1-OG515	Longpass filter; transmits light >515 nm
OF1-OG550	Longpass filter; transmits light >550 nm
OF1-OG590	Longpass filter; transmits light >590 nm

Collimating and Focusing Mirrors

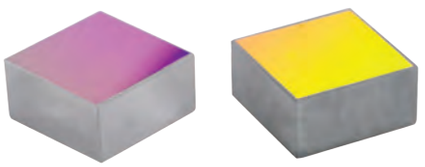
You can replace our standard aluminum-coated reflective mirrors with our UV-absorbing SAG+ Mirrors. These mirrors increase reflectance in the VIS-NIR range while increasing your spectrometer's sensitivity. They also absorb nearly all UV light – reducing the effects of excitation scattering in fluorescence measurements. They have excellent reflectivity (more than 95% across the VIS-NIR).

Item Code: SAG+UPG-HR



Grating and Wavelength Range

With a choice of multiple gratings, you can easily customize the spectral range and most efficient region of your HR Series Spectrometer. Our gratings are permanently fixed in place at the time of manufacture and are available in both ruled and holographic versions. See pages 34 and 35 for grating options and efficiency curves and consult an Ocean Optics Applications Scientist for details.

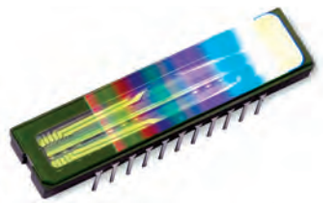


HR User-Configured Spectrometers

Detectors and Accessories for HR2000+/HR4000 Spectrometers

Detectors

The HR2000+ utilizes the Sony ILX511B linear silicon CCD array detector. Our HR4000 High-resolution Spectrometer utilizes the Toshiba TCD1304AP linear CCD array detector, which has some electronic advances over the Sony, such as an electronic shutter. Both are linear silicon CCD arrays, with an effective range of 200-1100 nm, and with the same dynamic range (1300:1). The Toshiba detector has a slightly better SNR of 300:1 versus 250:1.



L2 and L4 Detector Collection Lens

These cylindrical lenses ensure aberration-free performance and are fixed to the detector's window to focus light from the tall slit onto the shorter detector elements. The L2 and L4 increase light collection efficiency and help reduce stray light. They are also useful in configurations with large-diameter fibers for low light-level applications.

Detectors with OFLV Filters

OFLV Variable Longpass Order-sorting Filters are applied to the detector's window to eliminate second- and third-order effects. We use a patented coating technology to apply the filter to the substrate.

UV2 and UV4 Detector Window Upgrades

For any application <360 nm, we replace the detector's standard BK7 glass window with a quartz window. Quartz transmits in the UV and provides better UV performance.

Detector	Description	Spectrometer
DET2B-200-1100	Sony ILX511B detector, installed, w/200-1100 nm variable longpass filter and UV2 quartz window; best for UV-NIR systems configured with Grating # HC-1	HR2000+
DET2B-UV	Sony ILX511B detector, installed, with UV2 quartz window; best for systems configured for <360 nm	HR2000+
DET2B-VIS	Sony ILX511B detector, installed, with VIS BK7 window; best for systems configured for >400 nm	HR2000+
DET4-200-1100	Toshiba TCD1304AP detector, installed, w/200-1100 nm variable longpass filter and UV2 quartz window; best for UV-NIR systems configured with Grating # HC-1	HR4000
DET4-UV	Toshiba TCD1304AP detector, installed, with UV4 quartz window; best for systems configured for <360 nm	HR4000
DET4-VIS	Toshiba TCD1304AP detector, installed, with VIS BK7 window; best for systems configured for >400 nm	HR4000

Additional detector configurations – including a no-window option for deep UV applications – are available. Custom-configured HR2000+/HR4000 Spectrometers using the HC-1 extended-range grating require the DET2B-200-1100 or DET4-200-1100, which include quartz window and variable longpass filter. Please consult an Applications Scientist for details.

Technical Tip

With CCDs, a photodiode is covered by a transparent capacitor that accumulates the signal during an interval (integration period). A linear CCD array is the same architecture but consists of a single line of CCD devices instead of bare photodiodes. CCDs have low readout noise. But their capacitors absorb UV light, limiting response below 350 nm. There are two remedies: use proprietary processes to coat the CCD array with a phosphor that absorbs UV light and emits visible light or use a thin detector that is illuminated from the back. This exposes the photodiodes to UV light resulting in a device that is much more sensitive in the UV. Maya2000 Pro and QE65000 use back-thinned detectors.

Our optical bench accessories work in harmony with the detector to optimize spectrometer performance. For example, in the symmetrical crossed Czerny-Turner optical design, there are two mirrors that help move light around the optical bench on its way to the detector: the collimating mirror (first mirror), which makes parallel the light entering the bench and then reflects that light onto the grating; and the focusing (second) mirror, which focuses the light onto the detector plane. Newer-generation coated and dichroic thin-film optics like our SAG+ mirrors have helped to improve signal response at UV, Visible and near infrared wavelengths. For example, silver-coated mirrors have very high reflection values (>97%) across Visible and near infrared wavelengths, and over a wide range of angles of incidence. Another first- and second-dichroic mirror option uses a UV-enhanced aluminum design to greatly boost signal <300 nm.

HR User-Configured Spectrometers

Choosing the Right Grating

Groove Density

The groove density (mm^{-1}) of a grating determines its dispersion, while the angle of the groove determines the most efficient region of the spectrum. The greater the groove density, the better the optical resolution possible, but the more truncated the spectral range.

Spectral Range

The dispersion of the grating across the linear array is also expressed as the "size" of the spectra on the array. The spectral range (bandwidth) is a function of the groove density and does not change. When you choose a starting wavelength for a spectrometer, you add its spectral range to the starting wavelength to determine the wavelength range. For several gratings, the spectral range of a grating varies according to the starting wavelength range. The rule of thumb is this: the higher the starting wavelength, the more truncated the spectral range.

Blaze Wavelength

For ruled gratings, blaze wavelength is the peak wavelength in an efficiency curve. For holographic gratings, it is the most efficient wavelength region.

Best Efficiency (>30%)

All ruled or holographically etched gratings optimize first-order spectra at certain wavelength regions; the "best" or "most efficient" region is the range where efficiency is >30%. In some cases, gratings have a greater spectral range than is efficiently diffracted. For example, Grating 1 has about a 650 nm spectral range, but is most efficient from 200-575 nm. In this case, wavelengths >575 nm will have lower intensity due to the grating's reduced efficiency.

Grating and Wavelength Range

With a choice of multiple grating options, you can easily customize your HR Series Spectrometer for all sorts of applications across the UV-Shortwave NIR. Our gratings are fixed in place at the time of manufacture. Also, we've added grating options that provide flexibility for UV applications, Raman and more. Efficiency curves and other information for these "H" gratings are available in the QE65000/Maya2000 Pro Spectrometers section and on our website.

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
HC-1	UV-NIR	300/600 variable	900 nm	Variable	200-1050 nm
H1	UV	600	425-445 nm	300 nm	200-575 nm
H2	UV-VIS	600	415-445 nm	400 nm	250-800 nm
H3	VIS-Color	600	410-440 nm	500 nm	350-850 nm
H4	NIR	600	410-430 nm	750 nm	530-1100 nm
H5	UV-VIS	1200	205-220 nm	Holographic UV	200-400 nm
H6	NIR	1200	140-195 nm	750 nm	500-1100 nm
H7	UV-VIS	2400	72-102 nm	Holographic UV	200-500 nm
H9	VIS-NIR	1200	165-205 nm	Holographic VIS	400-800 nm
H10	UV-VIS	1800	95-140 nm	Holographic UV	200-635 nm
H11	UV-VIS	1800	75-135 nm	Holographic VIS	320-720 nm
H12	UV-VIS	2400	60-100 nm	Holographic VIS	260-780 nm*
H13	UV-NIR	300	800-900 nm	500 nm	300-1100 nm
H14	NIR	600	410-420 nm	1000 nm	650-1100 nm

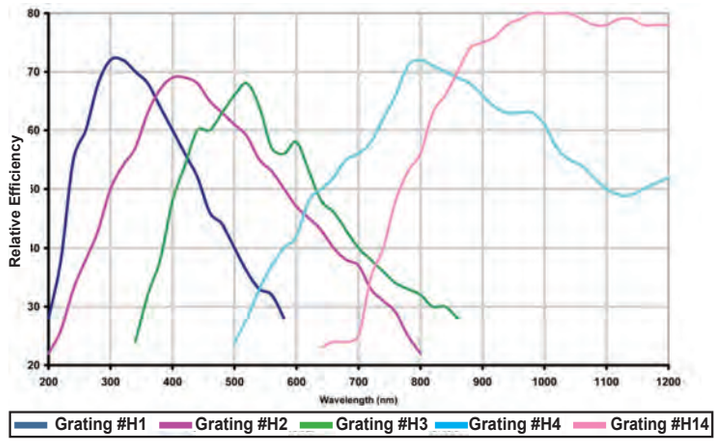
*Consult an Applications Scientist regarding setups >720 nm.
Note: Additional information on gratings is available at Oceanoptics.com.

HR User-Configured Spectrometers

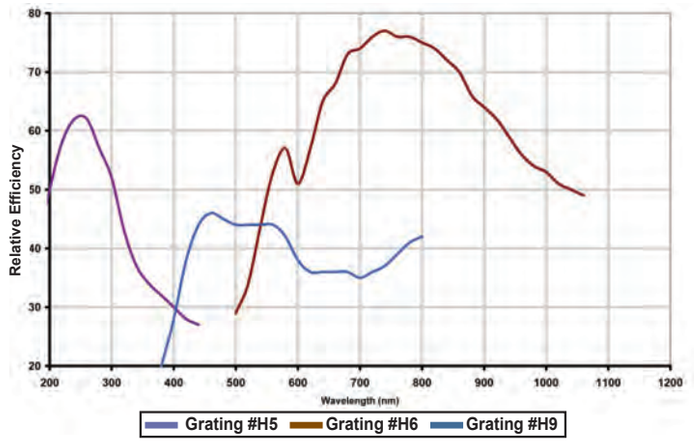
Gratings for HR2000+/HR4000 Spectrometers

The graphs below are grating efficiency curves for gratings with groove densities of 600, 1200, 1800 and 2400 mm^{-1} (the HC-1 has variable groove density). Additional information is available at www.oceanoptics.com/Products/bench_grating_hr.asp.

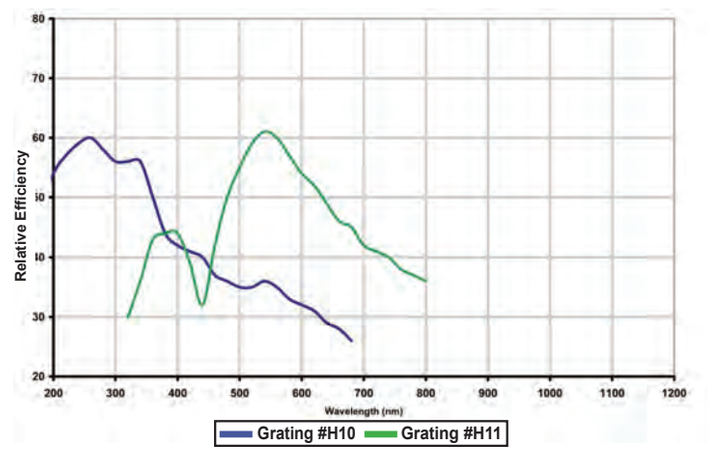
Groove Density of 600 mm^{-1}



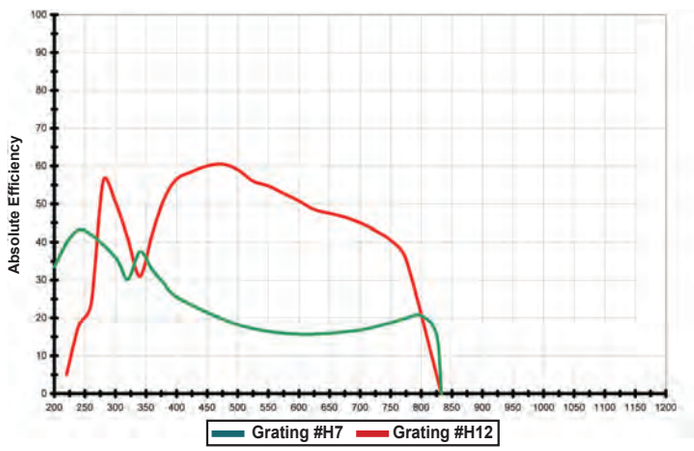
Groove Density of 1200 mm^{-1}



Groove Density of 1800 mm^{-1}



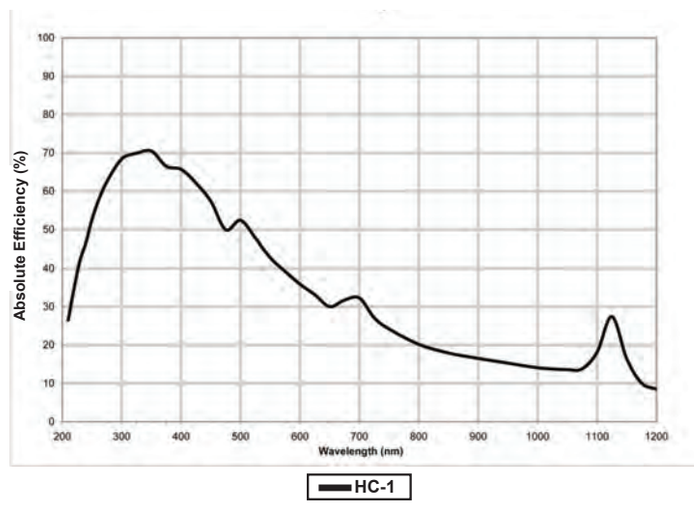
Groove Density of 2400 mm^{-1}



Grating Selection Tips:

- These efficiency curves relate only to the grating. System response is affected by a number of variables, including detector response.
- The HC-1 grating is a good option for broad spectral coverage (~200-1050 nm) without sacrificing optical resolution.
- We now offer gratings that provide even greater flexibility for your application needs. Among the new options are five different gratings, each blazed at 250 nm or lower, for UV applications; and options for Raman and more. These "H" gratings are designed for HR2000+/HR4000, QE65000 and Maya2000 Pro Spectrometers. Grating efficiency curves and other information are available in the QE65000/Maya2000 Pro Spectrometers section and at our website.

Variable Groove Density of 600 mm^{-1}/300 mm^{-1}



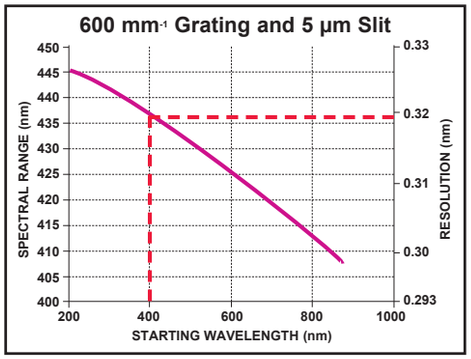
HR User-Configured Spectrometers

Predicted Ranges and Resolution

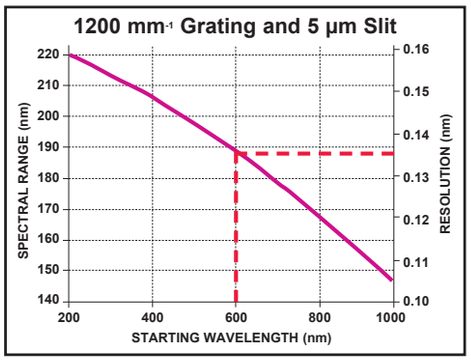
Predicted Ranges and Resolution

These graphs demonstrate the range and resolution of your "HR" Bench Spectrometer with a 5 µm slit.

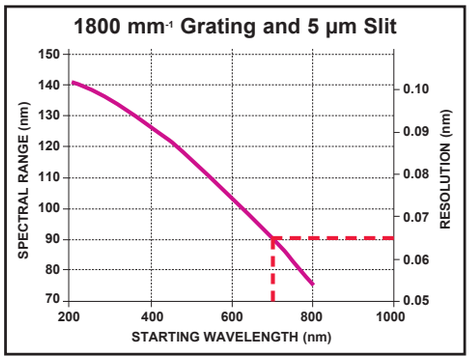
"HR" Bench with Sony Detector: HR2000+



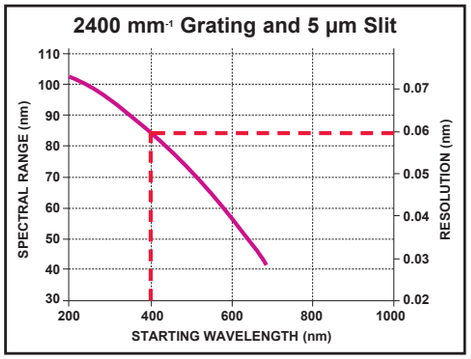
Example:
If the starting wavelength is 400 nm, then the range is ~437 nm, providing a 400-837 nm wavelength range and 0.32 nm resolution.



Example:
If the starting wavelength is 600 nm, then the range is ~188 nm, providing a 600-788 nm wavelength range and 0.137 nm resolution.

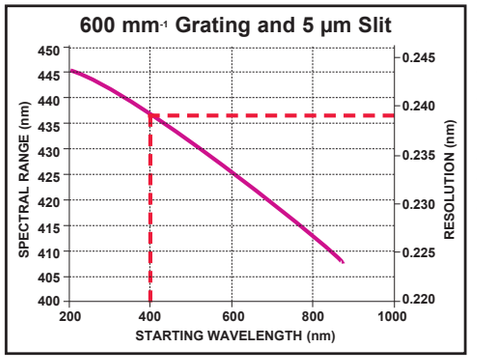


Example:
If the starting wavelength is 700 nm, then the range is ~90 nm, providing a 700-790 nm wavelength range and 0.065 nm resolution.

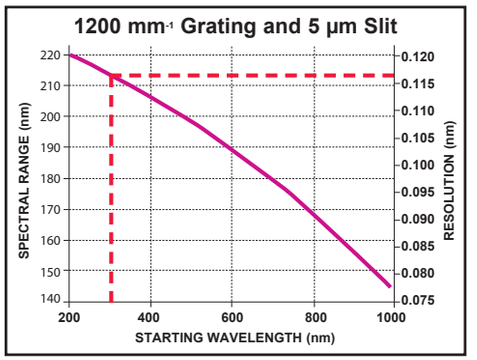


Example:
If the starting wavelength is 400 nm, then the range is ~82 nm, providing a 400-482 nm wavelength range and 0.06 nm resolution.

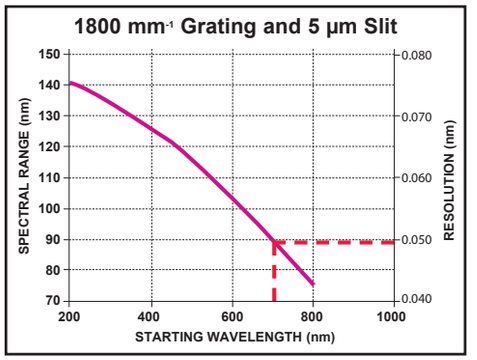
"HR" Bench with Toshiba Detector: HR4000



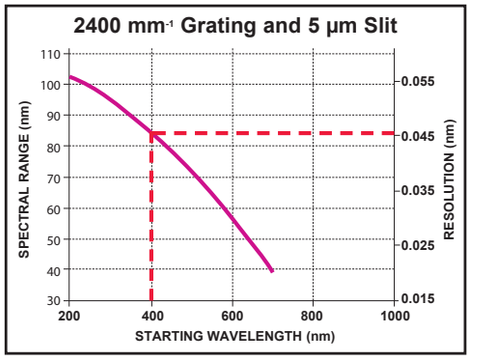
Example:
If the starting wavelength is 400 nm, then the range is ~437 nm, providing a 400-837 nm wavelength range and 0.239 nm resolution.



Example:
If the starting wavelength is 300 nm, then the range is ~215 nm, providing a 300-515 nm wavelength range and 0.117 nm resolution.



Example:
If the starting wavelength is 700 nm, then the range is ~90 nm, providing a 700-790 nm wavelength range and 0.05 nm resolution.



Example:
If the starting wavelength is 400 nm, then the range is ~82 nm, providing a 600-682 nm wavelength range and 0.045 nm resolution.

HR Series Spectrometers

Breakout Box for Ultimate Control

Breakout Box

For easier access to a variety of functions in the HR Series, the HR4-BREAKOUT is a passive module that separates signals from the spectrometer's 30-pin accessory port to an array of standard connectors and headers. The Breakout Box allows multiple interfaces to the spectrometer.

- External triggering
- General Purpose Inputs/Outputs (GPIO)
- RS-232 interface
- Light sources
- Analog Inputs/Outputs

In addition to the accessory connector, the Breakout Box features a circuit board based on a neutral breadboard pattern that allows custom circuitry to be prototyped on the board itself. The Breakout Box receives its power from the spectrometer, which runs off a PC via a USB port, or requires a separate 5-volt power supply when the spectrometer interfaces to a PC via the serial port. If you are wiring custom circuitry on the Breakout Box, you likely will need the USB-CBL-PS power supply (purchased separately). The Breakout Box can be used with the following spectrometers:

- USB4000 Plug-and-Play Spectrometers
- HR4000 High-resolution Spectrometers
- HR2000+ High-speed, High-resolution Spectrometer
- QE65000 Scientific-grade Spectrometer

Item Code: HR4-BREAKOUT
HR4, USB4, HR2+, QE adapter for external connections

Item Code: HR4-CBL-DB15
Accessory cable

Technical Tip: Spectrometer Triggering Options

We've enhanced the triggering functions for Ocean Optics spectrometers to provide accurate timing and synchronization between our spectrometers and other devices. Four low-jitter trigger modes and normal (free-running spectral acquisition) operating modes are now possible. Applications include the pulsing of a light source to occur when acquiring a spectra and synchronizing spectral acquisition to coordinate with samples moving through a process stream or sensors reaching a certain temperature level.

Triggering provides precise timing between devices. Each spectrometer can be triggered so that sending the spectrometer a pulse causes it to do something such as a turn off or on a light, activate a pulse in a light source or start or end spectral acquisition in the spectrometer. For example, in the External Triggering mode, an event outside the sampling system (such as a button push, lever activation or laser) electronically pulses the spectrometer's trigger pin and starts acquisition of the spectra with microsecond accuracy.

Most of our spectrometers can be operated using Normal mode (the spectrometer continuously acquires spectra) and four trigger modes:

- **External Software Trigger.** While the spectrometer is in free-running mode, data collected in the period up to the triggering event is transferred to software.
- **External Hardware Level Trigger.** The spectrometer waits for a sharp rise in voltage on the trigger input pin, and then acquires spectra until the voltage is removed.
- **External Synchronous Trigger.** The spectrometer acquires data from an external trigger event (such as a push button) until the next time the trigger is activated; the spectrometer then ceases spectral acquisition and begins a new acquisition. Integration time cannot be set and is the effective period between triggers.
- **External Hardware Edge Trigger.** The spectrometer waits for a sharp rise in voltage on the trigger input pin and then acquires one spectrum. One spectrum will be acquired for each trigger unless an acquisition is already in progress.

More detailed information on this topic is available at http://www.oceanoptics.com/technical.asp.

QE65000 and Maya2000 Pro Spectrometers

Scientific-Grade Spectroscopy in a Small Footprint

Ocean Optics offers highly sensitive spectrometers specifically suited for low light-level applications such as fluorescence, DNA sequencing and Raman spectroscopy. The QE65000 achieves up to 90% quantum efficiency with high signal-to-noise and excellent signal processing speed. Although the QE65000 features a back-illuminated detector that has great response in the UV, the Maya2000 Pro is an even better choice for deep-UV response (<190 nm).

User-configured and Application-ready Options

Both the QE65000 and Maya systems can be optimized for your application needs by specifying various optical bench accessories and grating options. In addition, the QE65000 is available in three application-ready models:

- **QE65000-ABS**
  Preconfigured for absorbance measurements and includes an HC1-QE grating (starting at 200 nm), an OFLV-QE-200 order sorting filter and a 10 µm entrance slit. Spectrometer Operating Software and our Annual Service Package are also included.

- **QE65000-FL**
  Preconfigured for fluorescence measurements and includes an HC1-QE grating (starting at 350 nm), OFLV-QE-350 and a 200 µm entrance slit. Spectrometer Operating Software and our Annual Service Package are also included.

- **QE65000-RAMAN**
  Preconfigured for low light-level Raman spectroscopy and includes an H6 grating (starting at 780 nm) and a 50 µm entrance slit. Operating software and service packages are available separately.

Comparing QE65000 and Maya2000 Pro Spectrometers

Choose the QE65000 Scientific-grade Spectrometer for low light-level applications such as Raman and fluorescence, particularly when you need to integrate over long periods of time. Its TE-cooled detector features low noise and low dark signal and holds stability to +/-0.1 ºC of set temperature within two minutes.

The Maya2000 Pro Spectrometer is a perfect choice for deep-UV applications such as plasma monitoring in semiconductor processing and biological sample analysis in life sciences, as well as high sensitivity requirements that don't require long integration times. And because there's no thermoelectric cooling involved, the Maya2000 Pro is slightly less expensive than the QE65000.

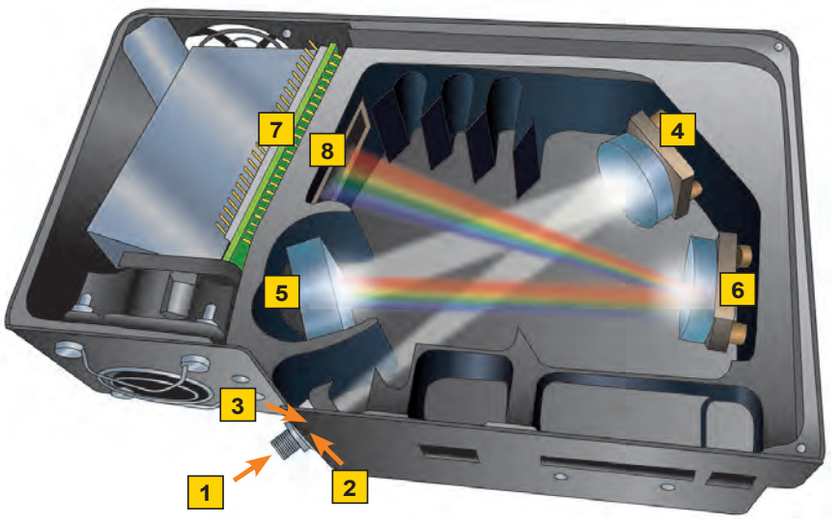
	Maya2000 Pro	QE65000
Spectral range:	200-1100 nm with window; deep UV (<190 nm) configuration also available	200-1100 nm
Integration time:	6 ms-5 seconds	8 ms-15 minutes
Sensitivity:	~0.32 Counts/e-	~0.065 Counts/e-
Quantum efficiency:	75% peak QE	Up to 90%
Dynamic range:	10000:1 (typical: ~12000:1)	7.5 x 10^9 (system); 25000:1 single acquisition
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm	<0.08% at 600 nm; 0.4% at 435 nm
Thermoelectric cooling:	No	Yes
Strobe functions:	Yes	Yes

QE65000 and Maya2000 Pro Spectrometers

Optimizing QE65000 and Maya2000 Pro Spectrometers for Your Application

Our high-sensitivity back-thinned 2D FFT-CCD spectrometers for low light-level, UV-sensitivity and other scientific applications are available in several versatile options: an improved version of our thermoelectrically cooled QE65000 Spectrometer, distinguished by improved stray light and low noise characteristics; and the uncooled Maya2000 Pro®, which offers greater than 75% quantum efficiency, high dynamic range and excellent UV response.

QE65000 and Maya2000 Pro optical bench options are described below. Although the bench diagram is specific to the QE65000, the optical design is nearly identical to the Maya2000 Pro. The primary differences are the detector and thermoelectric cooler.



1 SMA 905 Connector
Light from a fiber enters the optical bench through the SMA 905 Connector. The SMA 905 bulkhead provides a precise locus for the end of the optical fiber, fixed slit, absorbance filter and fiber clad mode aperture.

2 Fixed Entrance Slit: specify slit size
Light passes through the installed slit, which acts as the entrance aperture. Slits are available in widths from 5 µm to 200 µm. Each is permanently fixed to the SMA 905 bulkhead. (Without a slit, a fiber acts as the entrance aperture.)

3 Longpass Absorbing Filter: optional
If selected, an OF-1 absorbing filter is installed between the slit and the clad mode aperture in the SMA 905 bulkhead. The filter is used to limit bandwidth of light entering the spectrometer.

4 Collimating Mirror: specify standard or SAG+
The collimating mirror is matched to the 0.22 numerical aperture of our optical fiber. Light reflects from this mirror, as a collimated beam, toward the grating. Opt to install a standard mirror or a SAG+UPG-HR mirror.

5 Grating: specify grating
We install the grating on a platform that we then rotate to select the starting wavelength you've specified. Then we permanently fix the grating in place to eliminate mechanical shifts or drift.

6 Focusing Mirror: specify standard or SAG+
This mirror focuses first-order spectra on the detector plane and sends higher orders to light traps built into the optical bench. Both the collimating and focusing mirrors are made in-house to guarantee the highest reflectance and the lowest stray light possible. Opt for a standard mirror or a UV-absorbing SAG+UPG-HR mirror.

7 Detector with TE cooling
The TE-cooled, back-thinned, "2D" detector provides great signal processing speed, improved signal-to-noise ratio and great native response in the UV. It generates virtually no dark noise, allowing for long integration times.

8 OFLV Filters: optional
Our proprietary filters precisely block second- and third-order light from reaching specific detector elements.

Technical Tip

In a typical symmetrical crossed Czerny-Turner optical design, there are two mirrors that help move light around the optical bench on its way to the detector: the collimating mirror (first mirror), which makes parallel the light entering the bench and then reflects that light onto the grating; and the focusing (second) mirror, which focuses the light onto the detector plane.

The SAG+ mirrors we use were developed by our sister company Ocean Thin Films. These silver-coated mirrors have very high reflection values – >97% across Visible and near infrared wavelengths. What's more, they absorb nearly all UV light, a characteristic that reduces the effects of excitation scattering in fluorescence measurements.

QE65000 Spectrometer

Scientific-Grade Spectroscopy in a Small Footprint

QE65000

The QE65000 Spectrometer is the most sensitive spectrometer we've developed. Its Hamamatsu FFT-CCD detector provides 90% quantum efficiency as well as superior signal-to-noise ratio and signal processing speed.

QE65000's onboard programmable microcontroller puts you in command of the spectrometer and its accessories and provides 10 user-programmable digital inputs/outputs as well as a pulse generator for triggering other devices.

The QE65000's great quantum efficiency is not its only distinguishing feature. Its 2D area detector lets us bin (or sum) a vertical row of pixels. That offers significant improvement in the signal-to-noise ratio (>1000:1) performance and signal processing speed of the detector compared with a linear CCD, where signals are digitally added by an external circuit.

Because the QE65000's detector is back-thinned, it has outstanding native response in the UV. It's an excellent option for low light-level applications such as fluorescence, Raman spectroscopy, DNA sequencing, astronomy and thin-film reflectivity. Its TE-cooled detector features low noise and low dark signal, enabling low light-level detection and long integration times from 8 ms to 15 minutes.

Features

- Onboard programming
- Multiple interface and bench options
- Quantum efficiency of 90%
- Ideal for low light level applications

Physical	
Dimensions:	182 mm x 110 mm x 47 mm
Weight:	1.18 kg (without power supply)
Detector	
Detector:	Hamamatsu S7031-1006
Detector range:	200-1100 nm
Pixels:	1024 x 58 (1044 x 64 total pixels)
Pixel size:	24 μm^2
Pixel well depth:	300,000 electrons/well, 1.5 m elec/column
Sensitivity:	22 electrons/count all λ; 26 photons/count @ 250 nm
Quantum efficiency:	90% peak; 65% at 250 nm
Optical Bench	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input and output
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits or fiber (no slit)
Grating options:	Multiple grating options, UV through Shortwave NIR
HC-1 grating:	Provides 200-1050 nm range (best efficiency)
OFLV filter options:	OFLV-QE (200-950 nm); OFLV-QE-250 (250-1000 nm); OFLV-QE-300 (300-1050 nm); OFLV-QE-350 (350-1100 nm); OFLV-QE-400 (400-1150 nm)
Other filter options:	Longpass OF-1 filters
Fiber optic connector:	SMA 905 to 0.22 NA single-strand optical fiber
Spectroscopic	
Wavelength range:	Grating dependent
Optical resolution:	~0.14-7.7 nm (FWHM) (slit dependent)
Signal-to-noise ratio:	1000:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	3 RMS counts
Dynamic range:	7.5 x 10^9 (system), 25000:1 for a single acquisition
Integration time:	8 ms-15 minutes
Stray light:	<0.08% at 600 nm; 0.4% at 435 nm
Corrected linearity:	>99%
Electronics	
Power consumption:	500 mA @ 5 VDC (no TE cooling); 3.5 A @ 5 VDC (with TE cooling)
Data transfer speed:	Full scans to memory every 8 ms with USB 2.0 port, 18 ms with USB1.1 port, 300 ms with serial port
Inputs/Outputs:	10 onboard digital user-programmable GPIOs (general purpose inputs/outputs)
Breakout box:	Yes, HR4-BREAKOUT
Trigger modes:	4 modes
Gated delay feature:	Yes
Connector:	30-pin connector
Power-up time:	<5 seconds
Dark current:	4000 e-/pixel/sec @ 25 °C; 200 e-/pixel/sec @ 0 °C
Temperature and Thermoelectric (TE) Cooling	
Temperature limits:	0 °C to 50.0 °C; no condensation
Set point:	Lowest set point is 40 °C below ambient
Stability:	+/-0.1 °C of set temperature in <2 minutes

Maya2000 Pro Spectrometer

High Sensitivity and Deep UV Measurement

	Maya2000 Pro
Dimensions:	149 mm x 109 mm x 50 mm
Weight:	0.96 kg (without power supply)
Detector:	Hamamatsu S10420
Architecture:	Back-thinned, 2D
Thermoelectric cooling:	No
Pixels:	All: 2068 x 70 Active: 2048 x 64
Pixel size:	14 µm square
Column height:	896 µm
Pixel depth:	200,000 e-
Peak QE:	75%
QE @ 250 nm:	65%
CCD effective number of bits:	~14 bit
Integration time:	7.2 ms – 5 seconds
A/D converter:	16 bit, 250 kHz
Dynamic range:	10000:1+ (typical: ~15000:1+)
Signal-to-noise ratio:	450:1
Non-linearity (uncorrected):	~10.0%
Linearity (corrected):	<1.0%
Column sensitivity:	~0.32 Counts/e-
2D Imaging:	Yes

Maya2000 Pro

Our Maya2000 Pro® Spectrometer offers you the perfect solution for applications that demand low light-level, UV-sensitive operation.

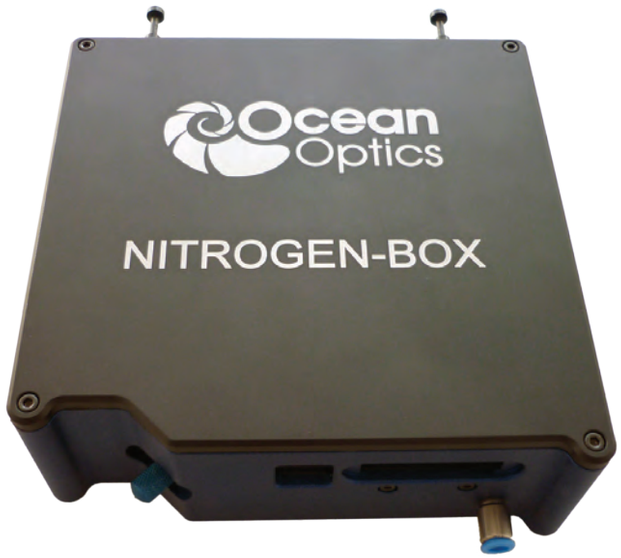
This back-thinned, 2D FFT-CCD, uncooled instrument offers greater than 75% quantum efficiency, high dynamic range and UV response to 190 nm and lower. The Maya2000 Pro can deliver accurate analysis down to 185 nm with high dynamic range and good signal-to-noise ratio.

The Hamamatsu FFT-CCD detector used in the Maya2000 Pro has excellent performance characteristics. Because of their UV response, FFT-CCD detectors do not require UV-sensitive coatings and provide performance advantages such as low dark current and good signal processing.

Maya2000 Pro has very good response across the UV and is a great choice for vacuum ultraviolet applications such as analysis of semi-conductor materials, measurement of biological samples and noble gases, and determination of chemical elements such as sulfur.

Features

- Low-noise electronics
- Optical resolution to ~0.035 nm (FWHM)
- Multiple grating options including HC-1 composite grating for coverage from 200-1050 nm (additional charge)
- Slits available in widths of 5, 10, 25, 50, 100 and 200 µm
- Optional filters to eliminate second- and third-order effects
- Fully controllable strobe signals (single or continuous)
- 10 onboard digital user- programmable GPIOs



Nitrogen Purgebox for Maya VUV Applications

Maya2000 Pro Spectrometers have excellent response <190 nm and are even useful for vacuum ultraviolet (VUV) measurements to ~150 nm. But because oxygen and water absorb in the VUV spectral band, maintaining sufficient signal outside a vacuum is not possible without an option such as the Maya Nitrogen Purgebox. The purgebox flushes the environment with nitrogen to help mitigate water and oxygen absorption in the VUV.

QE65000 and Maya2000 Pro Spectrometers

Bench Accessories for Your High-sensitivity Spectrometers

SMA 905 Connector

This precision connector aligns to the spectrometer's entrance slit and ensures concentricity of the fiber. While SMA 905 is standard, connector adapters are available for mating to ST or FC connectors.

Fixed Entrance Slits

One option available with the user-configured spectrometer is the size of the entrance aperture, with the width determining the amount of light entering the bench. A slit is fixed in place; it only can be changed by our technicians.

Slit	Description	QE Pixel Resolution	Maya Pixel Resolution
SLIT-5	5-µm wide x 1-mm high	~2.0 pixels	~1.5 pixels
SLIT-10	10-µm wide x 1-mm high	~2.2 pixels	~2.0 pixels
SLIT-25	25-µm wide x 1-mm high	~2.6 pixels	~2.5 pixels
SLIT-50	50-µm wide x 1-mm high	~3.3 pixels	~4.2 pixels
SLIT-100	100-µm wide x 1-mm high	~4.7 pixels	~8.0 pixels
SLIT-200	200-µm wide x 1-mm high	~8.9 pixels	~15.3 pixels

Longpass Absorbing Filter

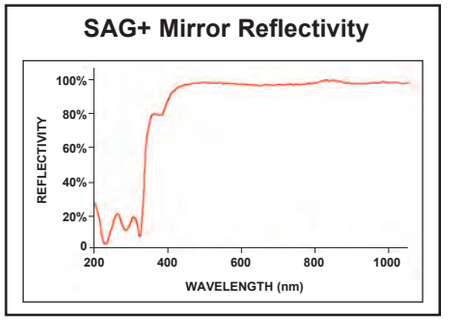
We offer longpass absorbing or blocking filters; each filter has a transmission band and a blocking band to restrict radiation to a certain wavelength region for eliminating second- and third-order effects. These filters are installed permanently between the slit and the clad mode aperture in the bulkhead of the SMA 905 Connector.

Item	Description
OF1-WG305	Longpass filter; transmits light >305 nm
OF1-GG375	Longpass filter; transmits light >375 nm
OF1-GG395	Longpass filter; transmits light >395 nm
OF1-GG475	Longpass filter; transmits light >475 nm
OF1-OG515	Longpass filter; transmits light >515 nm
OF1-OG550	Longpass filter; transmits light >550 nm
OF1-OG590	Longpass filter; transmits light >590 nm

Collimating and Focusing Mirrors

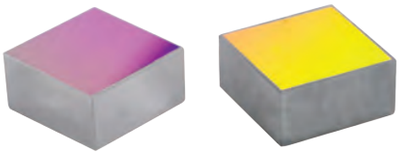
You can replace the standard aluminum-coated reflective mirrors with our proprietary, UV-absorbing SAG+ Mirrors, which increase reflectance in the VIS-NIR and, in turn, increase the sensitivity of the spectrometer. SAG+ Mirrors are often specified for fluorescence. These mirrors also absorb nearly all UV light, which reduces the effects of excitation scattering in fluorescence measurements. Unlike most silver-coated mirrors, the SAG+ mirrors won't oxidize.

Item Code: SAG+UPG-HR



Grating and Wavelength Range

With a choice of multiple gratings, you can easily customize the spectral range and most efficient region of your QE65000 or Maya2000 Pro Spectrometer. Our gratings are permanently fixed in place at the time of manufacture and are available in both ruled and holographic versions. See pages 44-47 for grating options and efficiency curves and consult an Ocean Optics Applications Scientist for details.

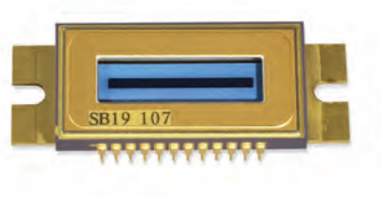


QE65000 and Maya2000 Pro Spectrometers

Detectors and Accessories for Your High-sensitivity Spectrometers

Back-thinned Area Detectors

The Hamamatsu FFT-CCD detectors used in the QE65000 and Maya2000 Pro have great UV response and provide up to 90% quantum efficiency (defined as how efficiently a photon is converted to a photo-electron). The QE65000 uses the S7031-1006 2D array detector and the Maya2000 Pro uses the S10420 detector. Each detector is responsive from 200-1100 nm.



Detectors with OFLV Filters

OFLV Variable Longpass Order-sorting Filters are applied to the detector's window to eliminate second- and third-order effects. We use a patented coating technology to apply the filter to the substrate.

QE65000 Detector Options

Item	Description
DET-QE	Hamamatsu S7031 detector, installed, w/no variable longpass filter
DET-QE-OFLV-200	Hamamatsu S7031 detector, installed, w/OFLV-QE-200 variable longpass filter
DET-QE-OFLV-250	Hamamatsu S7031 detector, installed, w/OFLV-QE-250 variable longpass filter
DET-QE-OFLV-300	Hamamatsu S7031 detector, installed, w/OFLV-QE-300 variable longpass filter
DET-QE-OFLV-350	Hamamatsu S7031 detector, installed, w/OFLV-QE-350 variable longpass filter
DET-QE-OFLV-400	Hamamatsu S7031 detector, installed, w/OFLV-QE-400 variable longpass filter
DET-QE-WINDOWLESS	Hamamatsu S7031 detector, installed, with no window options; required for VUV applications

Maya2000 Pro Detector Options

Item	Description	Spectrometer
DET-MAYAPRO	Hamamatsu S10420 detector, installed, w/no variable longpass filter	Maya2000 Pro
DET-MAYAPRO-OFLV-200	Hamamatsu S10420 detector, installed, w/OFLV-200 variable longpass filter	Maya2000 Pro
DET-MAYAPRO-UV	Hamamatsu S10420 detector, installed, w/UV window	Maya2000 Pro
DET-MAYAPRO-VIS	Hamamatsu S10420 detector, installed, w/VIS window	Maya2000 Pro
DET-MAYAPRO-WINDOWLESS	Hamamatsu S10420 detector, installed, with no window options; required for VUV applications	Maya2000 Pro
MAYA-DEEP-UV	DET-MAYAPRO-UV, installed, w/MgF_2 window in place of standard UV window	Maya2000 Pro

Technical Tip

Just as flexibility is built into your spectrometer options, so, too, is flexibility built in to your experiment parameters. We use the term Scope Mode in software to indicate "raw signal" coming from the spectrometer. The Scope Mode spectrum is the digital signal created from the detector's analog signal, which is generated as the result of photons being converted into electrons. The arbitrary units of the Scope mode spectrum are called "counts."

By changing the integration time, adjusting signal averaging and so on you can condition the raw signal to maximize intensity or reduce noise, for example. Once you have optimized your base signal you are ready to enter a Processed Mode. Processed data involves taking a dark, taking a reference and then going into a specific mode such as absorbance, transmission, reflection, relative irradiance, absolute irradiance, color and so on. In a Processed Mode the y-axis units are no longer arbitrary and therefore can be used to make qualitative, and in some cases quantitative, comparisons.

QE65000 and Maya2000 Pro Spectrometers

Choosing the Right Grating

Groove Density

The groove density (lines/mm^{-1}) of a grating determines its dispersion, while the angle of the groove determines the most efficient region of the spectrum. The greater the groove density, the better the optical resolution possible, but the more truncated the spectral range.

Spectral Range

The dispersion of the grating across the linear array is also expressed as the "size" of the spectra on the array. The spectral range (bandwidth) is a function of the groove density and does not change. When you choose a starting wavelength for a spectrometer, you add its spectral range to the starting wavelength to determine the wavelength range. For several gratings, the spectral range of a grating varies according to the starting wavelength range. The rule of thumb is this: The higher the starting wavelength, the more truncated the spectral range.

Blaze Wavelength

For ruled gratings, the blaze wavelength is the peak wavelength in an efficiency curve. For holographic gratings, it is the most efficient wavelength region.

Best Efficiency (>30%)

All ruled or holographically etched gratings optimize first-order spectra at certain wavelength regions; the "best" or "most efficient" region is the range where efficiency is >30%. In some cases, gratings have a greater spectral range than is efficiently diffracted. For example, Grating 1 has about a 650 nm spectral range, but is most efficient from 200-575 nm. In this case, wavelengths >575 nm will have lower intensity due to the grating's reduced efficiency.

Grating and Wavelength Range

With a choice of multiple grating options, you can easily customize your QE65000 and Maya2000 Pro Spectrometers for various applications across the UV-Shortwave NIR. Our gratings are fixed in place at the time of manufacture. Also, we've added grating options that provide flexibility for UV applications, Raman and more. A table describing these new gratings, as well as efficiency curves and other information, is available beginning on page 46 and on our website.

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
HC-1 w/QE65000	UV-NIR	300/600 (variable)	750 nm	Variable	200-950 nm
HC-1 w/Maya2000 Pro	UV-NIR	300/600 (variable)	850 nm	Variable	200-1050 nm
H1	UV	600	373-390 nm	300 nm	200-575 nm
H2	UV-VIS	600	365-390 nm	400 nm	250-800 nm
H3	VIS-Color	600	360-386 nm	500 nm	350-850 nm
H4	NIR	600	360-377 nm	750 nm	530-1100 nm
H5	UV-VIS	1200	180-193 nm	Holographic UV	200-400 nm
H6	NIR	1200	123-170 nm	750 nm	500-1100 nm
H7	UV-VIS	2400	63-90 nm	Holographic UV	200-500 nm
H9	VIS-NIR	1200	145-180 nm	Holographic VIS	400-800 nm
H10	UV-VIS	1800	83-123 nm	Holographic UV	200-635 nm
H11	UV-VIS	1800	66-120 nm	Holographic VIS	320-720 nm
H12	UV-VIS	2400	52-88 nm	Holographic VIS	260-780 nm*
H13	UV-NIR	300	790 nm	500 nm	300-1100 nm
H14	NIR	600	360-370 nm	1000 nm	650-1100 nm

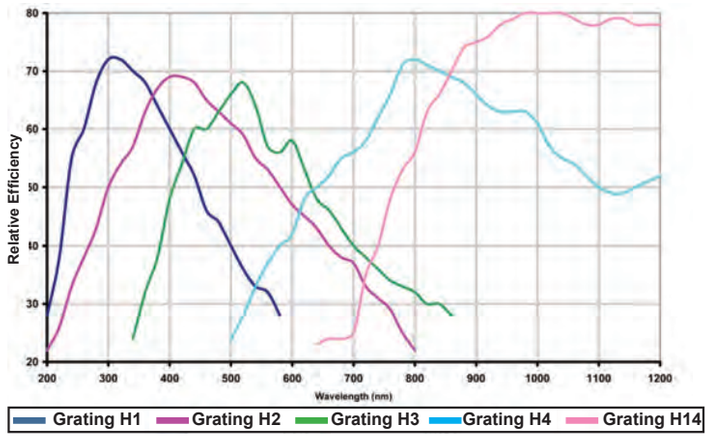
*Consult an Applications Scientist regarding setups >720 nm.

QE65000 and Maya2000 Pro Spectrometers

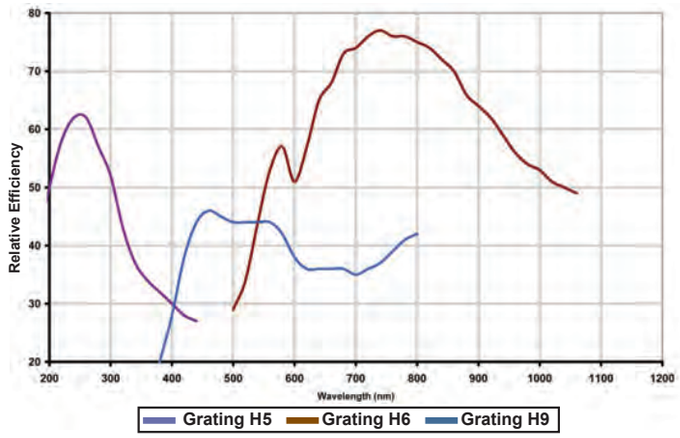
Gratings for QE65000/Maya2000 Pro Spectrometers

The graphs below are grating efficiency curves for gratings with groove densities of 600, 1200, 1800 and 2400 mm^{-1}. Additional information is available at www.oceanoptics.com/Products/bench_grating_hr.asp. Newer grating curves are on the next page.

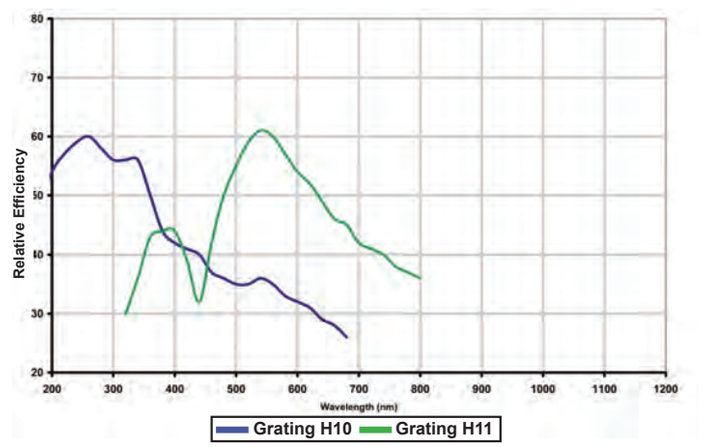
Groove Density of 600 mm^{-1}



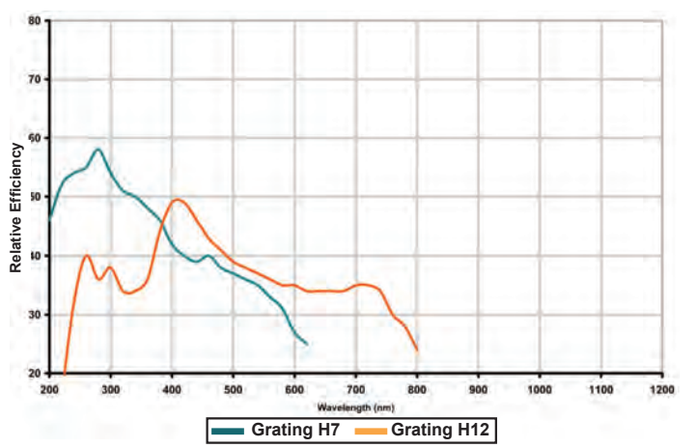
Groove Density of 1200 mm^{-1}



Groove Density of 1800 mm^{-1}



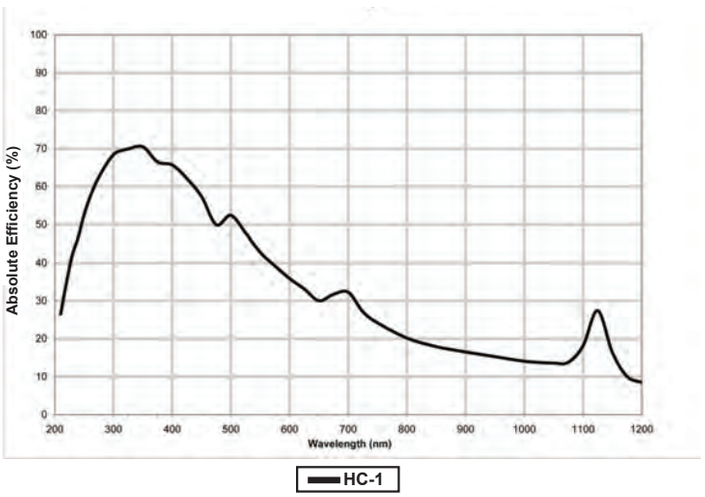
Groove Density of 2400 mm^{-1}



Grating Selection Tips:

- These efficiency curves relate only to the grating. System response is affected by a number of variables, including detector response.
- Grating selection often involves trade-offs. For example, gratings with very high groove density (mm^{-1}) allow greater optical resolution but at the expense of a truncated spectral range. If the user is characterizing two or three closely aligned laser wavelengths, such a trade-off of resolution for range might be acceptable. For other applications, a wider range with good resolution would make better sense.
- We've added several different gratings to provide even more flexibility. Turn the page for details.

Variable Groove Density of 600 mm^{-1}/300 mm^{-1}



QE65000 and Maya2000 Pro Spectrometers

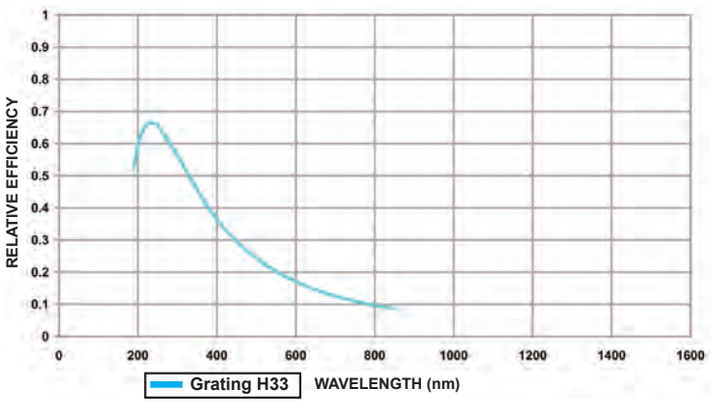
Gratings for QE65000/Maya2000 Pro Spectrometers

We've added grating options for QE65000 and Maya2000 Pro Spectrometers that provide added flexibility for UV applications, Raman analysis and more. A table describing these new gratings, as well as efficiency curves and other information, is available beginning on this page and is posted at our website. Please take note that the x and y axis scaling varies from graph to graph. These new gratings are also available for use in HR Series Spectrometers.

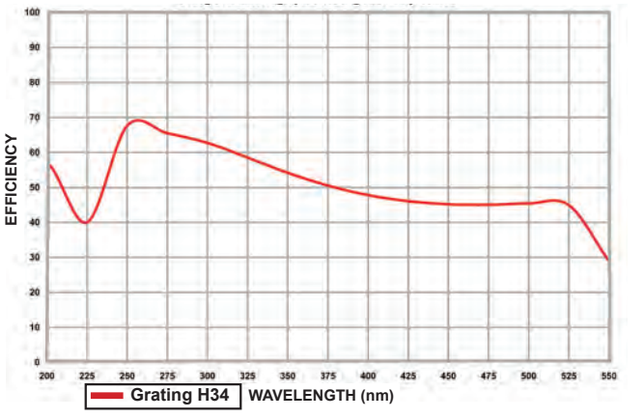
New grating options are just one area of enhanced performance we've addressed with our high-sensitivity, scientific-grade spectrometer offering. Soon to be released are spectrometer options with even greater sensitivity, improved response in certain regions from the UV-NIR, replaceable slits and improved thermal wavelength stability. With our extensive offering of gratings and optical bench accessories, thousands of customized spectrometer configurations are possible. That's flexibility that few manufacturers can match.

Grating Number	Intended Use	Groove Density	Blaze Wavelength	Best Efficiency (>30%)
H33	Absorbance	300	200 nm	200-450 nm
H34	UV Raman	3600	250 nm	200-550 nm
H35	NIR Raman	1200	1000 nm	525-1625 nm
H36	VIS Raman	900	500 nm	325-1225 nm
H5U	Absorbance	1200	250 nm	225-450 nm
H7U	Absorbance	2400	240 nm	200-800 nm
H10U	Absorbance	1800	250 nm	210-475 nm

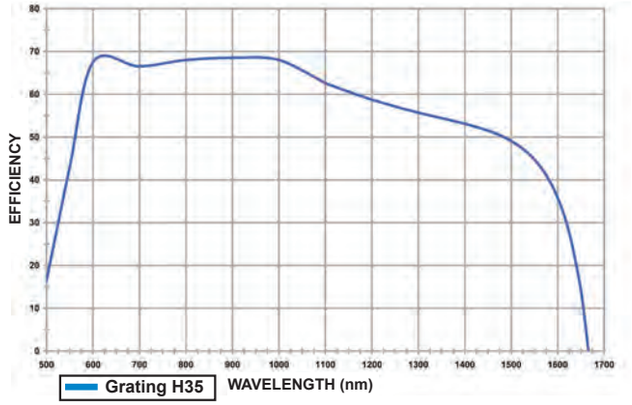
Groove Density of 300 mm^{-1}



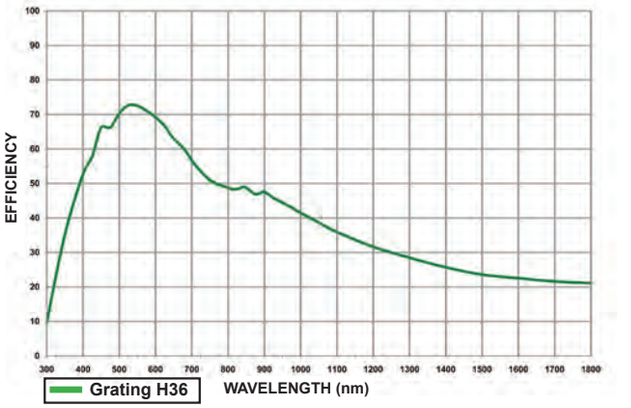
Groove Density of 3600 mm^{-1}



Groove Density of 1200 mm^{-1}, Blazed at 1000 nm



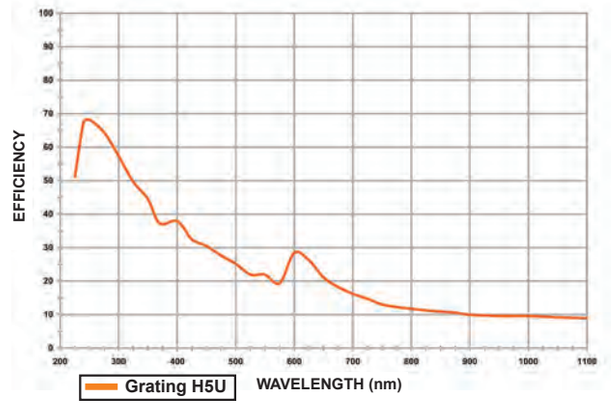
Groove Density of 900 mm^{-1}



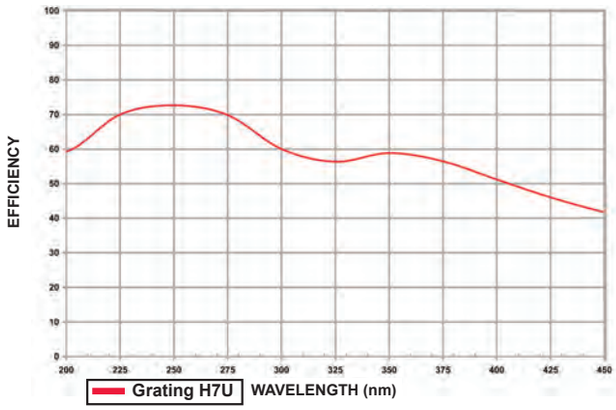
QE65000 and Maya2000 Pro Spectrometers

Gratings for QE65000/Maya2000 Pro Spectrometers

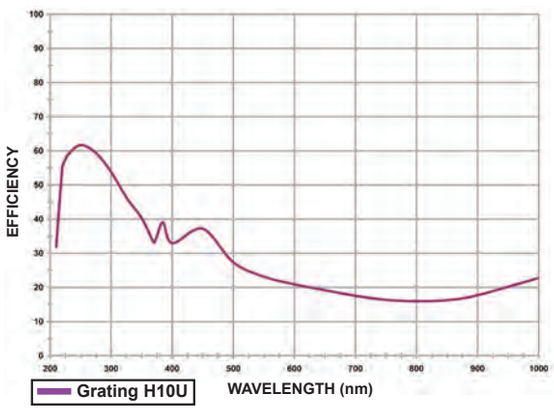
Groove Density of 1200 mm^{-1}, Blazed at 1000 nm



Groove Density of 2400 mm^{-1}



Groove Density of 800 mm^{-1}



Technical Tip: Ruled or Holographic?

A ruled grating is formed by mechanically ruling grooves into a thin coating of gold or aluminum on a large glass blank. Ruled gratings provide good performance at lower groove densities and over broad ranges. Holographic gratings are formed by the interference of expanded Gaussian beams at the surface of a photoresist-covered substrate that is chemically developed into a master grating. The grating may be coated or replicated.

Tradeoffs with ruled and holographic gratings include performance at high or low groove frequencies, the diffraction efficiency or intensity diffracted into the appropriate order, and stray light performance.

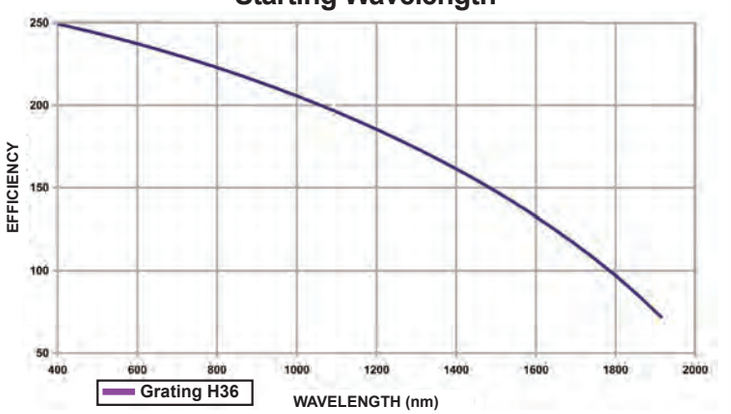
New Grating #H36 Ideal for Modular QE65000 Raman Systems

Grating #H36 is a 900 mm-1 grating that is well suited for applications over a wide UV-NIR range and makes a great choice for modular Raman systems utilizing the QE65000 Spectrometer.

The grating is blazed at 500 nm and has good response at both the 532 nm and 785 nm laser illumination wavelengths typical of Raman spectroscopy. In the graph here, you'll see the predicted spectral range possible for Grating #H36 as a function of starting wavelength.

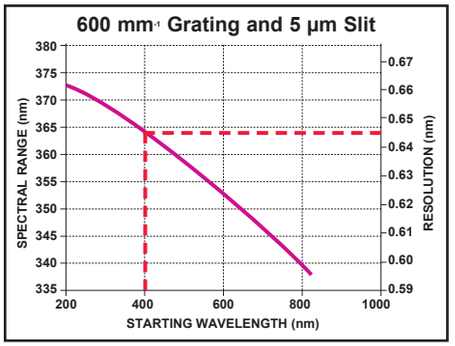
Details on modular and turnkey Raman options are available in the LIBS and Raman section.

Predicted Spectral Range for Grating H36 by Starting Wavelength

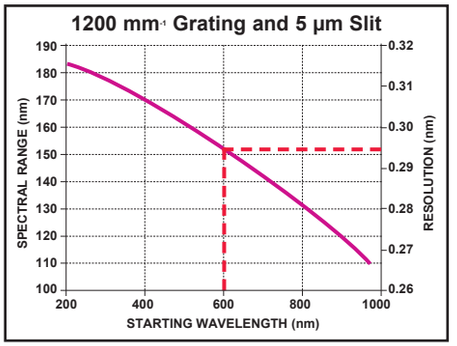


QE65000 Spectrometers

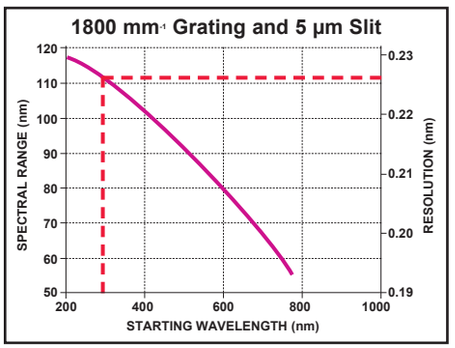
Predicted Ranges and Resolution



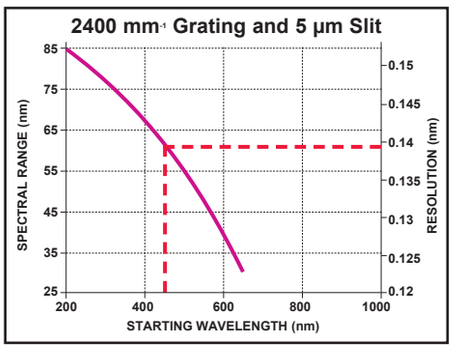
Example:
If the starting wavelength is 400 nm, then the range is ~364 nm, providing a 400-764 nm wavelength range and 0.645 nm resolution.



Example:
If the starting wavelength is 600 nm, then the range is ~152 nm, providing a 600-752 nm wavelength range and 0.295 nm resolution.



Example:
If the starting wavelength is 300 nm, then the range is ~112 nm, providing a 300-412 nm wavelength range and 0.226 nm resolution.



Example:
If the starting wavelength is 450 nm, then the range is ~62 nm, providing a 450-512 nm wavelength range and 0.139 nm resolution.

Note: These predicted range and resolution figures apply only to QE65000 Spectrometers.

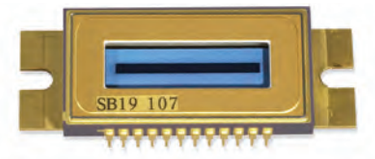
QE65000 Detector

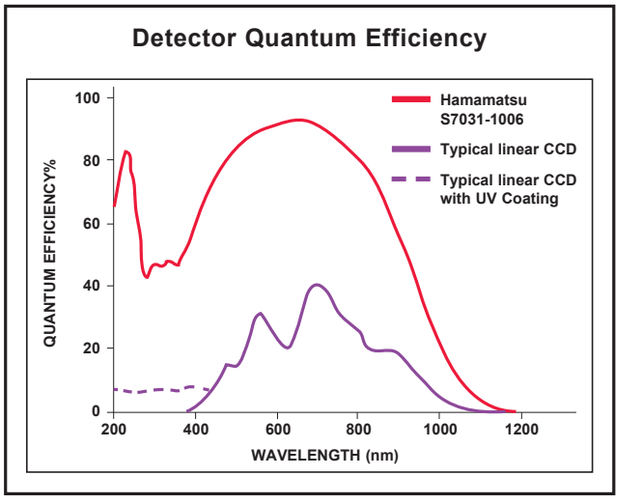
About the QE65000 Detector

The QE65000's Hamamatsu S7031-1006 FFT-CCD area detector provides 90% quantum efficiency (defined as how efficiently a photon is converted to a photoelectron). The TE-cooled detector features low noise and low dark signal, which enables low-light-level detection and long integration times, thus achieving a wide dynamic range. Maya2000 Pro Spectrometers have a similar detector but without the TE cooling device.

The S7031 is a 2D array, which allows us to bin pixels in a vertical column to acquire light from the entire height of the spectrometer's slit image. This improves light collection and signal-to-noise significantly. Because the detector is back-thinned (or back-illuminated), it has great native response in the UV and does not require the UV detector upgrade that we apply to other detectors.

In our spectrometers with linear CCDs, the slit's width, not its height, regulates the amount of light entering the bench because linear CCDs cannot efficiently collect the light from the entire height of the slit. But in the QE65000, the 2D area detector can better take advantage of the height of the entrance slit and the additional light, greatly improving system sensitivity.





Application Notes

Maya2000 Pro Spectral Measurements Extend to 153 nm

Our Maya2000 Pro Spectrometer delivers high quantum efficiency and high dynamic range and is responsive in the deep UV (~185-300 nm). The Extra-Deep UV option extends spectral measurements to 153 nm.

Introduction

Spectral measurements to 153 nm can be achieved easily and economically with the high-sensitivity Maya2000 Pro with the Extra-Deep UV option. A variety of materials have spectral signatures in the vacuum ultraviolet (VUV) spectral region (from 10 nm-200 nm); VUV spectroscopy is useful for applications ranging from biomedicine to semiconductor testing.

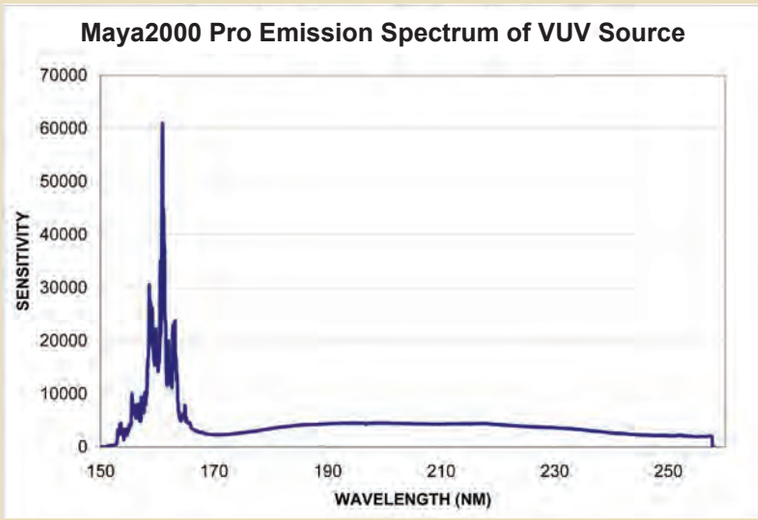
Because the spectral response of standard silicon charge-coupled device (CCD) detectors drops off rapidly at wavelengths as long as 400 nm, and because oxygen and water absorb in the VUV spectral band, maintaining sufficient signal outside a vacuum is not possible.

Nitrogen purging of the spectrometer helps to mitigate water and oxygen absorption in the VUV. Spectrometers with a vacuum purging feature require custom configuration and are often too expensive and unwieldy for many common applications.

The Maya2000 Pro with the Extra-Deep UV option's clever design changes all that. The spectrometer features a 101.6-mm focal length optical bench with a compact crossed Czerny-Turner design and a back-thinned CCD detector that offers superior UV and VUV performance. To minimize signal attenuation inside the optical path, the spectrometer bench is purged with nitrogen, achieving a robust signal for VUV experiments at wavelengths as low as 153 nm.

Experimental Conditions

To test performance, we started with a Maya2000 Pro configured with a high resolution, UV-enhanced 2400 g/mm holographic diffraction grating and a 5 µm slit. The back-thinned detector (Hamamatsu S10420-1106) features a peak quantum efficiency of 75%, with UV quantum efficiencies as high as 50%. A custom magnesium fluoride (MgF2) glass window is placed over the detector for improved transmission over VUV wavelengths. The test sample for the experiment was a VUV deuterium lamp with a VUV-grade optical window, coupled directly to the spectrometer. We enclosed the source and spectrometer and purged the region with standard laboratory-grade nitrogen.



The sharply defined spectral peaks at wavelengths as low as 153 nm are measured using the Maya2000 Pro.

Results

Integration time for the measurement was 50 ms. The resultant emission spectrum shows sharply defined spectral peaks at wavelengths as low as 153 nm, with a strong central peak around 161 nm (see spectra). The system operated with a spectral resolution of 0.1 nm and a SNR of 450:1.

We have also used the system to measure a solution containing carbon, hydrogen/deuterium, nitrogen, oxygen, sulfur, chlorine, bromine, silicon and fluorine chromatographically separated into a column and placed in a vacuum chamber with a helium plasma mixture. VUV spectral features were clearly apparent in the spectrum, suggesting a wide variety of short-wavelength applications is achievable.

Conclusions

The results demonstrate that the reliable and economical Maya2000 Pro can be easily extended to VUV applications. If you have spectroscopy experiments or applications in the VUV, look no further than the Maya2000 Pro as your short-wavelength, affordable, robust solution.

NIR and Mid-IR Spectrometers

Full Range of Options from 900-3400 nm

We offer two great technologies for your NIR (900-2500 nm) and Mid-IR (900-3400 nm) application needs:

- **NIRQuest® Spectrometers**
  Feature a fixed optical bench, fiber input and an InGaAs array of detector elements. Array-based systems are a must for capturing transient phenomena and are recommended for high speed acquisition in general.

- **SIR-Series Spectrometers**
  These rotating grating (scanning) spectrometers use a stepper motor with optical encoder to rotate a grating through 45,000 steps. The detector is fixed in placed and because of its large area, has exceptional optical resolution and signal to noise. SIRs can be used with optical fibers or in free-beam mode using direct-attach lenses.

NIR and Mid-IR Spectrometer Models at a Glance

With NIRQuest and SIR Spectrometers, you can opt for the standard, default configuration or mix and match gratings, slits and other accessories for a custom setup:

Type	Wavelength Range	Models	Best for These Application Needs
Array-based	800-1600 nm	NIRQuest512-XR	Response at Shortwave NIR wavelengths (<900 nm)
Array-based	900-1700 nm	NIRQuest512	Optimum response at ~1600 nm and good optical resolution (~3.0 nm FWHM)
Array-based	1100-1900 nm	NIRQuest512-1.9	Good response from 1100-1900 nm with good optical resolution ~3.1 nm (FWHM)
Array-based	900-2050 nm	NIRQuest256-2.1	Good response at higher wavelengths (peak detector response ~1900 nm) and optical resolution <8.0 nm (FWHM)
Array-based	900-2200 nm	NIRQuest512-2.2	Good response across 900-2200 nm without sacrificing optical resolution performance (~4.6 nm FWHM)
Array-based	900-2500 nm	NIRQuest512-2.5	Good optical resolution (~6.3 nm FWHM) and low dark noise at long integration times
Array-based	900-2500 nm	NIRQuest256-2.5	Good response at higher wavelengths (peak detector response ~2200 nm) and optical resolution <10.0 nm (FWHM)
Scanning	900-2600 nm	SIR-2600	Good optical resolution and SNR performance, especially for characterizing lasers
Scanning	1300-3400 nm	SIR-3400	Good optical resolution and SNR performance at longer wavelengths, especially for characterizing lasers

Tech Tip: NIR Wavelength Calibration

Spectrometer wavelength calibration sources are useful tools for maintaining calibration in your spectrometer. For NIRQuest, use our AR-1 Argon Source (696-1704 nm) or XE-1 Xenon Source (916-1984 nm), which have atomic emission lines that extend into the NIR. With a wavelength calibration source, you can recalibrate your spectrometer using a spreadsheet program such as Microsoft Excel or a calculator that performs third-order polynomial regressions.

NIRQuest Spectrometers

Near-Infrared Measurements for Nearly Anything

NIRQuest Spectrometers

These small-footprint spectrometers cover various ranges from 900-2500 nm and are ideal for demanding applications ranging from moisture detection and chemical analysis to high-resolution laser and optical fiber characterization. Each NIRQuest spectrometer model is preset with optical bench and grating options appropriate for a wide range of NIR applications. We also offer a full range of slit, filter and grating options to optimize your setup for higher resolution needs or other performance requirements.

Features

- Choice of multiple spectrometer options for optimizing setups across the range from 800-2500 nm.
- Wide range of gratings, slits and accessories for maximum flexibility
- External hardware triggering function for capturing data when and external event occurs or to trigger and event after data acquisition

Physical	NIRQuest512-XR	NIRQuest512	NIRQuest512-1.9
Dimensions (mm):	182 x 110 x 47	182 x 110 x 47	182 x 110 x 47
Weight:	1.18 kg (2.6 lb.)	1.18 kg (2.6 lb.)	1.18 kg (2.6 lb.)
Optical Bench			
Entrance aperture (standard):	25 µm	25 µm	25 µm
Entrance aperture (custom options):	10 µm, 50 µm, 100 µm and 200 µm (or no slit)	10 µm, 50 µm, 100 µm and 200 µm (or no slit)	10 µm, 50 µm, 100 µm and 200 µm (or no slit)
Grating options (standard):	Grating NIR3, 150 l/mm, 900-1700 nm	Grating NIR3, 150 l/mm, 900-1700 nm	Grating NIR3, 150 l/mm, 900-1700 nm
Grating options (custom):	NIR10, NIR11, NIR12, NIR13 and NIR14	NIR10, NIR11, NIR12, NIR13 and NIR14	NIR10, NIR11, NIR12, NIR13 and NIR14
Longpass filter:	OF1-CGA-780 filter (standard); non-fluorescing, transmits >1000 nm	OF1-RG830 longpass NIR filter (optional)	OF1-CGA1000 (standard); non-fluorescing, transmits >1000 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber	SMA 905 to 0.22 numerical aperture single-strand optical fiber	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Spectroscopic			
Wavelength range:	800-1600 nm w/Grating NIR3	900-1700 nm w/Grating NIR3	1100-1900 w/Grating NIR3
Optical resolution (FWHM):	~3.1 nm w/25 µm slit	~3.1 nm w/25 µm slit	~3.1 nm w/25 µm slit
Signal-to-noise ratio at full signal:	>15000:1 @ 100 ms integration; >13000:1 @ 1000 ms integration	>15000:1 @ 100 ms integration; >13000:1 @ 1000 ms integration	>15000:1 @ 100 ms integration; >13000:1 @ 1000 ms integration
A/D resolution	16-bit	16-bit	16-bit
Dark noise:	6 RMS counts @ 100 ms	6 RMS counts @ 100 ms	6 RMS counts @ 100 ms
	12 RMS counts @ 1 s	12 RMS counts @ 1 s	12 RMS counts @ 250 ms
Dynamic range:	150M (system); 15K:1 for a single acquisition	150M (system); 15K:1 for a single acquisition	7.5M (system); 10K:1 for a single acquisition
Integration time:	1 ms -120 seconds	1 ms -120 seconds	1 ms -1 second
Noise Equivalent Power:	0.5pW	0.5pW	10.0pW
Electronics			
Power consumption:	USB power +5V, 0.5 A maximum; DC input jack +5V, 3 A maximum	USB power +5V, 0.5 A maximum; DC input jack +5V, 3 A maximum	USB power +5V, 0.5 A maximum; DC input jack +5V, 3 A maximum
Data transfer speed:	Full scan to memory every 5 ms with USB 2.0 port	Full scan to memory every 5 ms with USB 2.0 port	Full scan to memory every 5 ms with USB 2.0 port
Inputs/outputs:	External trigger input + single strobe output	External trigger input + single strobe output	External trigger input + single strobe output
Trigger modes:	4 modes	4 modes	4 modes
Connector:	30-pin connector	30-pin connector	30-pin connector

NIRQuest Spectrometers

Specifications Comparison Table

Physical	NIRQuest256-2.1	NIRQuest512-2.2	NIRQuest512-2.5	NIRQuest256-2.5
Dimensions (mm):	182 x 110 x 47	182 x 110 x 47	182 x 110 x 47	182 x 110 x 47
Weight:	1.18 kg (2.6 lb.)	1.18 kg (2.6 lb.)	1.18 kg (2.6 lb.)	1.18 kg (2.6 lb.)
Optical Bench				
Design:	f/4, symmetrical crossed Czerny-Turner	f/4, symmetrical crossed Czerny-Turner	f/4, symmetrical crossed Czerny-Turner	f/4, symmetrical crossed Czerny-Turner
Entrance aperture (standard):	25 µm	25 µm	25 µm	25 µm
Entrance aperture (custom options):	10 µm, 50 µm, 100 µm and 200 µm (or no slit)	10 µm, 50 µm, 100 µm and 200 µm (or no slit)	10 µm, 50 µm, 100 µm and 200 µm (or no slit)	10 µm, 50 µm, 100 µm and 200 µm (or no slit)
Grating options (standard):	Grating NIR2, 100 l/mm, 900-2050 nm	Grating NIR2, 100 l/mm, 900-2050 nm	Grating NIR1, 75 l/mm, 1075-2500 nm	Grating NIR1, 75 l/mm, 1075-2500 nm
Grating options (custom):	NIR2, NIR3, NIR10, NIR11, NIR12 and NIR13	NIR2, NIR3, NIR10, NIR11, NIR12 and NIR13	NIR2, NIR3, NIR10, NIR11, NIR12 and NIR13	NIR2, NIR3, NIR10, NIR11, NIR12 and NIR13
Order-sorting filter:	Yes (standard w/NIR2)	Yes (standard w/NIR2)	Yes (standard w/NIR1)	Yes (standard w/NIR1)
Longpass filter:	OF1-RG830 longpass NIR filter (optional)	OF1-RG830 longpass NIR filter (optional)	OF1-RG830 longpass NIR filter (optional)	OF1-RG830 longpass NIR filter (optional)
Collimating and focusing mirrors:	Gold-coated for enhanced NIR reflectivity	Gold-coated for enhanced NIR reflectivity	Gold-coated for enhanced NIR reflectivity	Gold-coated for enhanced NIR reflectivity
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber	SMA 905 to 0.22 numerical aperture single-strand optical fiber	SMA 905 to 0.22 numerical aperture single-strand optical fiber	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Spectroscopic				
Wavelength range:	900-2050 nm w/Grating NIR2	900-2200 nm w/Grating NIR2	900-2500 nm w/Grating NIR1	900-2500 nm w/Grating NIR1
Optical resolution (FWHM):	~7.6 nm w/25 µm slit	~5.0 nm w/25 µm slit	~6.3 nm w/25 µm slit	~ 9.5 nm w/25 µm slit
Signal-to-noise ratio at full signal:	10000:1 @ 100 ms integration	10000:1 @ 100 ms integration	10000:1 @ 100 ms integration	7500:1 @ 10 ms integration
A/D resolution	16-bit	16-bit	16-bit	16-bit
Dark noise:	6 RMS counts @ 100 ms	6 RMS counts @ 100 ms	16 RMS counts @ 10 ms	8 RMS counts @ 10 ms
	12 RMS counts @ 250 ms	12 RMS counts @ 250 ms	24 RMS counts @ 30 ms	12 RMS counts @ 30 ms
Dynamic range:	15M (system); 10K:1 for a single acquisition	7.5M (system); 10K:1 for a single acquisition	100K (system); 7.5K:1 for a single acquisition	500K (system); 7.5K:1 for a single acquisition
Integration time:	1 ms-2 s	1 ms-1 s	1 ms – 30 ms	1 ms-60 ms
Noise Equivalent Power:	5.0pW	10.0pW	100.0pW	25.0pW
Electronics				
Power consumption:	USB power +5V, 0.5 A maximum; DC input jack +5V, 3 A maximum	USB power +5V, 0.5 A maximum; DC input jack +5V, 3 A maximum	USB power +5V, 0.5 A maximum; DC input jack +5V, 3 A maximum	USB power +5V, 0.5 A maximum; DC input jack +5V, 3 A maximum
Data transfer speed:	Full scan to memory every 5 ms with USB 2.0 port	Full scan to memory every 5 ms with USB 2.0 port	Full scan to memory every 5 ms with USB 2.0 port	Full scan to memory every 5 ms with USB 2.0 port
Inputs/outputs:	External trigger input + single strobe output	External trigger input + single strobe output	External trigger input + single strobe output	External trigger input + single strobe output
Breakout box compatibility:	Yes	Yes	Yes	Yes
Gated delay:	Yes, with external hardware trigger delay	Yes, with external hardware trigger delay	Yes, with external hardware trigger delay	Yes, with external hardware trigger delay
Connector:	30-pin connector	30-pin connector	30-pin connector	30-pin connector
Temperature and Thermoelectric Cooling				
Temperature limits (environmental):	10-35 ºC (0-90% non-condensing)	10-35 ºC (0-90% non-condensing)	10-35 ºC (0-90% non-condensing)	10-35 ºC (0-90% non-condensing)
TEC setpoint (software controlled):	Control at -20 ºC (up to 45 ºC below ambient)	Control at -20 ºC (up to 45 ºC below ambient)	Control at -20 ºC (up to 45 ºC below ambient)	Control at -20 ºC (up to 45 ºC below ambient)
TEC stability:	'+/-0.5 ºC of set temperature in <1 minute; typical long-term stability +/-0.1 ºC	'+/-0.5 ºC of set temperature in <1 minute; typical long-term stability +/-0.1 ºC	+/-0.5 ºC of set temperature in <1 minute; typical long-term stability +/-0.1 ºC	'+/-0.5 ºC of set temperature in <1 minute; typical long-term stability +/-0.1 ºC

NIRQuest Spectrometers

Optical Bench Options for Your Custom NIRQuest Spectrometer

Each NIRQuest® model is available as a standard configuration comprising some combination of InGaAs array detector, grating, order-sorting filter and 25 µm slit. In addition, you can customize your NIRQuest by mixing and matching optical bench accessories with the assistance of an Ocean Optics Applications Scientist. Here are your options:

Detectors

Each NIRQuest Spectrometer uses a different Hamamatsu InGaAs-array detector and comes with a preconfigured combination of that detector and optical bench components. If you wish to customize your setup – for example, change the slit size – you'll need to itemize the components, beginning with these detector options:

Item	Description
NQ256-2.1	NIR Spectrometer, 900-2100 nm, 256-element InGaAs array
NQ256-2.5	NIR Spectrometer, 900-2500 nm, 256-element InGaAs array
NQ512-XR	NIR Spectrometer, 800-1600 nm, 512-element InGaAs array
NQ512	NIR Spectrometer, 900-1700 nm, 512-element InGaAs array
NQ512-1.9	NIR Spectrometer, 1100-1900 nm, 512-element InGaAs array
NQ512-2.2	NIR Spectrometer, 900-2200 nm, 512-element InGaAs array
NQ512-2.5	NIR Spectrometer, 900-2500 nm, 512-element InGaAs array

Fixed Entrance Slits

Our entrance slits are rectangular apertures that are 1 mm tall and come in various widths. The standard NIRQuest configuration has a 25 µm slit. Here are your other options:

Slit	Description	Pixel Resolution (approximate), by Model	
		NIRQuest512 Models	NIRQuest256 Models
SLIT-10	10 µm width x 1 mm height	1.3 pixels	1.5 pixels
SLIT-25	25 µm width x 1 mm height	2.0 pixels	1.7 pixels
SLIT-50	50 µm width x 1 mm height	2.3 pixels	2.0 pixels
SLIT-100	100 µm width x 1 mm height	4.2 pixels	2.5 pixels
SLIT-200	200 µm width x 1 mm height	7.9 pixels	4.0 pixels

Order-sorting and Longpass Filters

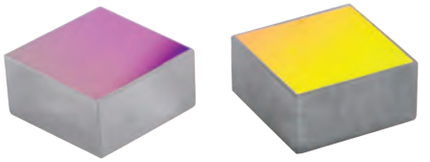
Order-sorting filters and longpass filters are installed in the optical bench. Order-sorting filters are standard with all NIRQuest models except the NIRQuest512. For custom NIRQuest orders, you'll need to specify the appropriate OSF filter (see table). The OF1-RG830 is a longpass filter recommended for custom configurations with Grating NIR1, Grating NIR2 or Grating NIR3 (with an NQ512 Spectrometer). OF1-RG830 is not recommended in setups with a 10 µm slit.

Item	Description
OSF-NIRQUEST256-2.1	Order-sorting filter, installed, for custom NIRQUEST256-2.1 configurations
OSF-NIRQUEST256-2.5	Order-sorting filter, installed, for custom NIRQUEST256-2.5 configurations
OSF-NIRQUEST512-xx	Order-sorting filter, installed, for custom NIRQUEST512 configurations; contact an Applications Scientist for details
OF1-RG830	Longpass filter, installed, transmits >830 nm; recommended for custom NIR-Quest configurations with Grating NIR1, Grating NIR2 or Grating NIR3

NIRQuest Spectrometers
Choosing the Right Grating

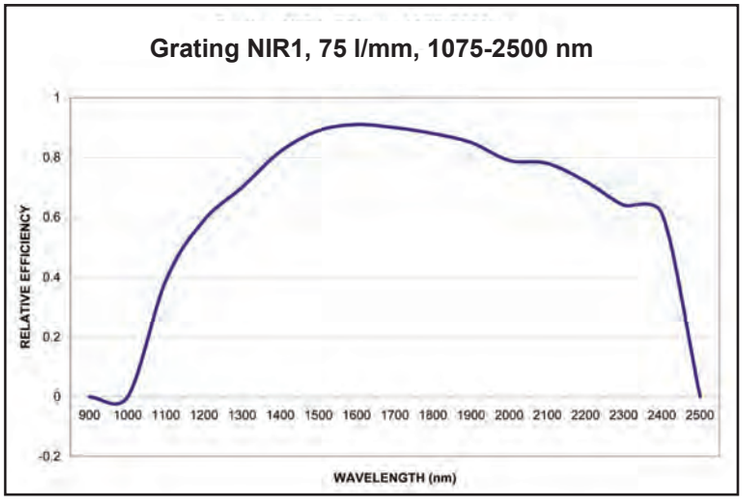
Grating Options

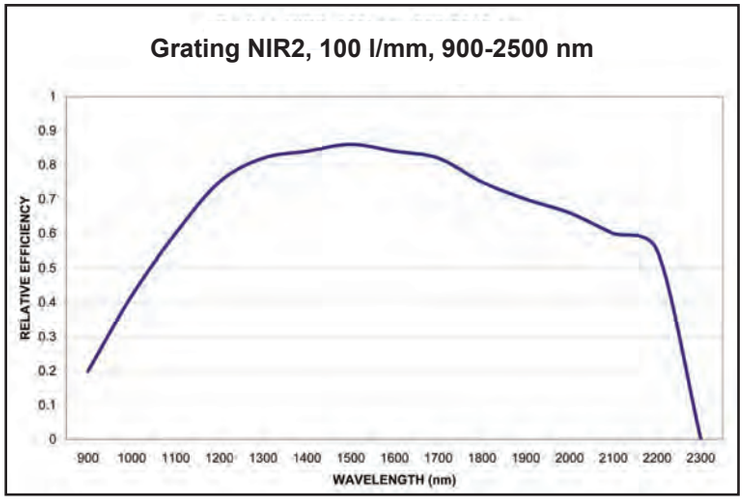
Customized NIRQuest Spectrometers are available with a choice of multiple gratings. With each grating, you consider its groove density (which helps determine the resolution), its spectral range (which helps determine the wavelength range) and its blaze wavelength (which helps determine the most efficient range).



Grating	Intended Use	Groove Density (lines/mm)	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
NIR1	NIRQuest256-2.5	75	1600 nm	1700 nm	1075-2500 nm
NIR2	NIRQuest256-2.1, NIRQuest256-2.5, NIRQuest512-2.2	100	1200 nm	1600 nm	900-2050 nm
NIR3	NIRQuest256-2.1, NIRQuest256-2.5, NIRQuest512, NIRQuest512-1.9, NIRQuest512-2.2, NIRQuest512-XR	150	~800 nm	1100 nm	900-1700 nm
NIR10	NIRQuest256-2.1, NIRQuest256-2.5, NIRQuest512, NIRQuest512-1.9, NIRQuest512-2.2, NIRQuest512-XR	300	350-380 nm	1200 nm	750-2200 nm
NIR11	NIRQuest256-2.1, NIRQuest256-2.5, NIRQuest512, NIRQuest512-1.9, NIRQuest512-2.2, NIRQuest512-XR	400	240-290 nm	1600 nm	980-2500 nm
NIR12	NIRQuest256-2.1, NIRQuest256-2.5, NIRQuest512, NIRQuest512-1.9, NIRQuest512-2.2, NIRQuest512-XR	500	160-220 nm	1370 nm	900-2500 nm
NIR13	NIRQuest256-2.1, NIRQuest256-2.5, NIRQuest512, NIRQuest512-1.9, NIRQuest512-2.2, NIRQuest512-XR	600	100-180 nm	1200 nm	800-2500 nm
NIR14	NIRQuest512, NIRQuest512-1.9, NIRQuest512-XR	1000	50-90 nm	1310 nm	900-1700 nm

Additional grating options, adjustments to starting and ending wavelengths and similar customization may be available. Also, spectral range can vary by starting wavelength. With the exception of NIRQuest512-XR, starting wavelengths should be set at ≥ 900 nm. Please contact an Applications Scientist for details.





For more grating curves, see next page.

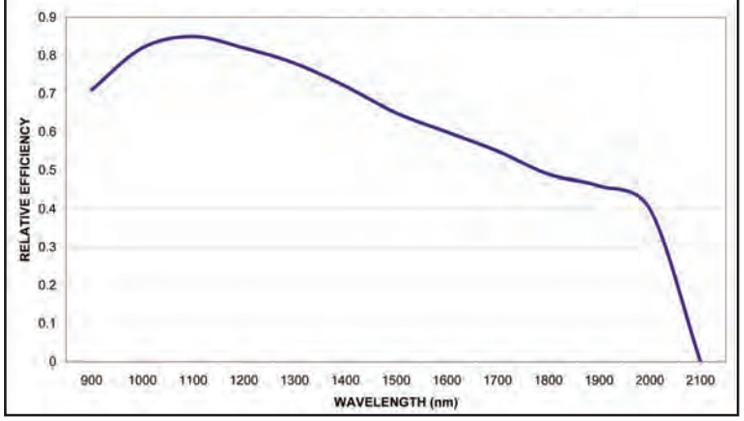
Technical Tip

Gratings and slits are fixed in place and can only be replaced at our manufacturing facility. That's why it's important to consider all the variables involved in system performance, including detector and grating response, slit size and other bench accessories. Our Applications Scientists have configured thousands of spectrometers for all sorts of applications and can offer invaluable consultation as you consider your application.

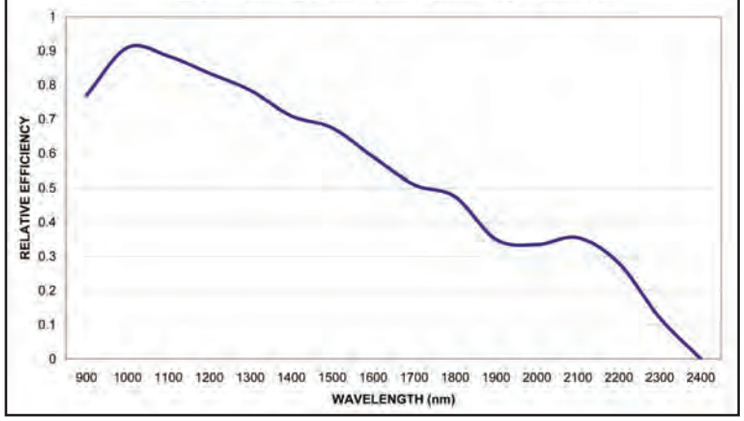
NIRQuest Spectrometers

NIRQuest Grating Efficiency Curves

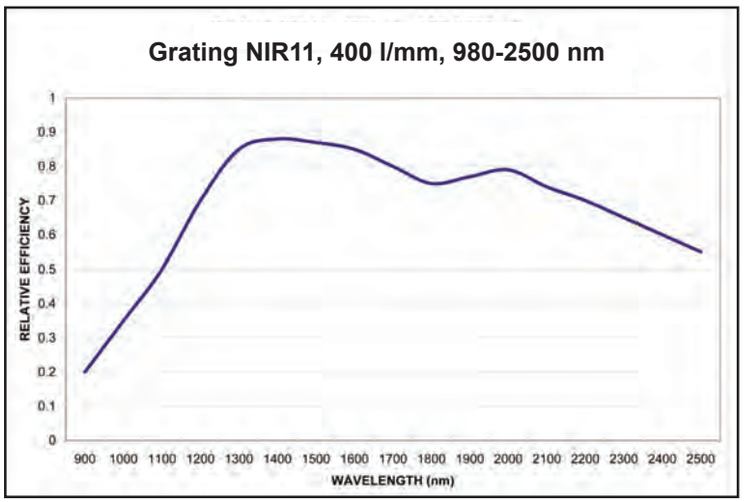
Grating NIR3, 150 l/mm, 900-1700 nm



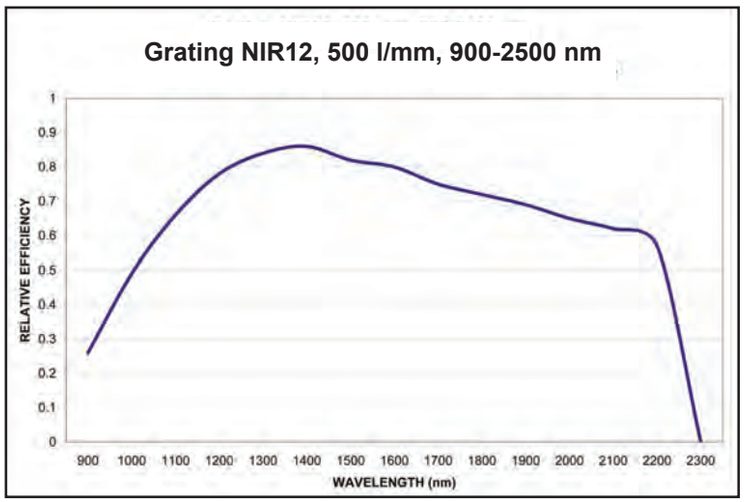
Grating NIR10, 300 l/mm, 750-2200 nm



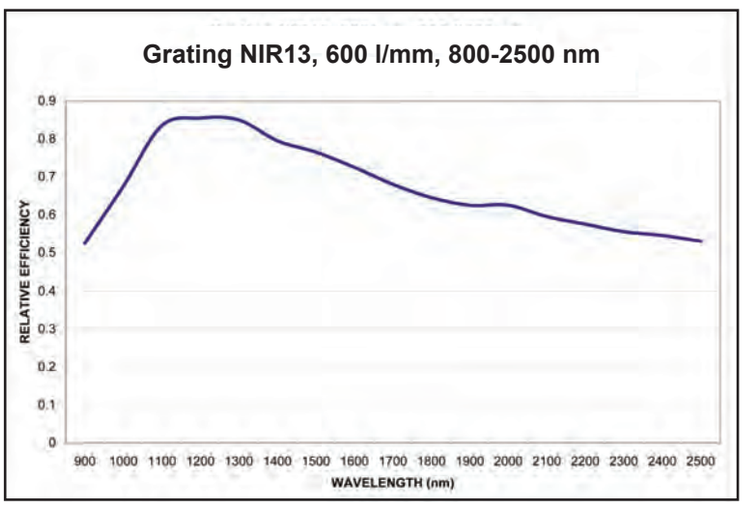
Grating NIR11, 400 l/mm, 980-2500 nm



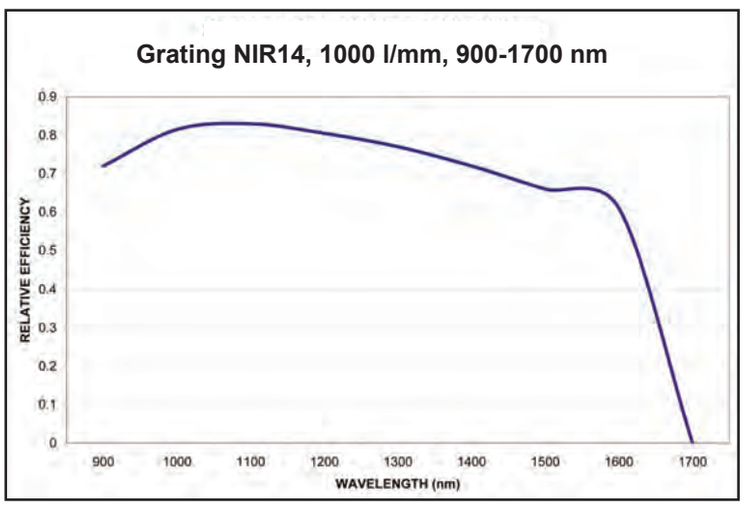
Grating NIR12, 500 l/mm, 900-2500 nm



Grating NIR13, 600 l/mm, 800-2500 nm



Grating NIR14, 1000 l/mm, 900-1700 nm

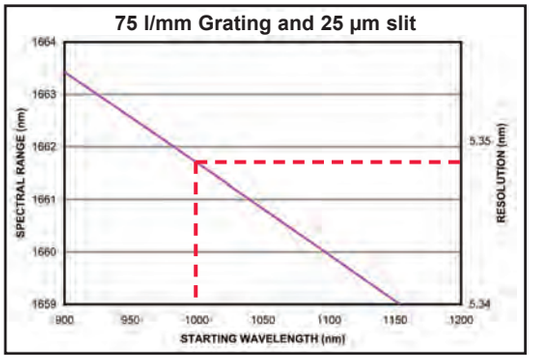


NIRQuest User-Configured Spectrometers

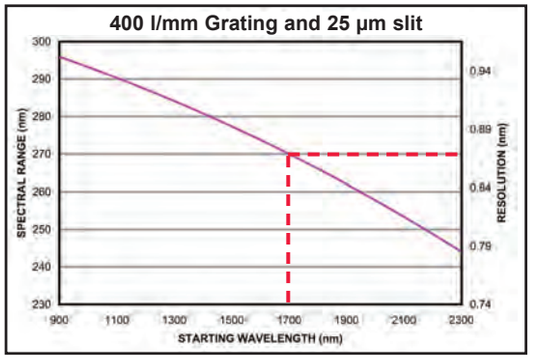
Predicted Ranges and Resolution

Predicted Ranges and Resolution

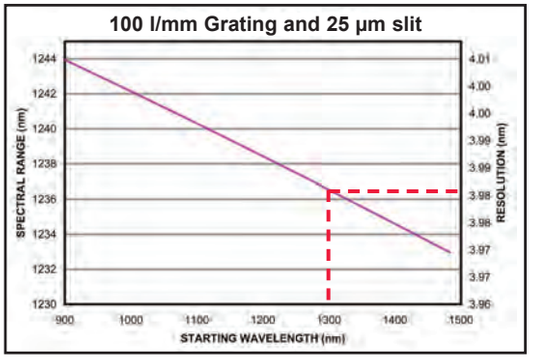
These graphs demonstrate the range and resolution of a NIRQuest512 model spectrometer with a 25 µm slit.



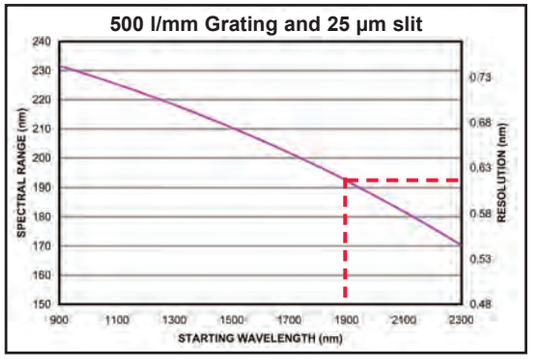
Example:
If the starting wavelength is 1000 nm, then the range is ~1662 nm, providing a 1000-2662 nm wavelength range and 5.34 nm resolution.



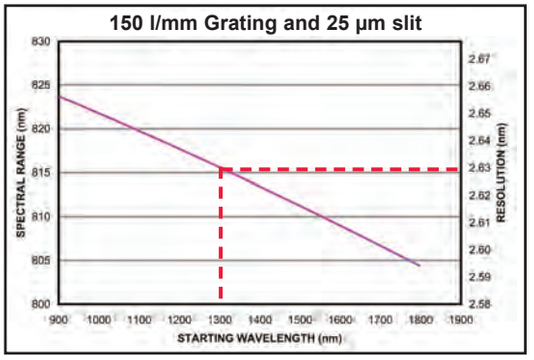
Example:
If the starting wavelength is 1700 nm, then the range is ~270 nm, providing a 1700-1970 nm wavelength range and 0.85 nm resolution.



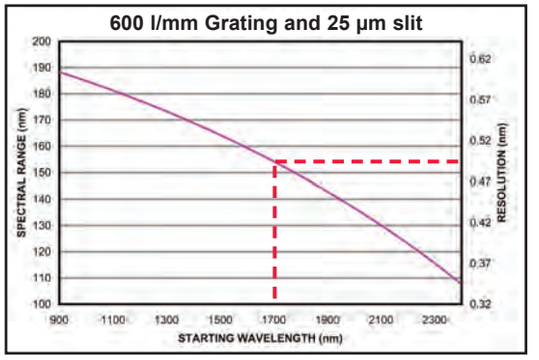
Example:
If the starting wavelength is 1300 nm, then the range is ~1236 nm, providing a 1300-2536 nm wavelength range and 3.98 nm resolution.



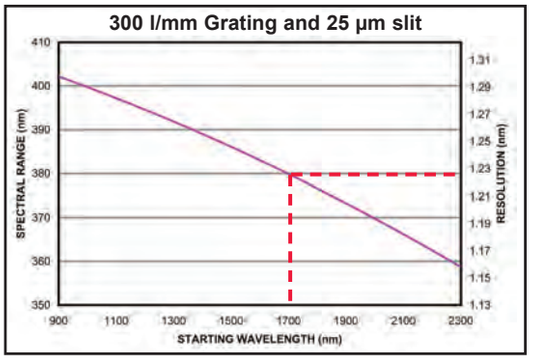
Example:
If the starting wavelength is 1900 nm, then the range is ~192 nm, providing a 1900-2092 nm wavelength range and 0.62 nm resolution.



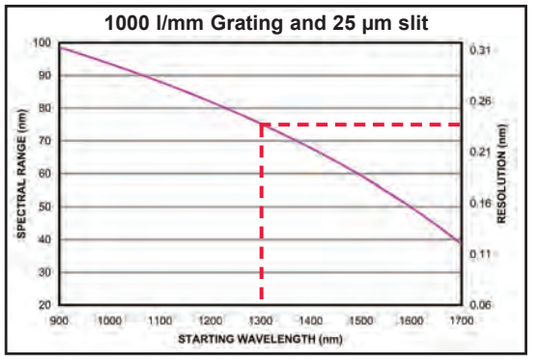
Example:
If the starting wavelength is 1300 nm, then the range is ~815 nm, providing a 1300-2115 nm wavelength range and 2.63 nm resolution.



Example:
If the starting wavelength is 1700 nm, then the range is ~154 nm, providing a 1700-1854 nm wavelength range and 0.49 nm resolution.



Example:
If the starting wavelength is 1700 nm, then the range is ~380 nm, providing a 1700-2080 nm wavelength range and 1.23 nm resolution.



Example:
If the starting wavelength is 1300 nm, then the range is ~74 nm, providing a 1300-1374 nm wavelength range and 0.24 nm resolution.

Application Notes

High-resolution NIR Analysis

New detector and optical bench options make it possible to configure near-infrared spectrometer setups for high-resolution applications such as laser and optical fiber characterization. Our NIRQuest Series spectrometers cover various segments of the 900-2500 nm region and serve a variety of application needs.

Introduction

Near-infrared spectroscopy is a common analytical technique for chemistry and process control, where typical applications include identification of species and determination of water and fat content. In applications like those, absorbance peaks are often broad and optical resolution requirements of lesser concern than performance parameters such as low noise and high sensitivity.

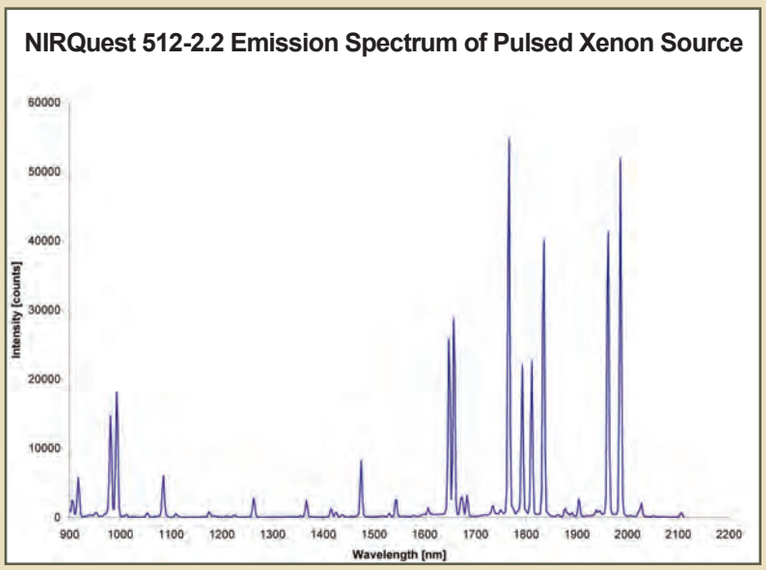
Yet there also are a number of NIR applications where optical resolution of <5.0 nm (FWHM) or better is critical. Characterization of laser lines – including, for example, solid state lasers at <1064 nm and at wavelengths from 1020-1050 nm, as well as semiconductor lasers with response in the 900-1800 nm range – often require even better optical resolution. Optical fiber characterization is another high-resolution NIR application.

Experimental Conditions

To test the optical resolution performance of our NIRQuest512-2.2 Spectrometer, which has a Hamamatsu G9206-512W InGaAs-array detector and is responsive from 900-2200 nm, we measured the spectrum of a xenon source used for spectrometer wavelength calibration. The low-pressure gas-discharge source has a number of closely aligned emission lines in the region from ~820-2000 nm, making it a good choice for our experiment.

The NIRQuest512-2.2 was configured with a 100 lines/mm grating set to 900-2050 nm, with a 25 µm slit and gold-coated collimating and focusing mirrors for enhanced reflectivity. This is the standard bench configuration for the NIRQuest product line, which includes models for 900-1700 nm, 900-2050 nm, 900-2200 nm and 900-2500 nm. Additional grating options and slit sizes are available for custom setups.

We used a 50 µm VIS-NIR optical fiber to collect signal from the xenon source. (For optimum results, we recommend the use of a 50 µm diameter or smaller optical fiber with all of our spectrometer wavelength calibration sources.) NIRQuest512-2.2 integration time was set to 350 ms and spectral averaging set to 5.



The closely aligned peaks of a xenon source used for spectrometer wavelength calibration can be distinguished with the high-resolution NIRQuest NIR spectrometer.

Results

The spectrum from the xenon calibration source illustrates that optical resolution of ~4.6 nm (FWHM) is possible with the NIRQuest512-2.2 in its standard configuration (above). What's more, even better optical resolution is possible in a NIRQuest512-2.2 configured with a grating that has a narrower spectral bandwidth. For example, a NIRQuest512-2.2 with a 600 l/mm grating set over a 100-nanometer bandwidth and configured with a 25 µm slit would yield optical resolution of <0.5 nm (FWHM). Resolution would improve even more with a 10 µm slit, but at the expense of throughput. For most laser applications, that's likely to be an acceptable trade-off.

Conclusions

New NIR detectors and optical bench options allow researchers to experience high optical resolution performance in the region from 900-2500 nm. This elevates the versatility of smaller footprint, more modular NIR spectrometers for applications previously thought to be out of reach.

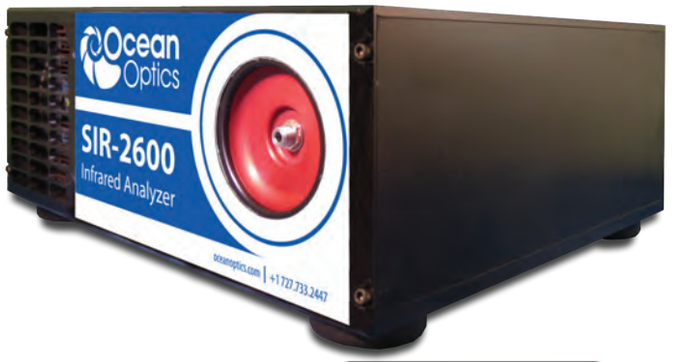
In addition, NIRQuest has external hardware triggering functions that allow users to capture data when an external event occurs, or to trigger an event after data acquisition. This can be especially useful for synchronizing a laser event to spectral acquisition and for capturing data from automated processes or from devices that flash synchronously.

SIR Series Spectrometers

Scanning Infrared Spectroscopy

SIR-Series

Our SIR-Series Spectrometers are fiber-based systems that use a unique design that allows rapid spectral scans over their entire spectral range.



NOW WITH TRIGGERING!

SIR Systems can also provide real-time data from several discrete wavelengths. The system's compact design allows you to integrate the SIR easily into OEM applications and online process environments. SIRs are especially useful for laser-based applications.

SIR spectrometers use single-point detectors and high angular resolution-tunable grating systems. The zero-backlash mechanical design provides superior accuracy and repeatability.

This combination, along with an innovative 24-bit A/D converter, provides high spectral resolution and very high signal-to-noise data.

Features

- USB 2.0 compliant
- Fast data transfer
- Rugged aluminum housing
- Extended IR range

Specifications

	SIR-2600	SIR-3400
Range:	0.9-2.6 µm	1-3.4 µm
Detector:	Extended range InGaAs with 2 stage cooler	InAs with 3 stage cooler
Diffraction grating:	600 lines	300 lines
Optical design:	Czerny-Turner F3	Czerny-Turner F3
Slits available:	10 µm, 50 µm, 100 µm, 200 µm, 500 µm	10 µm, 50 µm, 100 µm, 200 µm, 500 µm
Optical input:	SMA-905/906 with optional lensed input	SMA-905/906 with optional lensed input
Analog resolution:	24-bit, 16,777,216 counts	24-bit, 16,777,216 counts
Triggering options:	Internal and external synchronization	Internal and external synchronization

Technical Tip
IR Light Sources

Because SIR Spectrometers cover NIR and mid-IR wavelengths, you'll need to consider light sources with response in those regions. Our HL-2000 Tungsten Halogen Source has response to about 2500 nm, so you'll need something different for most SIR models. We recommend our Cool Red Light Source, a high-power silicon nitride emitter with output from ~600-6500 nm. Additional information on the Cool Red is available in the Light Sources section. Also, you'll need optical fibers and sampling accessories that will transmit at the longer mid-IR wavelengths. Consult an Applications Scientist for details.

SIR Bench Accessories	
SIR-DARK-SHUTTER	SIR Dark Reference Shutter
SIR-FS-LP2500	SIR High-Pass Filter Shutter - choice of two filters
SIR-SLIT-10	10 µm Slit for SIR Series
SIR-SLIT-50	50 µm Slit for SIR Series
SIR-SLIT-100	100 µm Slit for SIR Series
SIR-SLIT-200	200 µm Slit for SIR Series
SIR-SLIT-500	500 µm Slit for SIR Series

Spectrometer Accessories

Additional Options Add Value to Your Spectrometer

The SteadiQ provides an environmentally controlled atmosphere for your Ocean Optics spectrometer, helping to stabilize temperature effects and eliminate temperature drift in inclement conditions or extreme temperatures. The rugged, portable device ensures more accurate, reliable results in field applications including solar irradiance, volcanic observation, greenhouse monitoring and industrial environments such as cold food storage.

Available in both UV and VIS versions, the SteadiQ interfaces directly with our USB, HR, Maya, QE65000 and NIRQuest Series spectrometers. In extreme hot or cold conditions, SteadiQ operates independently from outside temperatures. It connects easily to the spectrometer with preconfigured plug-ins and communicates via the spectrometer's USB port.

Features

- Interfaces directly with your Ocean Optics spectrometer
- Operates independently from outside temperatures
- Perfect for extreme hot or cold conditions
- Available in UV-NIR (200-1100 nm) and VIS-NIR (400-2500 nm) versions
- Externally controlled dark measurement

Spectrometer Models Supported

- USB2000+
- USB4000
- HR2000+
- HR4000
- QE65000
- Maya2000 Pro
- NIRQuest512
- NIRQuest256-2.1
- NIRQuest256-2.5

Physical	
Dimensions:	465 mm x 300 mm x 414 mm
Weight (SteadiQ only):	12 kg
Spectroscopic	
Wavelength range SteadiQ-UV:	200-1100 nm (practical range depends on the spectrometer configuration)
Wavelength range SteadiQ-VIS:	400-2500 nm (depending on spectrometer configuration)
Temperature Stability	
Inside temperature:	23 °C ± 1 °C between +5 °C to +40 °C
	23 °C ± 2 °C between -20 °C and +60 °C
Electronics and Communication	
Operating voltage:	Including 110/220 VAC > 24 VDC; 7 A
Communication interface:	Via USB connection on the spectrometer

Application Notes

SteadiQ Helps in Solar Panel Testing

In environments where dramatic temperature swings can affect spectrometer performance, an environmentally controlled box such as SteadiQ can help keep your spectrometer operating reliably. Temperature effects such as baseline drift are lessened or eliminated.

In one recent case our customer, a well regarded international standards-setting organization, was faced with the challenge of making quality control measurements of photovoltaic panels being tested outdoors, where conditions ranged from -20 ºC to +50 ºC. The application required an unusual but effective custom configuration to cover UV-NIR wavelengths (200-1700 nm): a QE65000 Spectrometer in a SteadiQ-UV and a NIRQuest512 in a SteadiQ-VIS.

The SteadiQs were connected with a bifurcated mixed fiber (one leg UV-VIS and one VIS-NIR) with a customized glass-domed integrating sphere at the common end. The sphere itself was quite clever, with a dry air pump to prevent condensation inside the dome. The complete system was calibrated and used to perform absolute irradiance measurements under extreme conditions.

A tool like SteadiQ can be very effective for applications where environmental conditions are likely to create challenges. While some spectrometers have thermoelectric cooling functions, the benefit they provide may be limited to a certain level below the ambient temperature and, if large temperature changes are anticipated, may take a long time to reach the set point (stability).

RaySphere Spectrometer

The New RaySphere Solar Analysis System

RaySphere

Meet the new optical measurement system for absolute irradiance measurements of solar simulators and other radiant sources. The new RaySphere measures absolute irradiance over spectral ranges from the UV to the NIR (350 to 1700 nm).

RaySphere includes two thermoelectrically cooled detectors that perform repeatable and accurate spectral analysis of solar flashers from 350 to 1700 nm, and a second version contains a single cooled detector for measurement to 1100 nm.

This portable system is ideal for solar simulator manufacturers and research and development labs as a tool to validate the output of installed solar flashlamps.

The RaySphere system delivers the accuracy and resolution needed to measure and analyze the performance and stability of the flasher with ultralow jitter triggering electronics for timing the measurement to the flashes. Calibration is validated by an accredited certification lab to ensure accurate detection. This enables evaluation and qualification of the spectral distribution of solar flashers and simulators according to the IEC60904-9 (2007) standard.

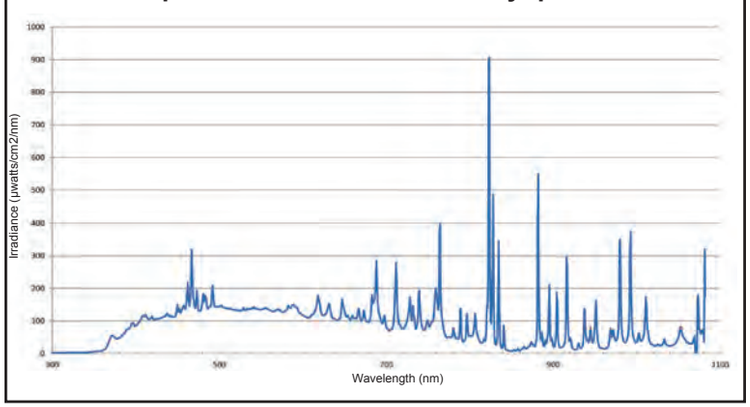
RaySphere includes high-speed electronics and an intuitive powerful software interface. Brief measurement times enable detection of a complete spectrum during a flash or even during a portion of the flash. The measurement can be triggered by a fast response photodiode that reacts on the increasing intensity of the flashlight with sub-microsecond response times.

Features

- Intuitive graphical interface
- Graphical and table display of classification results by wavelength bin
- Output of actual spectra in mW/cm^2/nm
- Output of actual measurement and triggering timing with +/- 41 µs resolution
- Printable classification report

	RaySphere	RaySphere 1700
Spectral range:	350-1100 nm	300-1700 nm
Spectral resolution:	1.9 nm (FWHM) for 300 - 1100 nm and 12.5 nm (FWHM) for 1100-1700 nm	1.9 nm (FWHM) for 300 - 1100 nm and 12.5 nm (FWHM) for 1100-1700 nm
Optical input:	50 mm integrating sphere	50 mm integrating sphere
Detector types:	TEC stabilized Hamamatsu CCD sensor	TEC stabilized Hamamatsu InGaAs sensor
Dynamic range:	25000:1 (Back-thinned Si); 15000:1 (InGaAs)	25000:1 (Back-thinned Si); 15000:1 (InGaAs)
Corrected linearity:	>99%	>99%
Minimum integration time:	8 ms	8 ms
Calibration:	Calibrated for irradiance measurements using national traceable standards (NIST, PTB, CNIM)	Calibrated for irradiance measurements using national traceable standards (NIST, PTB, CNIM)
Calibration accuracy:	Validated by accredited certification institute, typical values better than 2% accuracy in 400-1100 nm range	Validated by accredited certification institute, typical values better than 2% accuracy in 400-1100 nm range
Triggering options:	Built-in photo trigger, external trigger, manual trigger	Built-in photo trigger, external trigger, manual trigger
Operating environment:	Ambient temperatures 10-35 ºC	Ambient temperatures 10-35 ºC
Software:	Custom analysis software for Windows XP, Vista and 7 (32 and 64 bit)	Custom analysis software for Windows XP, Vista and 7 (32 and 64 bit)
Communications:	USB 2.0 high-speed	USB 2.0 high-speed

Spectrum Solar Simulator – RaySphere



Jaz Modular Spectroscopy

Meet Jaz® – the world's coolest modular measuring suite.

Like nothing you've ever seen before, Jaz is a community of stackable, modular and autonomous instruments that combine to create the ultimate in smart sensing for lab, field and anywhere your work takes you.

Jaz is unfettered by the limits of traditional optical sensing instrumentation. Its unique features and expandable platform make it uniquely suited for field applications, remote sensing, process flow, quality assurance and more.

Jaz brings you an unparalleled level of flexibility. With replaceable slits, a choice of various modules and more, Jaz is what you make it.

Smarter than the Average Spectrometer

Meet the Jaz Modular Sensing Suite

We designed Jaz® to incorporate a number of autonomous modules that share common networking and electronics. Because of its modular design, high-performance spectrometer, Ethernet connectivity, battery operation and PC-free performance, Jaz is nimble in a virtually endless array of applications.

And, since your Jaz can operate independently of your computer, there's no limit to where it can take you.

Customize your Jaz modules to include light sources, multiple channels and more. The choices are only limited by your imagination.

Make Jaz Your Own

Imagine having all the gear needed for optical sensing in one, convenient form. That's what we've done with Jaz while blending the functionality of all its parts into a single, seamless instrument.

A basic Jaz includes the spectrometer module and onboard DPU. All other modules are optional so you can mix and match for the configuration that best handles your application. Jaz has a home in the lab, the field, the process line and anywhere you need reliable, accurate optical sensing.

Operating software and development packages are available separately.

In the Lab

Jaz's Ethernet connectivity and battery operation make it a brilliant lab companion – perfect for remote sensing and sharing data across your network. Mix and match Jaz modules to optimize setups for absorbance, reflectance and emission applications.

In the Field

With Jaz's onboard display and microprocessor, you're free to roam! Ideal for field analysis, Jaz does its processing in a convenient, handheld modular stack – storing data to an SD card and processing spectra through its powerful onboard DPU.

Multichannel Sampling

With Jaz, you can add up to eight spectrometer modules for the most simple and convenient multichannel analysis ever. Jaz's spectrometers are incredibly robust for demanding environments and even temperatures of -10 °C to +55 °C.

Jaz Modules
Here's How it Breaks Down

Jaz Spectrometer Module
- Benchmarked to the performance standards of the USB2000+ Spectrometer
- 200-1100 nm Sony ILX511B CCD array detector
- Multiple gratings available

Jaz DPU Module
- 128 x 64 OLED display
- Choice of two screen/button orientations
- Embedded microprocessor for data processing
- Custom programmable scripting

Jaz Ethernet Module
- 100 Mbps, IEEE 802.3 compliant connectivity
- SD card slot
- Enables remote access via any computer on the same network
- Single-cable solution that provides PoE

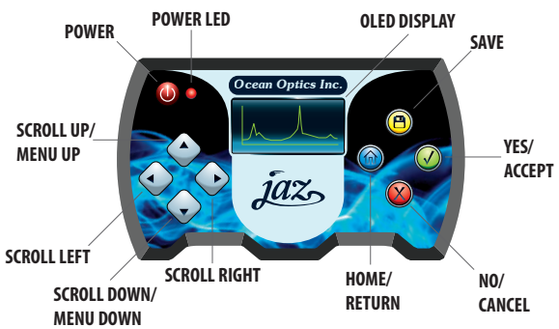
Jaz Industrial Module
- Communicates with RS-232 and RS-485
- Provides analog and digital inputs/outputs

Jaz Battery Module
- Lithium-Ion battery for up to 8 hours of use
- Rechargeable from Ethernet, USB or external power supply
- 2 SD card slots for memory and other functions

Jaz Light Source Modules
- VIS-NIR Tungsten Halogen
- UV-VIS Deuterium-Tungsten Halogen
- Pulsed Xenon
- LED options

Jaz Side Mount Module
- Lets you affix Jaz to tripod, breadboard and more
- Has ¼"-20 threaded mounts on three sides of the module

* Illustration only - your configuration may vary.



Have it your way

In Jaz, modularity takes on a new dimension – the "z" dimension. Our configuration stacks modules vertically, with each layer adding more functionality. The drawing above conveys all the options available for making spectral measurements. Toward the bottom of the stack you'll notice the NeoFox Sport. NeoFox is its own instrument – the detector part of our optical oxygen sensor systems – and wouldn't appear in a stack like this, but we included it here to demonstrate that the Jaz architecture can be engineered into other types of monolithic, portable sensing devices. For more on NeoFox, see page 164.

Under the Hood

Mix and match Jaz modules to create a smart, reliable system specifically for your own application.

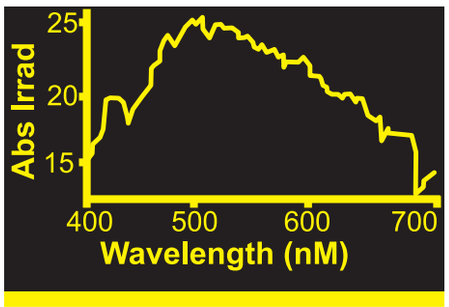
Not sure which configuration best suits your application? Contact an Ocean Optics Applications Scientist or visit us online at www.oceanoptics.com.

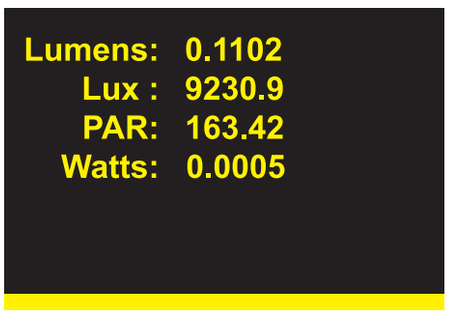
Spectrometer	
Physical:	109.2 mm x 63.5 mm x 57 mm LWH; 352 g (JAZ-COMBO only)
Detector:	Sony ILX511B linear silicon CCD array (200-1100 nm)
Wavelength range:	Grating dependent (extended-range grating available for 200-1025 nm coverage)
Optical resolution:	~0.3-10.0 nm FWHM
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	50 RMS counts
Dynamic range:	8.5 x 10^7 (system); 1300:1 for a single acquisition
Integration time:	870 µs to 65 seconds (20 s typical maximum)
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Sensitivity:	75 photons/count at 400 nm; 41 photons/count at 600 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture optical fiber
Electronics connector:	19-pin MHDMI connector; use ADP-MHDMI-RS232 adapter to interface to RS-232
Channels supported:	Up to 8 spectrometers
OEM integration supported:	Yes
Power options:	Wall transformer (+5VDC); Power over Ethernet (Class III PoE provides 12 Watts); USB; integrated battery module (JAZ-B); Solar charger and external batteries
Inputs/Outputs:	Yes, 4 onboard digital user-programmable GPIOs
Communications and Software	
Computer interface:	Onboard Blackfin® microprocessor
Operating systems:	Windows XP, Vista (32/64 bit), Windows 7 (32/64 bit); OS X and Linux when using the USB interface on PCs
Ethernet Module (optional)	IEEE 802.3-compliant 10/100; includes 2 GB SD card
Industrial Communications Module (optional):	Interfaces (RS-232, RS-485); 4 analog I/O, 8 digital I/O
Trigger modes:	Normal (free-running), Software, Synchronization and External Hardware
Strobe functions:	Continuous, Single, Lamp Enable
Operating software:	Basic Jaz software (included) operates from DPU interface; SpectraSuite (separate purchase) acquires data from USB or Ethernet connection; Overture software also available
Applications software:	Irradiance measurement and other options available; application is loaded to an SD card and operates from DPU interface
Development software:	Scripting program and API option for writing your own applications
Battery Options	
JAZ-B Module (optional integrated battery):	Rechargeable Lithium-Ion; lifetime depends on number of modules (~8 hours for JAZ-COMBO only)
Rechargeable battery accessories:	Lithium-Polymer solar battery, ~12 hours lifetime w/JAZ-COMBO; Lithium-Ion external battery, 21 hours lifetime w/JAZ-COMBO
SD card storage:	JAZ-B module includes (2) 2-GB SD cards
Light Source Options	
JAZ-UV-VIS (optional module):	Deuterium-Tungsten Halogen (210-1100 nm); lifetime is ~1,500 hours (recommended for UV absorbance)
JAZ-PX (optional module):	Pulsed Xenon (190-1100 nm); lifetime is 4 x 10^8 flashes to 50% of initial intensity
JAZ-VIS-NIR (optional module):	Tungsten Halogen (360-1100 nm); lifetime is 500-10,000 hours depending on power setting
LEDs (optional module w/replaceable bulbs):	365 nm, 405 nm, 470 nm, 590 nm, 640 nm and White wavelength options
Compliance	
CE mark:	Yes (all modules)
RoHs:	Yes (all modules)

Preconfigured Jaz Systems

Portable Setups for Field and Beyond

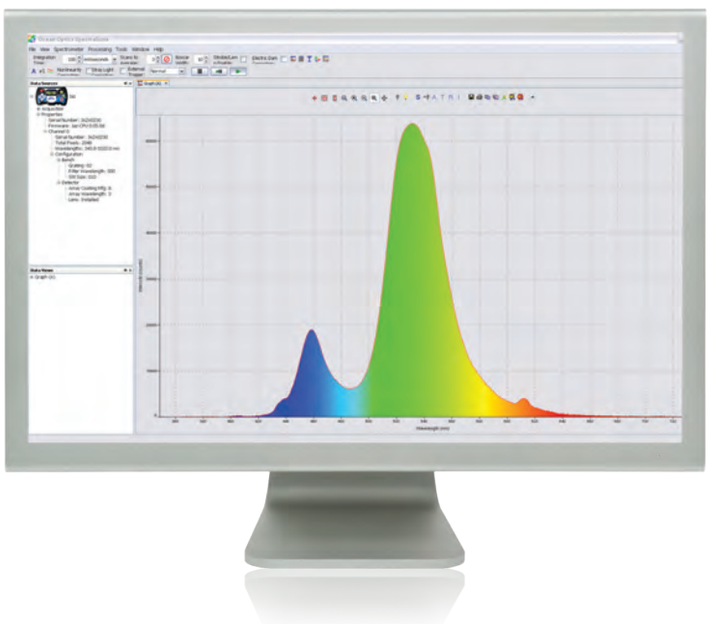
At the heart of the Jaz-ULM-200 is a spectroradiometrically calibrated spectrometer with built-in microprocessor and display. Also in the instrument stack is an Ethernet module for remote measurements, a battery module for handheld or field operation and a mounting fixture for orienting the system in different positions. Additional components include SD cards for data storage, a direct-attach cosine corrector for collecting radiation within a 180° Field of View, and both soft-sided and Pelican-brand carrying cases.





Special Software for Calculating Irradiance Values

With its Jaz-A-IRRAD irradiance software, the Jaz-ULM-200 allows users to capture, process and store full spectra without a PC. Jaz-A-IRRAD is stored on an SD card and loaded to the system. In just three simple clicks, the software collects spectral irradiance information from the selected light source. This data can be processed to give the intensity parameter of choice, including µW/cm^2/nm, lumens, lux, PAR or any other light intensity parameter. The system's three-button wizard simplifies operation so that even non-spectroscopy experts are able to perform fast and accurate measurements. More detailed analysis can be performed using SpectraSuite software on a PC.



Advantages of the Jaz-ULM-200

- All-in-one system with everything you need for irradiance measurements
- Simple calculation of key irradiance parameters in a single device
- Capture and storage of spectral characteristics right on the unit
- Lightweight, portable system convenient for lab, process or field
- Remote access and networking capability with built-in Ethernet

About the Applications

The Jaz-ULM-200 setup is an ideal solution for spectral irradiance applications such as process control in LED sorting systems, monitoring of LED output in greenhouse and other operations and quality control analysis of UV curing sources. The system is also conveniently appointed for solar irradiance measurements.

Preconfigured Jaz Systems

Portable Setups for Field and Beyond

Thanks to its small footprint, built-in computing power and onboard display, Jaz is an excellent option for field applications of all types. Build your own Jaz setup or select from one of these fully integrated, application-ready options:

Jaz-EL Spectrometers

We offer three versions of a lightweight, portable spectrometer system complete with integrated Lithium-Ion battery, SD card storage of your spectra and software for post-processing of data back in the lab. Each option is available with our standard line of Jaz accessories.

- JAZ-EL200 is for UV-VIS measurements from 200-850 nm
- JAZ-EL350 is for VIS-NIR measurements from 350-1000 nm
- For extended-range coverage, the JAZ-EL200-XR1 is responsive from 200-1025 nm

SpectroClip-JAZ-TR

This fully integrated system comprises the SpectroClip sampling optic, a two-channel Jaz spectrometer (each channel covers 350-1000 nm), a VIS-NIR light source, Ethernet and battery modules, three optical fibers, a reflection standard and a carrying case. Also included is a software script for optimizing the two-channel Jaz spectrometer setup. The SpectroClip-TR has two integrating spheres to collect light transmitted through the sample and reflected from the sample. SpectroClip-JAZ-TR is ideal for diffuse transmission/reflection measurements of flat samples such as leaves and other biological materials. There's additional information on SpectroClip on the next page.

Jaz Field System Specifications

Features	JAZ-EL200	JAZ-EL200-XR1	JAZ-EL350	SPECTROCLIP-JAZ-TR
Spectometer module:	Single channel	Single channel	Single channel	Two channel
Preconfigured spectral range:	200-850 nm	200-1025 nm	350-1000 nm	350-1000 nm (both channels)
Ethernet module:	Optional	Optional	Optional	Included
Battery module:	Included	Included	Included	Included
Light source module:	Optional; recommend UV-VIS source or Pulsed Xenon module	Optional; recommend UV-VIS source	Optional; recommend VIS-NIR source	Included (VIS-NIR source)
Optical fibers:	Optional	Optional	Optional	Included (3x 1-meter length QP-600-VIS-NIR patch cords)
Accessories:	Optional	Optional	Optional	Included (SpectroClip-TR) and reflection standard
Software:	Jaz Standard Operating Software and SpectraSuite Operating Software	Jaz Standard Operating Software and SpectraSuite Operating Software	Jaz Standard Operating Software and SpectraSuite Operating Software	Jaz Standard Operating Software and custom SpectroClip software script
Carrying case:	Optional; recommend Jaz-Pack-S shoulder holster	Optional; recommend Jaz-Pack-S shoulder holster	Optional; recommend Jaz-Pack-S shoulder holster	Included (Pelican case)
Spectrometer				
Entrance aperture:	25 µm width slit	25 µm width slit	25 µm width slit	25 µm width slit
Gratings:	Grating #1 (200-850 nm)	Grating #31 (200-1025 nm)	Grating #2 (350-1000 nm)	Grating #2 (350-1000 nm) (both channels)
Detector collection lens:	Yes, L2	Yes, L2	Yes, L2	Yes, L2
UV enhanced window:	Yes, installed with detector	Yes, installed with detector	No	No
Order sorting options:	200-850 nm filtering installed at the detector	200-850 nm filtering installed at the detector	350-1000 nm filtering installed at the detector	350-1000 nm filtering installed at the detector
Optical resolution:	~1.3 nm (FWHM)	1.7 nm (FWHM)	~1.3 nm (FWHM)	~1.3 nm (FWHM)

Jaz SpectroClip and Field Accessories

Convenient Tools for Jaz Field Analysis

We offer several handy tools for your Jaz field work, including extra battery power options, sampling devices and carrying cases. Thanks to its small size, built-in computing power and monolithic design, Jaz is ideal for applications requiring portability and reliability.

Jaz SpectroClip

SpectroClip is the perfect handheld device for measuring thin materials and other samples in the field and is especially suited to chlorophyll analysis in leaves and other plants. With SpectroClip and a suitable Jaz or other Ocean Optics spectrometer, you can easily measure diffuse flat objects in both transmission and reflection simultaneously. Samples with maximum thickness of 1 mm can be measured.

Two integrating spheres function as SpectroClip's collection probes and can be connected to any Ocean Optics spectrometer for acquiring data. The top integrating sphere also includes an input port for a fiber-coupled light source to illuminate your sample. SpectroClip's integrating spheres capture diffuse reflected or transmitted light more efficiently than lens-based collection optics. Indeed, SpectroClip is ideal for transmission measurements of very diffuse samples such as leaves, where scattering makes the use of collimating lenses impractical.

SpectroClip can be purchased as part of a fully integrated Jaz system (SpectroClip-Jaz-TR) or in one- or two-integrating sphere versions:

- **SpectroClip-R** has one integrating sphere to collect reflected light from your sample.
- **SpectroClip-TR** has two integrating spheres that collect both transmitted light through your sample and reflected light from the sample.

Jaz Field Accessories

Extra Power Options and Carrying Packs

Jaz Pack

Our Jaz Pack is the rough and tumble Jaz accessory made from lightweight, water-resistant fabric that stretches to hug your Jaz safely and securely. Its unique flip-top helps you see your OLED display in the brightest of sunshine and its adjustable fit easily accommodates your configuration.

Jaz Pack Shoulder Strap Item Code - JAZ-PACK-S

Jaz Pack Waist-belt Item Code - JAZ-PACK-W

Jaz Solar Pack

Harness the power of the sun when you're in the field! The Jaz Solar Pack is the handy accessory that powers and recharges your Jaz battery module via its mini-USB cable.

The Jaz Solar Pack recharges itself through the sun or electrical socket and can independently power your Jaz for up to 4 hours.

Item Code - JAZ-SOLAR

Jaz External Battery

The Jaz External Battery Pack is a multipurpose, rechargeable Lithium-Ion battery that connects directly to the 5V power connection on the DPU module of your Jaz. This powerful accessory is ideal for remote sensing and field applications and can triple the operating lifetime of your Jaz unit.

Item Code - JAZ-EXT-BP-50WH

About the Applications

With add-on software such as SpectraSuite-PAR, users can turn Jaz into a tool for calculating Photosynthetically Active Radiation (PAR). PAR is important in evaluating the effect of light on plant growth. It is defined as the integral over the range 400-700 nm of the absolute irradiance spectrum (the spectrum of light incident on the plants), which is then converted from µW/cm^2 to µmol/m^2/s.

The Jaz Spectrometer

Smart Design Makes all the Difference

We took a page from our USB2000+ miniature spectrometer and built the Jaz spectrometer module to be just as powerful and just as accurate. The system's 2048-pixel, Sony ILX511B linear silicon CCD array detector delivers outstanding performance and -- though Jaz's Czerny-Turner optical bench may be familiar -- the rest of the Jaz spectrometer module is anything but ordinary.

L2 Detector Collection Lens

Jaz's cylindrical lens ensures aberration-free performance and is fixed to the detector's window to focus light onto the shorter detector elements. It increases light-collection efficiency by 5x and reduces stray light.

Replaceable Slits

Unlike the fixed slits in most spectrometers, Jaz allows you to change your entrance aperture to suit your application. Most Jaz slits are 1 mm tall and come in various widths from 5 to 200 µm.

Slit	Description	Pixel Resolution
INTSMA-005	5 µm wide x 1 mm high	~3.0 pixels
INTSMA-010	10 µm wide x 1 mm high	~3.2 pixels
INTSMA-010S	10 µm wide x 50 µm high	~3.2 pixels
INTSMA-025	25 µm wide x 1 mm high	~4.2 pixels
INTSMA-050	50 µm wide x 1 mm high	~6.5 pixels
INTSMA-100	100 µm wide x 1 mm high	~12.0 pixels
INTSMA-200	200 µm wide x 1 mm high	~24.0 pixels

Grating and Wavelength Range

Choose from multiple gratings for each Jaz spectrometer channel. Your choice of grating groove density helps to determine optical resolution, spectral range and blaze wavelength.

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
1	UV	600	650 nm	300 nm	200-575 nm
2	UV-VIS	600	650 nm	400 nm	250-800 nm
3	VIS-Color	600	650 nm	500 nm	350-850 nm
4	NIR	600	625 nm	750 nm	530-1100 nm
5	UV-VIS	1200	300 nm	Holographic UV	200-400 nm
6	NIR	1200	200-270 nm	750 nm	500-1100 nm
7	UV-VIS	2400	100-140 nm	Holographic UV	200-500 nm
8	UV	3600	50-75 nm	Holographic UV	290-340 nm
9	VIS-NIR	1200	200-270 nm	Holographic VIS	400-800 nm
10	UV-VIS	1800	100-190 nm	Holographic UV	200-635 nm
11	UV-VIS	1800	120-160 nm	Holographic VIS	320-720 nm
12	UV-VIS	2400	50-120 nm	Holographic VIS	260-780 nm
14	NIR	600	625 nm	1000 nm	650-1100 nm
31	UV-NIR	500	200-1025 nm	250 nm	250-450 nm

Longpass Absorbing Filter

We offer longpass absorbing or blocking filters – each with a transmission band and a blocking band to restrict radiation to a certain wavelength region. This helps to eliminate second- and third-order effects. These filters are installed permanently between the slit and the clad mode aperture in the bulkhead of the SMA 905 connector.

Item	Description
OF1-WG305	Transmits light >305 nm
OF1-GG375	Transmits light >375 nm
OF1-GG475	Transmits light >475 nm
OF1-OG515	Transmits light >515 nm
OF1-OG550	Transmits light >550 nm
OF1-OG590	Transmits light >590 nm

Collimating and Focusing Mirrors

You can replace standard aluminum-coated reflective mirrors with our proprietary, UV-absorbing SAG+ Mirrors. These special mirrors increase reflectance in the VIS-NIR and increase the sensitivity of your Jaz. SAG+ Mirrors can be specified for fluorescence. These mirrors also absorb nearly all UV light to reduce the effects of excitation scattering in fluorescence measurements.

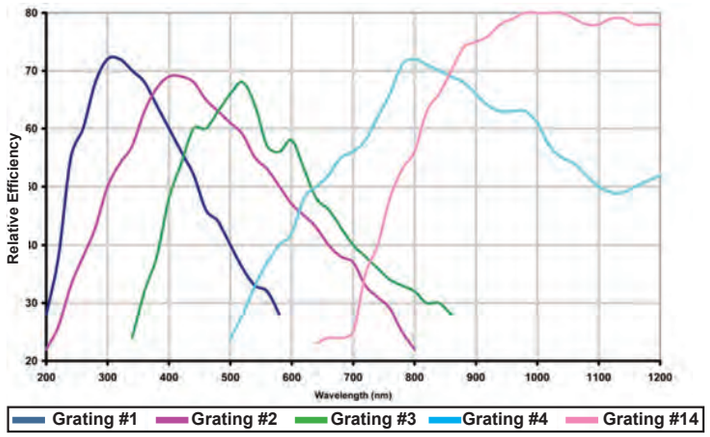
Detector Accessory Options

Detector	Description
DET2B-200-850	Sony ILX511B detector, installed, w/200-850 nm variable longpass filter and UV2 quartz window; best for UV-VIS systems configured with Grating #1 or #2
DET2B-350-1000	Sony ILX511B detector, installed, with 350-1000 nm variable longpass filter; best for VIS system configured with Grating #2 or #3
DET2B-UV	Sony ILX511B detector, installed, with UV2 quartz window; best for systems configured for <360 nm
DET2B-VIS	Sony ILX511B detector, installed, with VIS BK7 window; best for systems configured for >400 nm
DET2B-200-1100	Sony ILX511B detector, installed, w/200-850 nm variable longpass filter and UV2 quartz window; best for XR grating #31

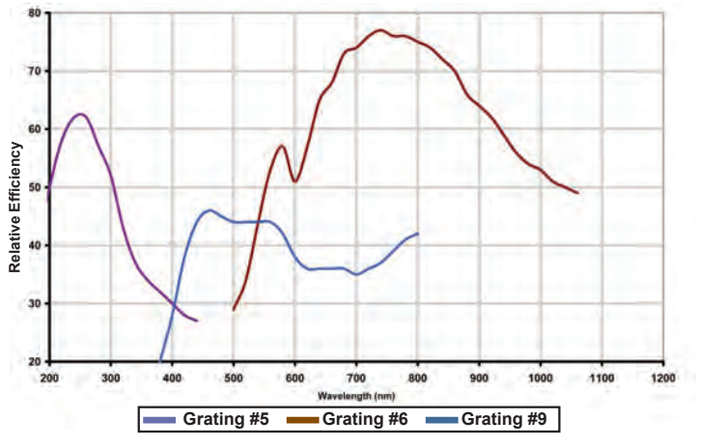
The Jaz Spectrometer
Optical Bench Options: Gratings

The graphs below are grating efficiency curves for gratings with groove densities of 500, 600, 1200, 1800 and 2400 mm^{-1}. Additional information is available at www.oceanoptics.com/Products/bench_grating_usb.asp.

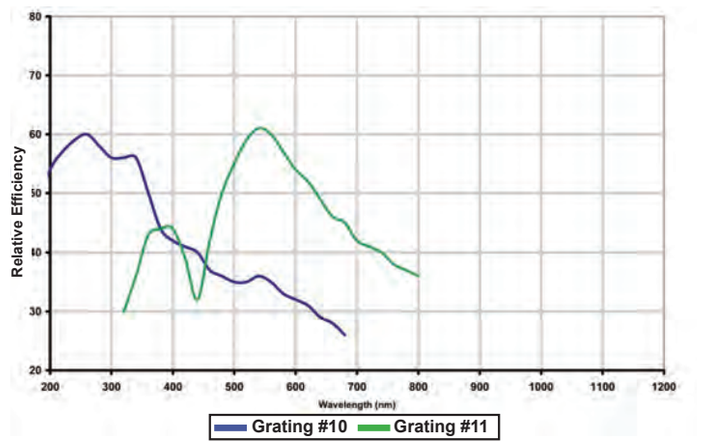
Groove Density of 600 mm^{-1}



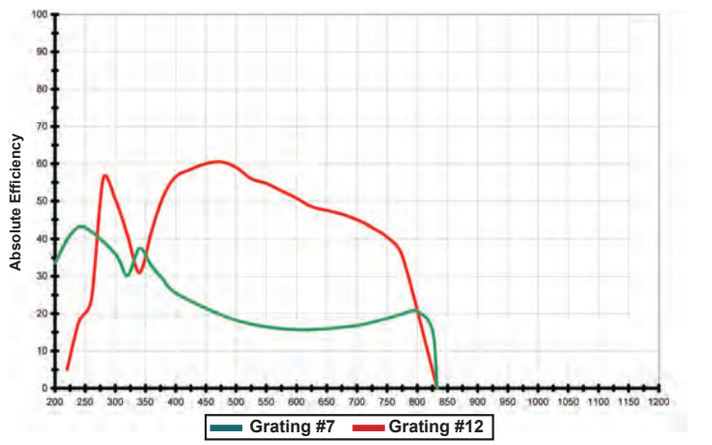
Groove Density of 1200 mm^{-1}



Groove Density of 1800 mm^{-1}



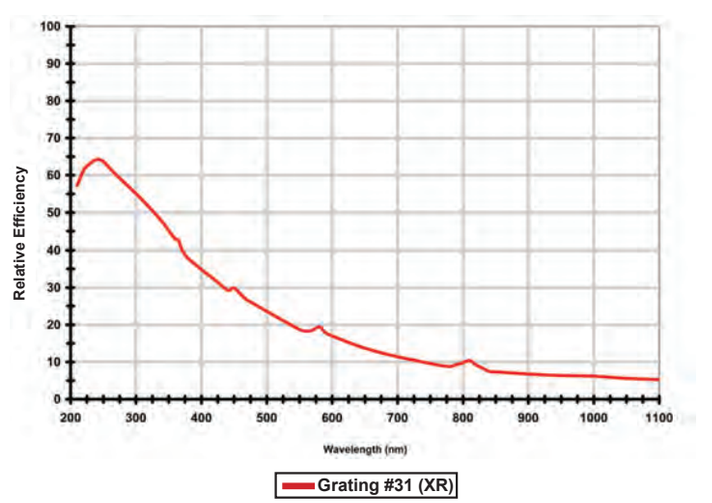
Groove Density of 2400 mm^{-1}



Grating Selection Tips:

- You must specify a grating for each Jaz spectrometer channel.
- These efficiency curves relate only to the grating. System response is affected by a number of variables, including detector response.
- Grating selection often involves trade-offs. For example, gratings with very high groove density (mm^{-1}) allow greater optical resolution but at the expense of a truncated spectral range. If the user is characterizing two or three closely aligned laser wavelengths, such a trade-off of resolution for range might be acceptable. For other applications, a wider range with good resolution would make better sense.
- The XR grating (#31) is a good option for broad spectral coverage (200-1025 nm) without sacrificing optical resolution (~2.0 nm FWHM with a 25 µm slit).

Groove Density of 500 mm^{-1}



Jaz DPU and Microprocessor Module

The Brains of the Operation

Jaz DPU Module

The Jaz DPU module combines a powerful onboard microprocessor and 128 x 64 OLED display that delivers clear and vivid viewing of spectra in real time. This clever user interface features an intuitive menu-driven system and touchpad and is available in two orientations to ensure convenient operation. Its embedded microprocessor provides quick and reliable data processing and easily orchestrates up to 8 spectrometer modules for multipoint sampling.

Item Codes: JAZ-DPU-GPIO-2, JAZ-DPU-GPIO-R

JAZ-DPU-GPIO-2, JAZ-DPU-GPIO-R	
Module dimensions:	109.2 mm x 63.2 mm x 14.2 mm
Module weight:	90.72 g
Display:	OLED
Area:	128 x 64 pixels; orientation can be rotated 180º
Display lifetime:	55,000 hours
Keypad:	Push-button function
	Available in 180º orientation versions (standard and reversed)
	Power and charging indicator
	Contact switches lifetime of 200,000 contacts (minimum)
	Anti-glare ethyl-butyl-acrylate overlay material
	RoHS compliant
	Temperature range: -40 ºC - +70 ºC (storage) and 0 ºC - +50 ºC (operating)
Microprocessor	Blackfin® embedded microprocessor with data processing and storage capability
SDRAM:	64 MB
Power consumption:	~1-2 Watts

Jaz Ethernet Module

Connectivity and More for Your Jaz

The Jaz Ethernet Module turns your Jaz spectrometer system into a powerful network appliance. Use it to power your Jaz over Ethernet connectivity, access Jaz remotely or share data with others on your network. The 100 Mb/S Ethernet connection is a single-cable solution that powers the system and enables remote access by any node on your network or via the Internet. The Jaz Ethernet Module also includes a 2 GB SD card slot for instant data storage.

A Jaz stack with an Ethernet Module has both USB and Ethernet port connectors, to connect the spectrometer to a computer via a USB port or to a network via a connection from the Ethernet port. This port connects to a Power over Ethernet (PoE) bridge or a switch to the network (e.g., a network hub). Your Jaz stack receives power from either connection, and both connections enable Jaz to be recognized by our software. Spectral acquisition time in a Jaz system with an Ethernet Module – 100 scans per second – is identical to the acquisition time using USB.

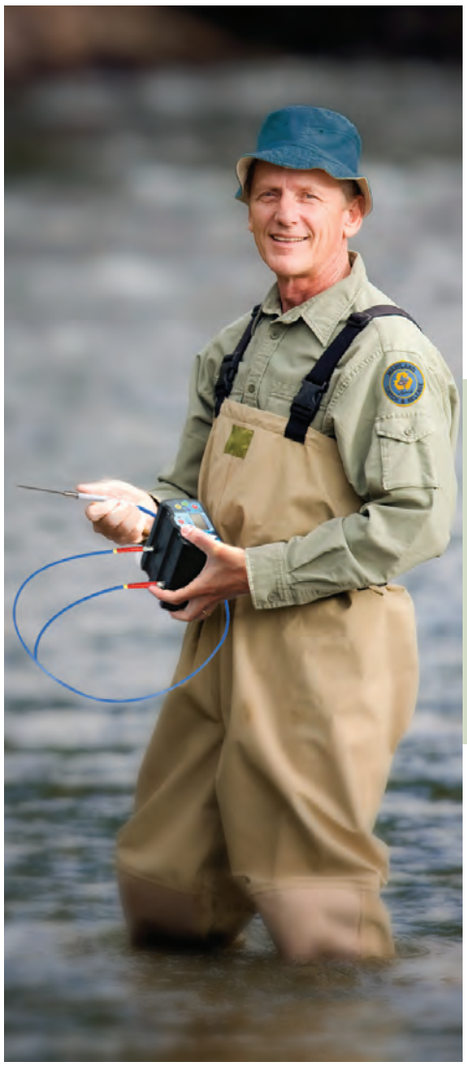
The Ethernet Module is a Class III PoE device that provides 12 watts of power and can recharge a JAZ-B Battery Module in approximately four hours (longer if the Jaz is in operation). The latter is particularly handy for a Jaz setup that's used as a handheld device in the lab or in the field.

Item Code: JAZ-E

JAZ-E Ethernet Module	
Dimensions:	109.2 mm x 63.2 mm x 20.8 mm
Weight:	90.72 g
Data transfer rate:	100 Mbps
Power over Ethernet (PoE) standard:	IEEE 802.3-compliant 10/100
Data storage:	2 GB SD card (stores up to 100,000 spectra)
Ethernet cable:	14 ft. length, ferrite bead included for electronic noise suppression
PoE adapter (not included):	Recommend D-Link DWL-P50 or equivalent

Jaz Battery and Memory Modules

Because You Need to Stay Mobile



JAZ-B Battery Module

The Jaz Battery and External Memory Module is built on a rechargeable Lithium-Ion battery that provides up to 8 hours battery life. It allows autonomous data collection with power-conserving sleep mode for long-term measurements. The Jaz Battery Module also includes two SD card slots for memory, applications and data storage. High-capacity SD cards (>2 GB) are not compatible with the battery module.

Item Code: JAZ-B

Jaz Solar Battery Supply

The Jaz Solar Pack is a handy accessory that powers and recharges your Jaz unit via its mini-USB cable. Jaz Solar Pack recharges itself through sun or socket and can independently power your Jaz for up to four hours.

Item Code: JAZ-SOLAR

JAZ-EXT-BP-50WH External Battery

This external battery pack connects to the 5V power connection of the Jaz DPU module and extends the charge of your Jaz by up to 3x. The JAZ-EXT-BP-50WH is a multipurpose, rechargeable Li-Ion battery rated at 50 watt-hours. It comes with an AC wall charger, a car charger and its own holster and belt clip.

Item Code: JAZ-EXT-BP-50WH

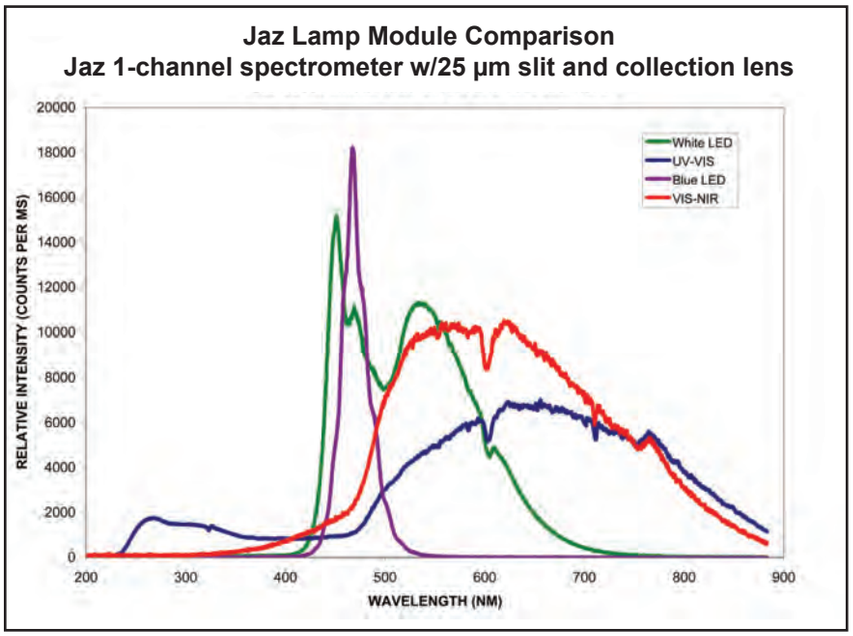
Jaz Battery Options	JAZ-B Battery Module	JAZ-SOLAR Solar Charger	JAZ-EXT-BP-50WH External Battery
Battery type:	Lithium-Ion	Lithium Polymer	Lithium-Ion
Rechargeable:	Yes (via wall power or PoE)	Yes (service lifetime minimum 500 full charges)	Yes (includes Quick AC charger and car kit charger)
Charging time:	When Jaz is off, 8 hours via USB and 4 hours via wall power and PoE	4 hours via USB; 2-3 hours via PoE; 2-3 hours via 12 VDC wall power	3 hours (from fully discharged) via PoE; 3 hours via 12 VDC wall power
Charging current:	~4A @ 5V maximum w/wall plug adapter or 0.5A @ 5V through the USB port	360 mA	2000 mA
Capacity:	14.8 Watt hours	~7-10 Watt hours	50 Watt hours
Lifetime when combined w/ JAZ-COMBO (DPU + single-channel spectrometer):	~8-10 hours	3-5 hours standard; ~12 hours w/ JAZ-B battery module	21 hours standard; 28 hours w/ JAZ-B battery module
Lifetime when combined w/ JAZ-COMBO and Light Source:	2 hours	~3 hours w/JAZ-B battery module	8.5 hours standard; 10.5 hours w/ JAZ-B battery module
Data storage via (2) SD card slots:	Yes	No	No
SD cards included:	Yes (2)	No	No

Jaz Light Sources

An Illuminating Difference

Whether your work takes you to the lab, the field or the process line, you can make the most of your Jaz modular sensing suite with the addition of an optional light source, optimized for your application needs.

These compact, low-cost, modular light sources fit directly into the Jaz stack of appliances and feature outstanding bulb life as well as lower power consumption than comparable sources.



For spectral output of Jaz PX, see page 73.

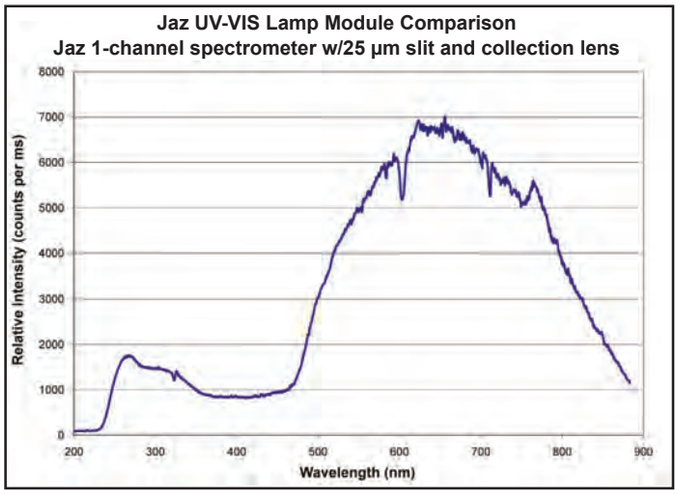
	Jaz-PX	Jaz-VIS-NIR	Jaz-UV-VIS	Jaz-LED
Dimensions:	109.2 mm x 63.5 mm x 31.8 mm	109.2 mm x 63.5 mm x 29.5 mm	109.2 mm x 63.5 mm x 26.7 mm	109.2 mm x 63.5 mm x 28.58 mm
Type:	Pulsed Xenon	Tungsten Halogen	Deuterium Tungsten Halogen	LED
Wavelength range:	190-1100 nm	360-1100 nm	210-400 nm (deuterium); 400-1100 nm (tungsten)	365 nm - White
Best for:	Absorbance, transmission, fluorescence and UV-VIS biore-flectance	Absorbance, transmission and reflection	Absorbance and transmission only	Excitation source for fluores-cence, luminescence
Stability:	<1% flash to flash	Decay rate is ~0.01%/hour @ power setting of 1024 and 0.1%/hour at setting of 4095	After 30-minute warm-up, 0.3% peak to peak over 4 hours	+/-0.5% (typical short-term) after warm-up
Time to stable output:	10 flashes	~20 minutes	10 minutes (deuterium); 1 minute (tungsten halogen)	~30 minutes (~5 minutes for <3% drift for 470 nm LED)
Lamp life:	4 x 10^8 flashes to 50% of initial intensity	>10,000 hours @ 1024 power setting; 500 hours @ 4095 power setting	~1500 hours (deuterium); 1500 hours (tungsten halogen)	>25,000 hours to 70% of initial intensity
Operating life in typical field setup:	~3 hours w/JAZ-COMBO and battery module	~6 hours w/JAZ-COMBO and battery module	~2 hours w/JAZ-COMBO and battery module	~25,000 hours to 70% of initial intensity (battery has negligible effect on LED life)
Power consumption:	4.5W	1W	7W	<0.2W
Operating tempera-ture:	0 ºC-+55 ºC	0 ºC-+55 ºC	0 ºC-+55 ºC	-10 ºC-+55 ºC
Storage temperature:	-20 ºC-+60 ºC	-20 ºC-+60 ºC	-20 ºC-+60 ºC	-20 ºC-+60 ºC
Connector:	SMA 905	SMA 905	SMA 905 (recommended for use with 200 µm-600 µm fibers)	SMA 905
Certification:	CE Mark/RoHS	CE Mark/RoHS	CE Mark/RoHS	CE Mark/RoHS

Jaz UV-VIS Light Source

Useful for UV Absorbance

The JAZ-UV-VIS is a unique deuterium-tungsten halogen source with combined output from 210-1100 nm. The JAZ-UV-VIS is a continuous light source that is most effective for absorbance measurements in the deep UV and is not recommended for reflection measurements. For reflection and fluorescence measurements, the Jaz-PX (see below) is a far superior option.

Item code: JAZ-UV-VIS



Jaz-UV-VIS	
Dimensions:	109.2 mm x 63.5 mm x 26.7 mm
Type:	Deuterium Tungsten Halogen
Wavelength range:	210-400 nm (deuterium); 400-1100 nm (tungsten halogen)
Best for:	Absorbance and transmission
Stability:	After 30-minute warm-up, 0.3% peak to peak over 4 hours
Time to stable output:	10 minutes (deuterium); 1 minute (tungsten halogen)
Lamp life:	~1500 hours (deuterium); 1500 hours (tungsten halogen)
Operating life in typical field setup:	~2 hours w/JAZ-COMBO and battery module
Power consumption:	7W
Operating temperature:	0 ºC - +55 ºC
Storage temperature:	-20 ºC - +60 ºC
Connector:	SMA 905 (recommended for use with 200 µm-600 µm fibers)
Certification:	CE Mark/RoHs

Pulsed Xenon Light Source for Jaz

High Intensity, Low Power, Versatility

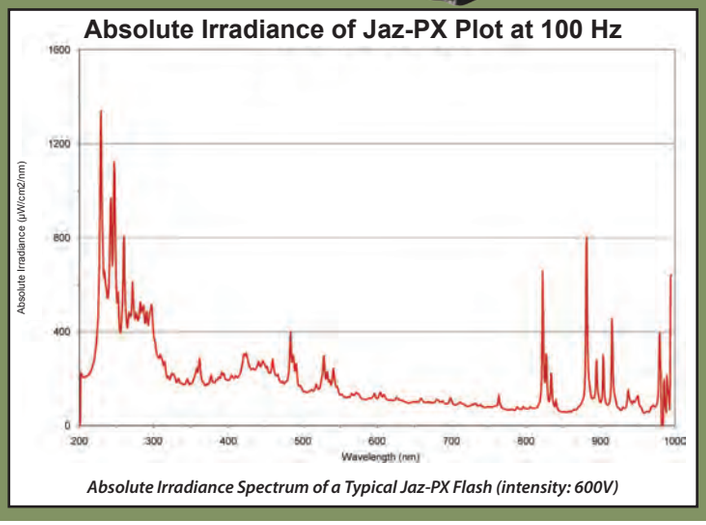
The Jaz-PX is a pulsed xenon light source for your Jaz modular sensing system. It features a pulsed, short-arc xenon lamp that is especially useful for UV-VIS applications such as absorbance, bioreflectance, fluorescence and phosphorescence. The Jaz-PX's lamp has a specified pulse frequency of 200 Hz (maximum 500 Hz) and spectral response from 190-1100 nm.

Jaz-PX operates in both free-running and triggered modes, which allows its pulses to be coordinated with other devices in your Jaz stack.

The Jaz-PX has an SMA 905 connector that couples to other Ocean Optics accessories, including optical fibers, cuvette holders, probes and other sampling optics.

Because of its pulsed signal, the Jaz-PX is less likely to cause solarization in optical fiber assemblies that can occur when fibers are illuminated with signals <360 nm.

Item Code: JAZ-PX



Absolute Irradiance Spectrum of a Typical Jaz-PX Flash (intensity: 600V)

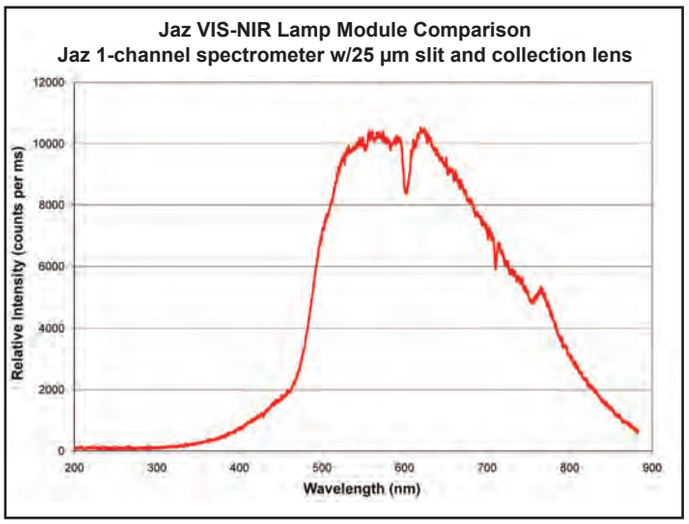
Jaz VIS-NIR Light Source

Strong Output from 360-1100 nm

The JAZ-VIS-NIR Light Source is a Tungsten Halogen source that provides reliable coverage of 360-1100 nm and requires little power to operate. This small, lightweight source is perfect for absorbance, transmission and reflection. Additionally, it provides up to 10,000 hours of lamp life.

Item code: JAZ-VIS-NIR

Jaz-VIS-NIR	
Dimensions:	109.2 mm x 63.5 mm x 29.5 mm
Type:	Tungsten Halogen
Wavelength range:	360-1100 nm
Best for:	Absorbance, transmission and reflection
Stability:	Decay rate is ~0.01%/hour @ power setting of 1024 and 0.1%/hour at setting of 4095
Time to stable output:	~20 minutes
Lamp life:	>10,000 hours @ 1024 power setting; 500 hours @ 4095 power setting
Operating life in typical field setup:	~6 hours w/JAZ-COMBO and battery module
Power consumption:	1W
Operating temperature:	0 ºC-+55 ºC
Storage temperature:	-20 ºC-+60 ºC
Connector:	SMA 905
Certification:	CE Mark/RoHS



Questions? If you're not sure which Jaz Light Source is the best for your application, contact an Ocean Optics Applications Scientist at info@oceanoptics.com. We'll help you find the source that's the perfect match.

Jaz LED Modules

Convenient and Simple

LED Modules	
Wavelength range options:	365 nm, 405 nm, 470 nm, 590 nm, 640 nm and White
Power consumption:	<0.2W
Power requirements:	5V @ 50 mA (maximum)
Stability:	+/-0.5% (typical short-term) after warm-up
Drift:	Typically <0.1% drift/hour after 30-minute warm-up (at constant temperature)
Time to stable output:	~30 minutes (~5 minutes for <3% drift for 470 nm LED)
Bulb life:	>25,000 hours to 70% of initial intensity
Bulb aperture (typical):	5 mm diameter with 12-20º viewing angle
Replaceable bulb assembly*:	Yes
Operating temperature:	-10 ºC-+55 ºC
Humidity:	0-95% non-condensing
Connector:	SMA 905
Certification:	CE Mark/RoHS

* Available by request

The Jaz LED modules allow you to switch out LED bulbs more quickly and easily. Instead of having to replace the entire module, simply replace the LED assembly – a small fixture with only three screws to manage. Your Applications Scientist can provide all the details.

Item Codes:

JAZ-INTLED-365	Interchangeable 365 nm LED module
JAZ-INTLED-405	Interchangeable 405 nm LED module
JAZ-INTLED-450	Interchangeable 470 nm LED module
JAZ-INTLED-590	Interchangeable 590 nm LED module
JAZ-INTLED-640	Interchangeable 640 nm LED module
JAZ-INTLED-WHITE	Interchangeable White LED module

Jaz Industrial Communications Module

Multifunctional Tool for Process and Lab

- Experiments connect directly to Indy module for analog and digital I/O (8 I/Os available)
- Enables Jaz to communicate with other devices via RS-232/RS-485 interfaces
- Provides measurement and control for portable, laboratory and "light-industrial" setups
- Installs in Jaz stack and can be mounted to DIN rail or a wall (with special accessories) or anywhere with ¼"-20 mount

The Jaz Indy is a multifunction module that allows the Jaz system to interface to industrial applications – in particular, RS-232 and RS-485 – and provides both analog and digital inputs/outputs. When combined with triggering capabilities and multichannel capacity, the Indy module makes Jaz an attractive optical-sensing option for multipoint sampling, reference monitoring and other applications in process and lab environments.

Item Code: JAZ-INDY

RS-232 connectivity:	300-115K Baud, +/-5V
RS-485 connectivity:	300-8M Baud
Analog inputs:	4 single-ended or 2 differential pairs
	+/-5V (single-ended) or 10V (differential pairs)
Analog outputs:	4
	+/- 5V (software configurable to 0-5V)
	16-bit (0.15mV/bit)
Digital I/O:	8
	Source 5V, TTL compatible
Current loop:	1 x 4-20 mA current loop, 2-wire Transmit
	1 x 4-20 mA current loop, 2-wire Receive
4-20 mA transmitter:	14 bit A/D resolution; can accept supply voltage of 8.5-35 V
4-20 mA receiver:	14 bit A/D resolution; over-current protected receiver capable of supplying 10-20 V
Enclosure:	Integrated into Jaz stack; optional DIN 3 rail mount available
Environment (use):	-10°C - +55°C, 0-95% humidity (non-condensing)
Environment (storage):	-40°C - +55°C, 0-95% humidity (non-condensing)
Certification:	CE Mark
Certification:	RoHS
Certification:	FCC Part 15, Class A

Technical Tip: Sample JAZ-INDY Application

In a demo setup we configured for a recent trade show, the JAZ-INDY used analog voltage output to control a voltage-controllable LLS Series LED Light Source (see Light Sources section). Using optical fibers, the LED transmitted light through a filter holder and back to the Jaz spectrometer. The unit's control logic was designed to increase the voltage to the LED if the peak intensity of the spectrum, as measured by the Jaz, fell below a certain level and to decrease the voltage if the intensity went above that level. This way the amount of light getting to the spectrometer remained constant. There were no changes to integration time, so auto-integration was not employed.

In the live demonstration, we put a neutral density filter in the filter holder, to simulate a sort of process change, and the light source would greatly increase in brightness to compensate.

Similar principles could apply to a process flow scenario. For example, consider a process in which a thin film is applied to glass. The spectrometer could observe the transmission of light through the glass and make small adjustments to the sputter electrode, via the Jaz Indy, to keep the optical density always in check.

We used the Jaz messaging system for the demonstration application, but our OmniDriver development platform also supports the Indy. In fact, the Jaz Indy has been added to the wrapper class as a feature. Contact an Applications Scientist for additional information.

Jaz Software Options

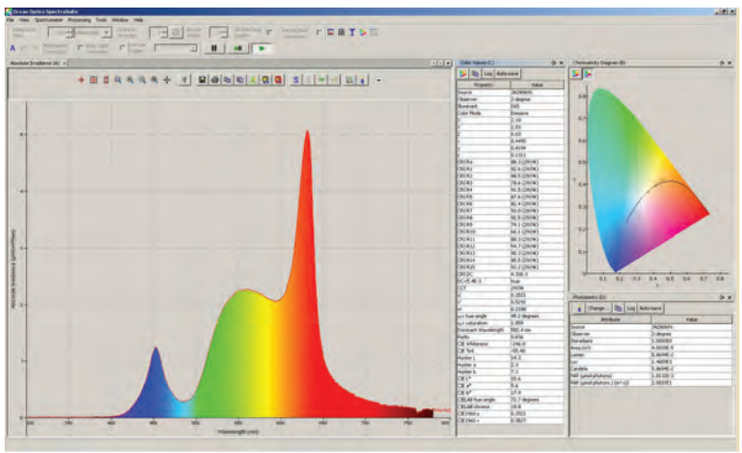
Get the Most out of Your Data

Although Jaz comes with its own basic software, additional processing power and functionality are available via several options:

- **SpectraSuite Spectrometer Software.** Our standard spectrometer operating software is ideal for post-acquisition processing of spectral data. For example, the user can capture data in Jaz software and save it to an SD card in the field, and then transfer the data to a PC in the lab for post-processing with SpectraSuite. This allows for more detailed analysis of your results. Included with every Jaz is Overture, a software program that provides basic spectroscopy functions such as absorbance, transmission and emission.

- **Applications Software.** Jaz applications are pre-loaded on an SD card and let you perform application-specific calculations on the Jaz display itself. The JAZ-A-IRRAD irradiance measurement application is a good example. Its post-processing mode can be manipulated to display parameters such as lumens, lux, PAR (Photosynthetically Active Radiation) and watts.

- **Development Software.** Much like our other spectrometers, Jaz can be used with software that you develop. Development tools range from a relatively simple but useful scripting tool conceived for non-programmers to a powerful application programming interface (API)



recommended only for experienced C developers with a background in spectroscopy or who attend a Jaz API training session.

- **Jaz Scripting Language.** The Jaz Scriptor provides both programmers and non-programmers with an accessible, intuitive interface to Jaz spectroscopy functions. A script is simply a text file containing a sequence of operations to be performed. Some scripts relate to controlling data acquisition from Jaz, while others provide for analysis, transformation and presentation of spectroscopy data. With the Scriptor, you can automate basic tasks such as obtaining a spectrum, controlling a light source and spectrometer in the Jaz stack, manipulating spectral data and saving spectral data to a file for further analysis.

- **Jaz API.** The API is a sophisticated developer's tool conceived for use by experienced C programmers seeking to develop customized Jaz software for OEM and other applications. The API makes available a large number of commands for each device in the stack and enables interaction among those devices. A sample application is included. Consultation with an Applications Scientist and specialized training are required.

Type	Description	How Delivered?	Operation
Standard operating:	Handles basic spectroscopic functions	Preloaded to your Jaz unit	From DPU interface onboard the Jaz
SpectraSuite and Overture:	Spectrometer operating software for data processing and analysis; add-on products	Deployed separately on CD for installation on the PC you connect your Jaz unit to	Acquires data from the Jaz via the USB connection on the DPU or an optional Ethernet module
Application programs:	Application-specific programs for irradiance (JAZ-A-IRRAD) and other measurements	Application is loaded to an SD card	From DPU interface onboard the Jaz; requires an SD card slot (Ethernet or Battery module)
Scripting program:	Jaz-specific tool (JAZ-SPL) for writing your own applications	Deployed separately on CD for installation on your PC for writing and testing scripts. Scripts are then transferred to SD card	From a PC remotely controlling an Ethernet-equipped Jaz or from the DPU interface onboard the Jaz
API:	Jaz-specific Advanced Programming Interface (JAZ-API) for writing your own applications	Deployed separately on CD for installation on Linux system for writing and testing scripts. Scripts are then transferred to SD card	From DPU interface onboard the Jaz; requires an SD card slot (Ethernet or Battery module)

Jaz Electronic Accessories
Cables, Power Supplies and More

We offer a variety of interace cables, adapters and power supplies for use with your Jaz system. These accessories make it easier to operate Jaz through serial port, RS-232 and more.

Item Code: ADP-MHDMI-RS232

Item	Description
JAZ-CBL-DB15	Jaz DB15 Accessory Cable This 1-foot-length MHDMI cable runs from the 19-pin connector on the JAZ-DPU to any external device with a DB-15 electrical connector. With the JAZ-CBL-DB15 in place, you can integrate Jaz functions with operation of external devices such as light sources.
ADP-MHDMI-RS232	Adapts Jaz module to RS-232 communications protocol. Includes JAZ-CBL-DB15 and DB15M-TO-DB9F serial port cable.
INTERNET-CBL	14' Ethernet cable with a ferrite bead to suppress noise
JAZ-PS-ETHERNET	Jaz Power Over Ethernet Adapter 802.3af compliant power over Ethernet with adjustable output power
USB-CBL-PS-JAZ-STACK	5V Universal 30 Watt Power Supply (International adapters are included)

Jaz Fixtures for Industrial Applications and More
Convenient Tools for Mounting Your Jaz

Jaz Side Mount

The aptly named Jaz Side Mount is precisely that – an integrated Jaz module with ¼"-20 threaded mounts on three sides of the module. This lets you attach your Jaz stack to a breadboard, tripod or other fixture. Also, you can use the in-the-stack Jaz Side Mount with the external mounting accessories to expand your range of positioning options.

Item Code: JAZ-MOUNT

Jaz Rail Mount

Conceived for use with standardized 35 mm DIN rails, this clever adapter for your Jaz securely holds up to three Jaz modules (excluding the DPU and end modules) for incredible convenience.

JAZ-MNT-DIN3

Wall Mount

With this easy-to-install bracket, mount your Jaz setup to any solid or hollow wall.

Item Code: JAZ-MNT-WALL

Application Notes

Using the Jaz-PX for Bioreflectivity and Color

Analysis of UV-VIS reflectance and reflected color of biological subjects – birds, insects, fruits, vegetables and more – is conveniently achieved with a Jaz® modular sensing system. Considerations such as instrument footprint, light source requirements and power needs are resolved using a Jaz configured for field portability.

Introduction

Various biological samples exhibit UV-VIS reflectivity and color characteristics of interest to researchers. Applications are diverse: For example, among some species of birds, insects and reptiles, UV reflectance and color play a role in mating behavior, recognizing species and assessing predator risk. Color as an indicator of fruit and vegetable ripening is significant; also, chlorophyll distribution in crops, measured using reflectance, can tell growers something about optimum fertilizer amounts. Many more similar applications, both in the field and in the lab, can be classified as bioreflectance applications.

Jaz provides a particularly compelling option for bioreflectance applications in the field, where portability, flexibility and ease of use are critical. Jaz is a modular spectrometer-based system that integrates into a single stack those components that otherwise would have to be handled separately: the spectrometer, microprocessor with low-power display (in place of a PC), light source, battery pack and even Ethernet capability for remote measurements. Reflection probes and other sampling optics connect easily to the Jaz, keeping the overall system footprint compact and manageable.

Experimental Conditions

A typical Jaz configuration for portable UV-VIS reflectance comprises the Jaz spectrometer set from 200-850 nm, with a 25 µm slit and L2 detector collection lens. Also installed in the Jaz stack is the Jaz-B battery module, which has two slots for SD card data storage, and the Jaz-PX, a high-intensity pulsed xenon light source with up to four hours battery life on a single charge. SpectraSuite spectrometer operating software is also recommended. Depending on experiment considerations, other options to consider are the Jaz-E Ethernet module and the SpectraSuite-PAR add-on software application, which is used to calculate Photosynthetically Active Radiation (PAR) values of horticultural samples.

Most bioreflectance applications involve diffuse reflection of solid surfaces. Our fiber optic reflection/backscattering probes can measure diffuse or specular reflectance from a surface; a good choice for most UV-VIS bioreflectance applications is our QR600-7-SR-125F, a premium-grade probe with 600 µm core diameter in a six-around-one fiber configuration. Also, the probe is solarization-resistant and has a 1/8" ferrule.

Results

Bioreflectance setups using miniature portable spectroscopy have become so simple to perform that even high school science students have little problem with such setups. In one example, a student measured the reflection at 90° of philodendron plant leaves, theorizing that reflectance values could be correlated to fertilizer levels. The results suggested that plant reflectance at wavelengths >700 nm was insensitive to the stress of over-fertilization (at 4x the recommended amount of fertilizer), while the peak within the 530-630 nm range was noticeably sensitive (i.e., had greater reflectivity) to stress. The increased reflectivity related to a decrease in chlorophyll and to the effects of osmosis. Water collected between the leaf cell membrane and the cell wall and exposed more of the leaf surface, which increased reflectivity.

Conclusions

The inherent flexibility of the Jaz sensing system can be exploited for a number of UV-VIS bioreflectance applications simply by mixing and matching Jaz modules and selecting sampling optics most appropriate for your application. A high-intensity, low-power pulsed xenon source and various options for meeting your system power requirements make Jaz an extremely reliable choice for field and other applications.

OEM

For the Original Equipment Manufacturer with demanding product development cycles and a need for scalability, Ocean Optics provides sound solutions in large or small runs.

Our optical sensing products deliver proven performance and are smaller and more flexible than comparable brands. These modular products are ideal for a variety of processes and easily scalable.

Ocean Optics is a unique and vertically integrated partner providing you with an entire range of parts and equipment for optical sensing measurements.

Your Dedicated OEM Partner

Since 1992, Ocean Optics has enabled over 150,000 customer solutions. With our vast variety of spectrometer models, custom photometric systems, light sources, sampling accessories, optical fibers and thousands of available configurations, Ocean Optics has the uncommon ability to assist you at the component level or with entire systems.

Whether you are developing a groundbreaking new anaytical technique or designing the next-generation system for sophisticated markets, Ocean Optics has the knowledge and experience to help you succeed.

Ocean Optics' OEM Division was established to guide you from product development through launch by providing you with outstanding pricing as well as customized assistance in getting the most from your Ocean Optics equipment. Ocean Optics is ISO 9001:2008 Certified, assuring adherence to the International Standards Organization's benchmarks in design, development, manufacturing and service.

Whether you're interested in smaller runs or larger volumes, Ocean Optics can provide you discounts that allow you to take your product from vision to reality.

Global Sales and Development Capabilities

Our OEM team provides support – from development to manufacturing– within nearly every major region in the world. We have dedicated OEM teams in the Americas, Europe and Asia-Pacific, putting us closer to where you are developing your next great product.

In addition, as a Halma company (LSE code: HLMA), we are part of a leading safety and environmental technology company with over 3,500 employees in 70 locations worldwide. Halma has a strong focus on innovation and the financial resources to help us invest in new and exciting technologies that benefit our customers.

Technical Expertise

We offer worldwide engineering support ranging from optical design and software engineering to rapid prototyping and feasibility testing. Our global OEM Team is available to directly address your needs – especially during the vital early phases of product design. Plus, our experience makes us the logical choice for supporting both modestly sized OEMs and larger-volume customers.

Clear Advantages

- More than 20,000 applications enabled
- Complete suite of miniature fiber optic spectrometers, optical sensors and accessories
- Custom optical fibers and probes
- Provider of sub-systems, instruments and fully integrated modules
- Proprietary technologies for optimizing spectrometer performance
- Easily scalable products – from tens to thousands of units
- The opportunity for entrepreneurs to co-market
- Dedicated OEM Engineering Team providing optical, electronic, mechanical and software support
- Dedicated OEM Sales and Applications support

OEM Products

The World's Most Innovative Spectroscopy Products

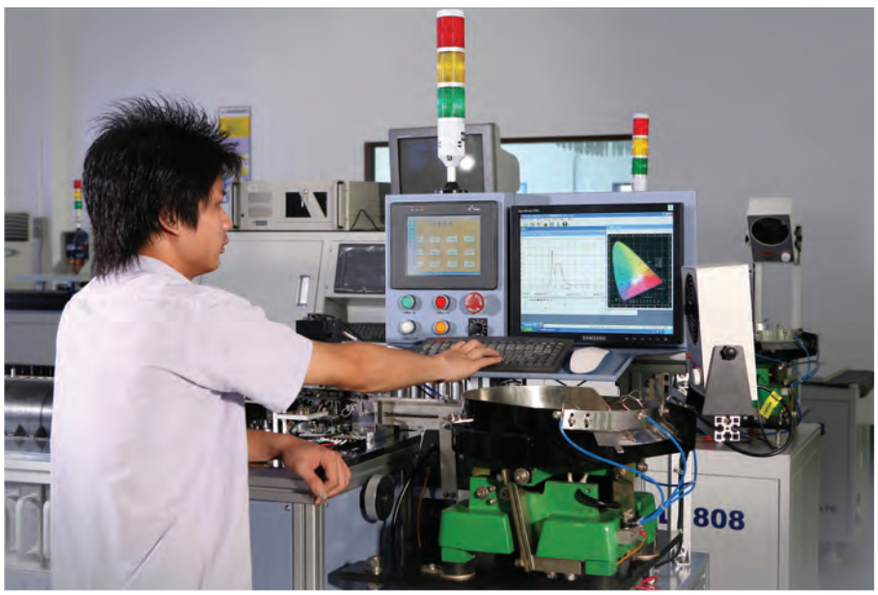
Our miniature spectrometers, fiber optic accessories, optical components and sensors are used in a vast array of OEM products. Ocean Optics is known for providing specialized solutions for a broad variety of manufacturing applications. We have worked with customers across a range of industries, from medical diagnostics to solid-state lighting and semiconductor processing.

The volumes you require, the delivery you need and the quality you demand are all assured under the Ocean Optics OEM program.

The diversity of Ocean Optics' spectrometers, accessories, fiber assemblies and sensor solutions allows us to effectively fulfill your requirements:

- Spectrometer models ranging from Deep UV (150 nm) to NIR (2500 nm)
- Sub-systems, instruments and full integrated models
- Custom photometric solutions inclusive of light source, free beam or fiber coupling to the sample, detector and interface electronics
- Collimating optics, sample holders, flow cells, filters and reference standards
- Probes, patch fibers, furcated assemblies and custom fiber assemblies
- Multi-channel systems
- O2 and pH probes and patches for in situ measurements
- Metrology laboratory for NIST traceable UV, VIS and NIR irradiance calibrations (210 - 2400 nm)

Our product offering is diverse and top-notch. Serving you with high-quality products is our top priority. Our parts are RoHS compliant and our procedures for quality assurance, production and continuous improvement have met ISO standards. Moreover, we can support you in meeting industry-specific requirements such as FDA, UL and CE approval.



STS Microspectrometer

The STS is a compact, low-cost spectrometer that's ideal for embedding into OEM devices. At just 40 mm x 42 mm x 24 mm, the STS has low stray light, high signal to noise and optical resolution of ~1.5 nm (FWHM) – remarkable performance for a spectrometer that size.

The STS is an especially attractive option for high-intensity applications such as LED characterization and absorbance/transmission measurements, yet versatile enough for an extensive range of spectral sensing requirements. Additional information is available in the following pages.

STS Series OEM Microspectrometer

Amazing Full-Spectrum Performance in a Tiny Footprint

The STS introduces a family of compact, low-cost spectrometers that's ideal for embedding into OEM devices. At just 40 mm x 42 mm x 24 mm (1.6" x 1.7" x 0.9"), the STS provides full spectral analysis with low stray light (≤0.2% SRPR @ 450 nm), high signal-to-noise ratio (>1500:1) and great optical resolution (~1.5 nm FWHM) – remarkable performance for a spectrometer its size. The STS is an especially attractive option for high-intensity applications such as LED characterization and absorbance/transmission measurements, yet versatile enough for an extensive range of spectral sensing requirements.

Key Features

Full Spectral Analysis in a Small Footprint
CMOS-based unit is less than 50 mm (2") square, weighs just 68 g (2.4 oz.)

Ideal for OEM Devices
Compact unit available at low cost and reproducible in large production quantities

UV-NIR Coverage
Now available with models covering ranges within 200-1100 nm

Remarkable Performance
Meets or exceeds optical resolution, stability, sensitivity and other performance criteria associated with larger, more expensive spectrometers

Physical	
Dimensions:	40 mm x 42 mm x 24 mm
Weight:	68 g (2.4 oz.), incl. fixed fiber
Operating temperature:	0-50 °C, 10 °C change/hour ramp
Storage temperature:	-20 to +75 °C
Detector	
Detector type:	ELIS-1024, 1024 pixel linear CMOS
Detector range:	200-1100 nm (uncoated)
Pixels/size:	1024, 7.8 x 125 µm
Pixel well depth:	800,000 e-
Optical Bench	
Design:	Crossed Czerny Turner, focal length 28 mm
Entrance aperture:	Shaped aperture; 10 µm, 25 µm, 100 µm and 200 µm slits
Gratings:	600 g/mm
Fiber optic connector:	~2 cm x 400 µm fixed fiber assembly (not detachable)
Quantum efficiency:	60% (@ 675 nm)
Spectroscopic	
Wavelength range:	UV (200-600 nm), VIS (350-800 nm), NIR (650-1100 nm)
Optical resolution:	FWHM 1.0 nm (10 µm slit), 1.5 nm (25 µm slit), 6.0 nm (100 µm slit), 12.0 nm (200 µm slit)
Signal-to-noise ratio:	>1500:1 (at maximum signal)
A/D resolution:	14 bits
Dark noise:	≤3 counts RMS
Dynamic range:	5 x 10^9 (system, 10 s max integration), 4600 single acq.
Integration time:	10 µs-10 s
Stray light:	≤0.25% @ 450 nm; ≤0.1% @ 750 nm
Corrected linearity:	< ⁺/-0.5% from 15-95% full scale
Max dark current:	~150 counts/second at 60 °C; ~50 counts/second at 35 °C
Electronics	
Power consumption:	0.75 W (average)
Power options:	USB or GPIO port
Data transfer speed:	USB full speed
Acquisition time:	60 scans/second (max) (more scans with binning)
Connector:	Micro-USB
Inputs/Outputs:	GPIO
Trigger modes:	3 modes
Strobe functions:	Single/Continuous
Gated delay feature:	Yes
Computer Requirements	
Computer interface:	USB 2.0, RS-232
Operating systems:	Any supported by OmniDriver/SeaBreeze or RS-232
Compliance	
CE mark:	Yes
RoHS:	Yes
Software	
Operating software:	SpectraSuite support (extra)
Dev. software:	OmniDriver/SeaBreeze driver support (extra)

STS Series OEM Microspectrometer

Amazing Full-Spectrum Performance in a Tiny Footprint

Robust Optical Bench Design

At the heart of the STS is a CMOS detector in a crossed Czerny Turner optical bench. The bench is distinguished by custom-molded collimating and focusing mirrors and a 600 lines/mm groove density grating that projects spectra onto the detector. Special coating technology minimizes etalon effects.

The unit achieves significantly better optical resolution and produces less stray light than most filter-based and other spectrometers of its size. For example, STS has 14-bit A/D resolution and has low power consumption of just 0.75 W. Plus, STS has triggering functions for instances when precise timing is necessary. For example, synchronizing measurements with an external event, such as the pulsing of an excitation lamp for fluorescence, is no challenge for the STS.

STS takes advantage of recent advances in CMOS detectors that elevate optoelectronic performance and improve system reproducibility. It uses a 1024-element ELIS-1024 linear image sensor that's responsive from 200-1100 nm and has excellent sensitivity (6.74V/lux-second typical). This new generation of CMOS detectors offers excellent performance with great value.

STS Options

We offer STS models for 200-600 nm (STS-UV), 350-800 nm (STS-VIS) and 650-1100 nm (STS-NIR) applications. Each unit has a fixed optical bench configuration, although you can select from standard slit sizes of 10, 25, 100 and 200 µm. Custom slits are also available. To optimize signal collection efficiency and improve reproducibility, STS utilizes a fixed-fiber design. The fiber has a 400 µm core and is 2 cm in length (including SMA connector). Custom configurations – including versions with different fiber lengths and with a cosine corrector – are available for high-volume applications.*

The STS is fully operational with SpectraSuite spectroscopy software. Operating software and software development tools are priced separately.

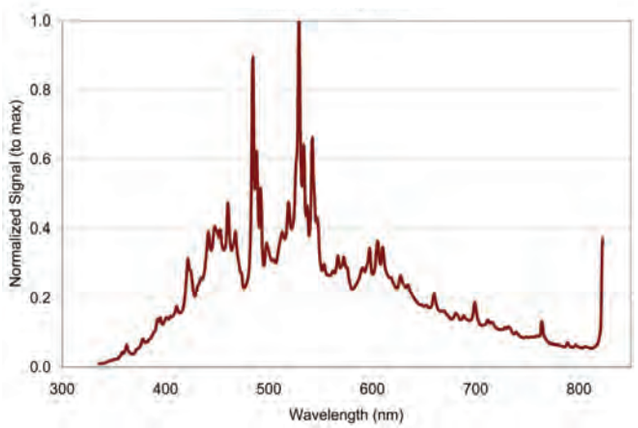
Markets and Applications

The STS was conceived as a low-cost, high-performance spectrometer for OEM and high-volume applications where one or more wavelengths are being monitored and a highly reproducible result is required. Life sciences, medical diagnostics, solid state lighting and environmental analysis are among the industries where STS is an attractive alternative to filter-based optical sensing systems and other microspectrometers.

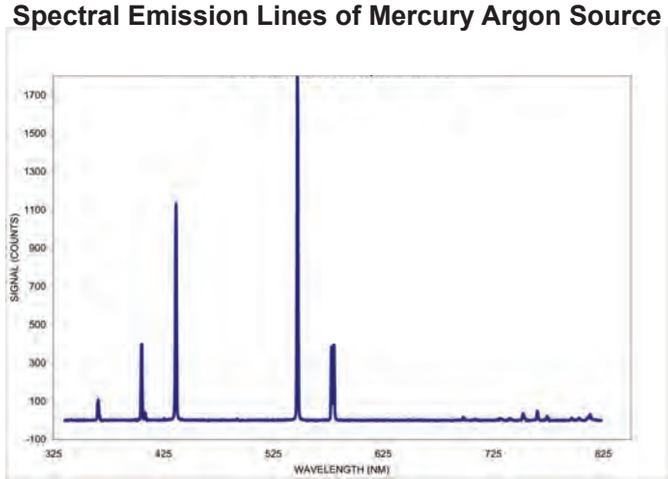
*Minimum quantities required. Contact an Ocean Optics OEM Representative for details.

Sample Results with STS OEM Microspectrometer

Spectral Output of Xenon Flash Lamp



Spectral Emission Lines of Mercury Argon Source



Customized OEM Service

Helping You Meet Your Goals

Do you have a great idea for a product that uses optical sensing? Whether you're an inventor at a startup or part of a product development team at a Fortune 500 company, Ocean Optics delivers products that meet your performance and cost specifications, along with on-demand integration support and the unique perspective of the company that invented the world's first miniature spectrometer.

Working with Entrepreneurs and Small Companies

Developing your great idea into a viable technology business is a challenging prospect for small companies. But we can offer an array of consultative services geared toward propelling you through product launch and ramp-up. What's more, we even can offer co-marketing services and access to our distribution network – the type of sales exposure that many startups struggle to accomplish.

One small-business customer recently developed a system for dental educators, researchers and clinicians that simply and accurately measures the useful energy a simulated resin restoration (a filling) receives from a dental curing light – a procedure affected by a number of variables that often leads to too much or too little exposure. Improper curing can lessen the lifetime of the filling and potentially damage the tooth.

By using an iterative approach to the system design and providing a combination of custom fiber, sampling optics and NIST-traceable radiometrically calibrated spectrometer, we were able to supply a highly reproducible system that the customer has released successfully. Its potential impact is staggering: 130 million dental restorations are performed each year in the U.S. alone.

Supporting Developers at Larger Corporations

Established companies are constantly striving to create new products and services – either to develop new markets or to preserve existing market share. We have significant experience with such companies, who benefit from our array of á la carte engineering, testing and validation services and our ability to scale our manufacturing processes to their high-volume needs.

For example, we recently supported a large manufacturer of medical devices for heart health with an application measuring blood oximetry at the distal end of a diposable catheter. Due to size limitations and special communications requirements, product development required highly customized engineering and design work. By drawing on our expertise in optical design and electronics, we were able to accomplish the customer's goals.

Ensuring Service for All Customers

Regardless of your company's size, the challenges of integrating components into a new product or system can be great. Because of that, we've created an OEM Developer's Program that provides technical guidance and discounted pricing throughout the product development cycle. With a Developer's Agreement, you ensure a 25% discount on the purchase of products for up to one year during the development process. If the development cycle is longer than one year, your agreement may be renewed at a reduced rate. In addition, we will develop a product specification unique to your system requirements to ensure reliable production and delivery of your product.

Worldwide Support

With locations in the United States, Europe and Asia, Ocean Optics' OEM Division is able to provide unparalleled service – before and after the sale.

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Light Sources

Our line of cleverly designed light sources covers the entire UV-NIR wavelength range and combines innovation with reliability to give you serious performance and precision.

These low-cost, modular light sources feature SMA 905 connectors for quick and easy connection.

From design features like built-in filter slots to optional accessories such as direct-attach cuvette holders, nothing is more convenient and simple to use than Ocean Optics light sources.

Tip

For long bulb life and accurate results, always allow your Ocean Optics light source to warm up for the recommended amount of time prior to use.

Light Sources

Sources for Illumination, Excitation and Calibration

The development of Ocean Optics miniature spectrometers created the need for comparably sized and priced accessories, including light sources. Since no such sources existed, we developed our own -- compact, modular sources for illumination, excitation and calibration.

Our light sources for illumination cover various wavelength ranges to enable absorbance, transmission and reflectance measurements from the deep UV to the mid-IR. Light-emitting diodes produce output for fluorescence measurements. For fast, reliable spectrometer wavelength calibrations, we offer a range of options. Design features such as built-in filter slots, combined with optional accessories such as direct-attach cuvette holders, make sampling simple.

Modular Light Source Options

UV Light Sources
We offer deuterium sources for UV absorbance and reflectance measurements. Our pulsed xenon lamps are long-life sources for absorbance, reflectance and fluorescence measurements, and for measuring optically or thermally labile samples.

Combination Deuterium and Tungsten Light Sources
Used as single illumination sources for UV-NIR measurements.

VIS-Mid-IR Light Sources
Tungsten halogen sources are standard VIS-NIR light sources for absorbance, reflectance of solid objects, and color measurement. Our Cool Red source has response into the mid-IR.

High-Powered LEDs
Used as excitation sources for fluorescence. Feature minimal warm-up and high stability. Power is lower and spectral width is wider than with lasers. We offer a full range of options for UV-NIR. LEDs are available individually and with rugged housings.

Radiometrically Calibrated Light Sources
Used to calibrate the absolute spectral intensity of a system in irradiance applications.

Wavelength Calibration Sources
Used to calibrate the wavelength of spectrophotometric systems. We offer a full range of options for your UV-VIS needs.

Type	Product	Wavelength Range	Output	Measurement Type
Deuterium Tungsten Halogen	DH-2000-BAL DH-2000	~215-2500 nm	Continuous	Absorbance, Fluorescence, Reflectance, Transmission
Miniature Deuterium Tungsten Halogen	DT-MINI-2-GS	~215-2500 nm	Continuous	Absorbance, Reflectance, Transmission
Deuterium	D-2000	~215-400 nm	Continuous	Absorbance, Fluorescence, Reflectance, Transmission
Xenon	PX-2 HPX-2000	220-750 nm 185-2000 nm	Pulsed Continuous	Absorbance, Fluorescence, Reflectance, Transmission
LEDs	Various	Many options from 240 nm-white	Pulsed or Continuous	Fluorescence
Tungsten Halogen	HL-2000	360-2500 nm	Continuous	Absorbance, Reflectance, Transmission
Silicone Nitride Emitter	COOL-RED	~1000-5000 nm	Continuous	Absorbance, Reflectance, Transmission
Calibrated Deuterium Tungsten Halogen	DH-2000-CAL	~220-1050 nm	Continuous	Calibration (Radiometric)
Calibrated Tungsten Halogen	HL-2000-CAL	380-1050 nm (typical)	Continuous	Calibration (Radiometric)
Mercury Argon	HG-1	253-1700 nm	Continuous	Calibration (Wavelength)
Argon	AR-1	700-1700 nm	Continuous	Calibration (Wavelength)
Neon	NE-1	540-754 nm	Continuous	Calibration (Wavelength)
Xenon	XE-1	916-984 nm	Continuous	Calibration (Wavelength)
Krypton	KR-1	427-893 nm	Continuous	Calibration (Wavelength)

Light Sources
Tools For Manipulating Light

Modifying Light
Ocean Optics products give you countless options for modifying the light transmitted to your spectrometer's detector. Depending on your application needs, we provide a number of methods for changing the way light interacts with your configuration.

For high-intensity applications such as laser characterization, steps must be taken to avoid detector saturation. In other cases, changing the fiber size or adding mirrors to your spectrometer bench may increase light collection efficiency.

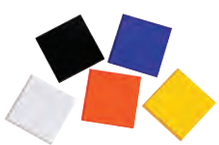
Entrance Aperture: Slit
An installed slit acts as the entrance aperture to the optical bench and regulates the amount of light that enters. You specify the slit size. Options range from 5 to 200 µm.

Installed Filters
In addition to the variable longpass filters (order-sorting filters applied to the detector's window), we offer optional bandpass and longpass blocking filters that restrict radiation in certain wavelength regions.

Optical Fiber
Our optical fibers are available in diameters ranging from 8 µm to 1000 µm. If you require more light for your application, you'll want a larger diameter fiber. In the absence of a slit, the fiber connected to the spectrometer acts as the optical bench's entrance aperture.

Linear Variable Filters
Our high-pass, low-pass and adjustable bandpass filters have excellent blocking characteristics and resistance to heat. They are ideal for spectrally shaping the light emitted from broadband sources.

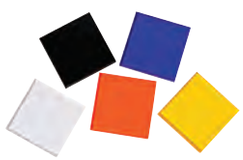
Loose Filters
Our loose filters fit into our light sources, cuvette holders and in-line filter holders. High-pass filters eliminate second- and third-order effects, test for stray light and block excitation energy. Balancing filters absorb energy in some regions while transmitting in others. Bandpass filters pass energy in one region and block light above and below that region.



Fiber Optic Variable Attenuator
Our FVA-UV Fiber Optic Variable Attenuator is an opto-mechanical device that helps control the amount of light transmitted between two fibers. This attenuates light uniformly at all wavelengths from the ultraviolet through the near-infrared.

Integration Time
This software setting is similar to the shutter speed of a camera. The higher the value specified, the longer the detector "looks" at incoming photons. Using our companion software, you can adjust this setting to suit different applications.

Neutral Density Filters
With a neutral density filter installed at your light source or sampling device, you can reduce the intensity of light that reaches the detector across all wavelengths. Filters are 2-mm thick and 8 mm in diameter and come in optical density levels of 0.6 (~25% transmission), 1.0 (~10%) and 2.0 (~1%).



Gershun Tube Kits
Gershun Tube Kits are ideal for solar irradiance measurements and feature an SMA 905-terminated barrel that attaches to a fiber or the spectrometer. This provides control of the aperture size. Simply select one of the interchangeable aluminum apertures to adjust the field of view of the device from 1° to 28°.

DH-2000-BAL

Balanced Deuterium Tungsten Halogen Light Source

We've applied our expertise in patterned dichroic filters to create the only combined-spectrum illumination source available that eliminates saturation and signal-to-noise issues associated with the D-alpha line in deuterium sources. Our DH-2000-BAL Deuterium Tungsten Halogen Light Source combines deuterium and tungsten halogen light sources into a single optical path that produces a powerful, stable output from 215-2500 nm.

About the D-alpha Line

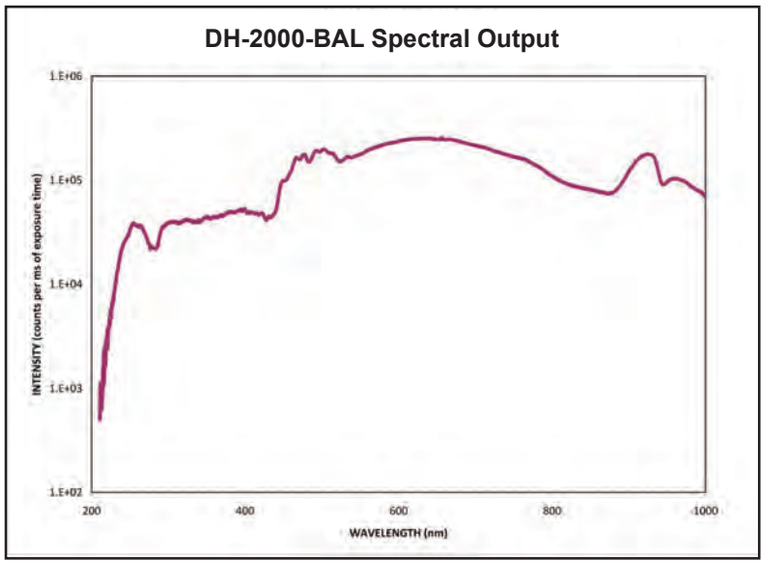
All deuterium-tungsten halogen sources have a D-alpha line, revealed as a jagged peak in the visible portion of the spectrum, that produces "unbalanced" output in the deuterium and tungsten halogen sources. Correcting for this deuterium line – a sharp spectral feature near 655 nm – is difficult.

For example, if you adjust spectrometer integration time to reduce the intensity of this saturated spectral line, the efficiency of the system at UV wavelengths drops significantly, compromising signal-to-noise performance. Also, spectrometer efficiency is greatest at about the same spectral range as the 655 nm line, exaggerating its effects.

Proprietary Filtering Technology

Using the same high-precision patterned dichroic filter technology that distinguishes our Linear Variable Filters, the DH-2000-BAL balances the intensity of the deuterium and tungsten halogen sources, producing a "smoother" spectrum across the entire wavelength range and eliminating problems associated with saturation. By comparison, most combination UV-NIR sources can be adjusted for relative intensity only.

Specifications	
Dimensions:	150 mm x 135 mm x 319 mm
Weight:	3.8 kg
Wavelength range:	215-400 nm (deuterium); 360-2500 nm (tungsten halogen)
Power consumption:	25 W (deuterium); 20 W (tungsten halogen); 190 W maximum
Power requirements:	85-264 V 50/60 Hz
Voltage:	Ignition 350 V/20°; tungsten bulb voltage is adjustable from 4.5 to 11.5 volts
Current:	Operating 85 V/0.3A
Stability:	<5 x 10^6 peak-to-peak (0.1-10.0 Hz)
Drift:	<0.01% per hour
Time to stable output:	40 minutes (deuterium); 20 minutes (tungsten)
Bulb life:	1,000 hours
Operating temperature:	5 °C - 35 °C
Humidity:	5-95% non-condensing at 40 °C
Electronic certifications:	CE; VDI/VDE 0160; EN 61010



Measured with HR2000+ with 25 µm Slit and 400 µm Optical Fiber

Technical Tip

Ultraviolet radiation below 300 nm degrades transmission in silica fibers, resulting in solarization (increased light absorption in the UV fiber that can invalidate data). For applications using the DH-2000 Light Sources <300 nm, we recommend solarization-resistant assemblies. See Page 137 for details.

DH-2000

Deuterium Tungsten Halogen Light Source

Our DH-2000 Deuterium Tungsten Halogen Light Source combines the continuous spectrum of deuterium and tungsten halogen light sources into a single optical path for powerful output from 215-2500 nm. In addition, Deep-UV versions of our DH-2000 are available with a 190-2000 nm range.

Options and Accessories: Shutter and Filter Holder

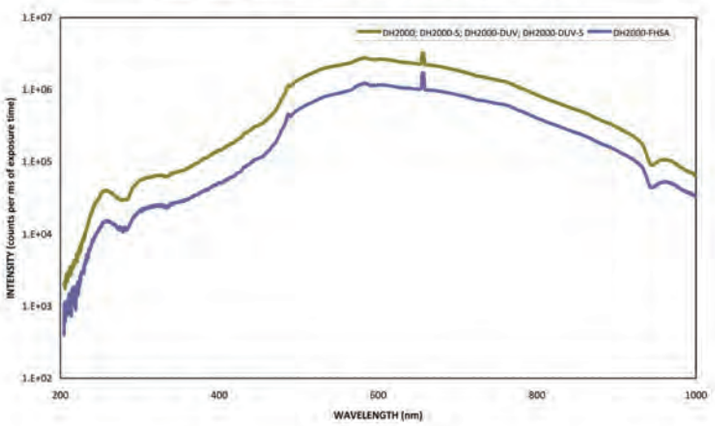
Integrated shutters are available for your DH-2000 and can be driven by either a switch or a TTL signal.

You can also include a filter holder with the source that accepts filters up to 4 mm in thickness and as large as 25 mm square or 25 mm round. The DH-2000 has an SMA 905 connector for easy coupling to our spectrometers and accessories via an optical fiber.

Adjustable Power

The DH-2000 has a potentiometer that adjusts the intensity of the tungsten halogen output. This allows you to adjust the optical power of the light source from 10-100%.

DH-2000 Series Spectral Output



Measured with HR2000+ Spectrometer with 25 µm Slit and 400 µm Optical Fiber

Item Code	Description
DH2000-DUV	Uses a Deep-UV deuterium bulb that provides 190-2000 nm wavelength range
DH2000-S	Includes shutter control via a TTL signal or manual switch up to 5 Hz
DH2000-S-DUV	Uses a Deep-UV deuterium bulb that provides a 190-2000 nm wavelength range; includes shutter control via a TTL signal or manual switch up to 5 Hz
DH2000-FHS	Includes a filter holder for filters up to 25 mm square or 25 mm round and 4 mm thick
DH2000-FHS-DUV	Uses a Deep-UV deuterium bulb that provides 190-2000 nm wavelength range; includes a filter holder for filters up to 25 mm square or 25 mm round and 4 mm thick

Specifications	
Dimensions:	150 mm x 135 mm x 319 mm
Weight:	3.5 kg
Power consumption:	25 W (deuterium); 20 W (tungsten halogen)
Wavelength range:	190-400 nm (deep-UV deuterium bulb) 215-2500 nm (standard deuterium and tungsten halogen bulbs)
Humidity:	5-95% without condensation at 40 °C
Lamp current:	Operating 85 V/0.3A
Lamp lifetime:	1,000 hours
Lamp voltage:	Ignition 580 V at 20 °C
Current voltage drift:	<0.01% per hour
Current voltage stability:	<5 x 10^6 peak-to-peak (0.1-10.0 Hz)
Operating temperature:	5 °C - 35 °C
Power requirements:	85-264 V 50/60 Hz
Radiation characteristic:	Aperture 0.5 mm, numerical aperture 26° (13°); focused Total power: 100 W
Power consumption:	Approximately 78VA
Warm-up time:	40 minutes (deuterium); 20 minutes (tungsten halogen)
Markings:	CE; VDI/VDE 0160; EN 61010

DT-MINI-2-GS

Mini Deuterium Tungsten Halogen Light Source

UV-NIR Spectral Range

The DT-MINI-2-GS Deuterium Tungsten Halogen Light Source combines the continuous spectrum of an RF-excited deuterium UV light source and a tungsten halogen VIS-NIR light source in a single optical path.

The combined-spectrum sources produce stable spectral output from ~215-2500 nm in a compact package.

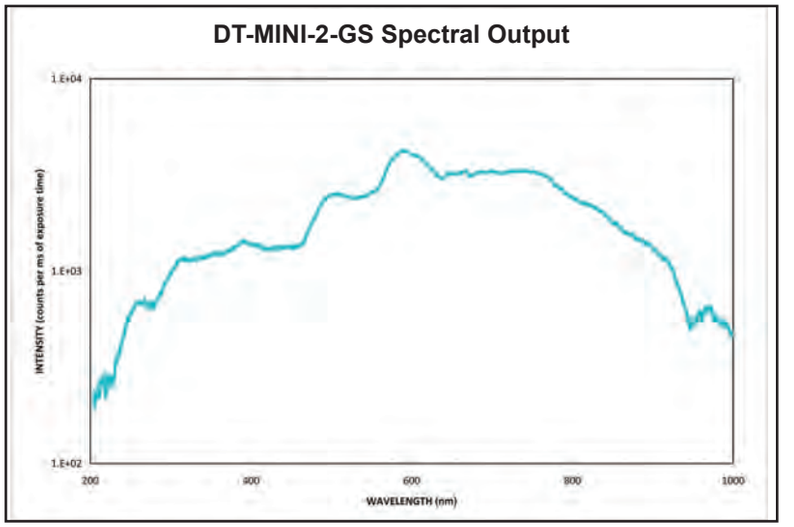
Powerful Output – 0.5 mm Aperture

The DT-MINI-2-GS Deuterium Tungsten Halogen Light Source also utilizes a bulb with a 0.5-mm diameter aperture. It also has a shutter for blocking the light path, which can be controlled via a manual switch or TTL.

There is also a switch for turning the deuterium source on and off, and one for turning the tungsten halogen source on and off; each switch can be used independently of the other.

Specifications	
Dimensions:	140 mm x 50 mm x 125 mm
Weight:	475 g
Wavelength range:	~215-2500 nm
Power consumption:	350 mA @ 12 VDC
Output:	3.8 watts (deuterium); 1.2 watts (tungsten halogen)
Stability:	~1.0% peak-to-peak (over 4 hours) after 30-minute warm-up
Time to stable output:	10 minutes (deuterium); 1 minute (tungsten halogen)
Bulb life:	~1500 hours (deuterium); 1500 hours (tungsten halogen)
Ignition delay:	<2.0 seconds (delay for cold start-up may be longer)
Connector:	SMA 905

Note: Use item code DT-MINI-2-B when ordering replacement bulbs for the DT-MINI series miniature deuterium tungsten halogen light sources.



Measured with HR2000+ Spectrometer with 25 µm Slit and 400 µm Optical Fiber

Technical Tip

The DT-MINI-2-GS is your go-to choice for application setups requiring UV and VIS-NIR illumination.

However, we also offer our USB-DT, which can be used as a standalone source, stacked atop a USB2000+ or USB4000 Spectrometer or connected to your HR- or QE- spectrometer using a breakout box. The latter allows you to control multiple functions through software.

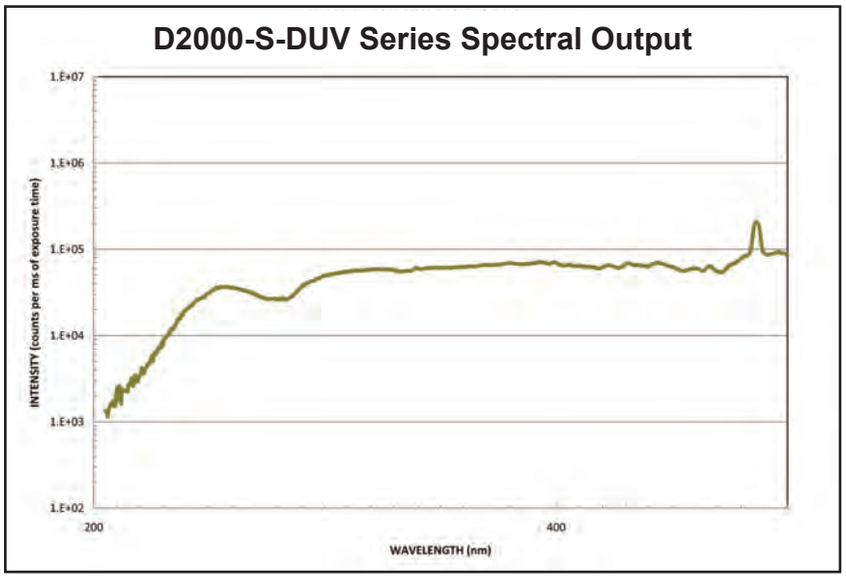
For assistance in selecting the optimum miniature deuterium tungsten halogen light source for your application, please contact an Ocean Optics Applications Scientist.

D-2000

Powerful, Stable Deuterium Source for UV Applications

Deuterium Light Source

The D-2000 Deuterium Light Source delivers robust, even output from 215-400 nm with peak-to-peak stability of less than 0.005% and drift of only +/-0.5% per hour. D-2000 is also available in a Deep-UV configuration that provides you a wavelength range of 190-400 nm.



Measured with HR2000+ Spectrometer with 25 µm Slit and 400 µm Optical Fiber

Options and Accessories

Integrated shutters are also available with the D-2000 and can be driven by a TTL signal. All versions of the D-2000 have an SMA 905 Connector for easy coupling to our spectrometers and fiber optic accessories, a safety shutter for blocking the light when the fiber is not attached, and safety goggles. The 1,000-hour deuterium bulb used in the D-2000 can be replaced easily.

Specifications	
Dimensions:	150 mm x 135 mm x 319 mm
Weight:	5.35 kg (without power cord)
Power consumption:	830 mA @ 230 VDC or 1660 mA @ 115 VDC
Wavelength range:	215-400 nm (standard bulb); 190-400 nm (deep-UV bulb)
Peak-to-peak stability:	<0.005% at 250 nm
Drift:	+/-0.5% per hour at 250 nm
Warm-up time:	40 minutes
Voltage and current:	Ignition 350V/20° operating 85 V/0.3A
Bulb lifetime:	1,000 hours for standard or deep-UV bulb
Operating temperature:	5 °C - 35 °C
Humidity:	5-95% without condensation at 40 °C
Radiation characteristic:	Aperture 0.5 mm, numerical aperture 26° (13°)
Power requirements:	85-264 V 50/60 Hz
Markings:	CE; VDI/VDE 0160; EN 61010
TTL-shutter input:	Up to 5 Hz maximum (shutter versions only)
Shutter speed:	10 ms minimum

Ordering Information	
Item	Description
D2000	Deuterium light source, 215-400 nm
D2000-DUV	D-2000 configured with a Deep-UV deuterium bulb that provides a 190-400 nm wavelength range
D2000-S	D-2000 configured with a shutter (controlled via a TTL signal or switch)
D2000-S-DUV	D-2000 configured with Deep-UV deuterium bulb that provides a 190-400 nm wavelength range and includes a shutter (controlled via a TTL signal or switch)
DH2000-BD	Replacement deuterium bulb for the D-2000 and the D-2000-S
DH2000-DUV-B	Replacement deuterium bulb for the D-2000-DUV and the D-2000-S-DUV

Technical Tip

Ultraviolet radiation below 300 nm degrades transmission in silica fibers, resulting in solarization (increased light absorption in the UV fiber that can invalidate data). For applications using the D-2000 Light Sources, we recommend solarization-resistant assemblies. See Page 137 for details.

HPX-2000

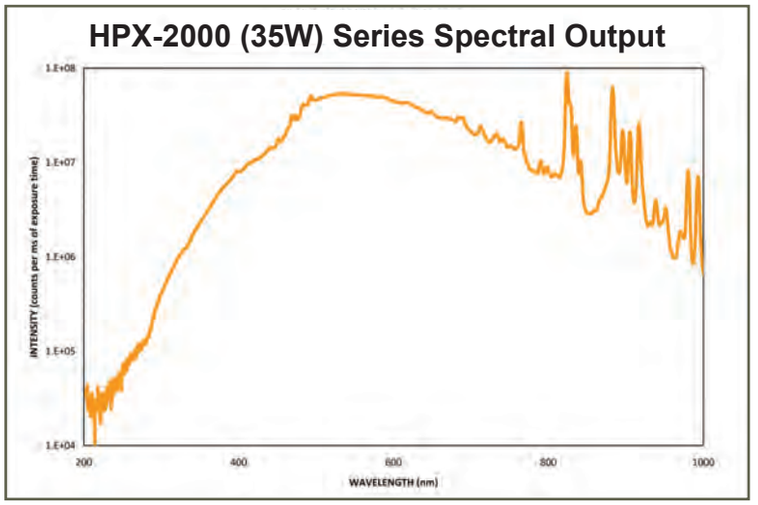
High-Powered Continuous Wave Xenon Light Source

High Power Output

The HPX-2000 Xenon Light Source is a high-power source that is a brilliant companion for fluorescence applications and for other applications where a high-intensity lamp is necessary. The 35-watt, short-arc lamp supplies a continuous spectrum from the UV through the NIR (185-2000 nm).

Integrated Shutter

The HPX-2000 features an integrated shutter that can be triggered by either a switch or by a TTL signal. The HPX-2000 also comes equipped with a slot for filters up to 25 mm in diameter or 25 mm square and up to 14 mm thick.



Measured with HR2000+ Spectrometer with 25 µm Slit and 400 µm Optical Fiber

Ordering Information	
Item	Description
HPX-2000	35-watt, continuous-wave xenon light source (185-2000 nm)

Specifications	
Dimensions:	145 mm x 165 mm x 260 mm
Weight:	5 kg
Power consumption:	60 W AC
Wavelength range:	185-2000 nm
Power output:	35 watts
Trigger input:	External TTL positive pulse via 15-pin connector (shutter)
Bulb lifetime:	1,000 hours minimum; 2,000 hours typical
Connector:	SMA 905

Replacing the Bulb

The HPX-2000 bulb may require replacement with prolonged use or breakage. In such cases, customers have two options:

- Remove the bulb module and send it to Ocean Optics for bulb replacement (REPAIR-HPX-1). You'll pay modest fees for the bulb and labor. Typical turnaround is several weeks.

- Order a new bulb module (HPX-2000-BM) and replace the entire bulb assembly in the field. Although this option is slightly more expensive, it's more convenient and can be accomplished relatively quickly.

Technical Tip

If you're using a Jaz spectrometer in your setup, consider the Jaz-PX for your pulsed xenon source needs. The Jaz-PX (see Jaz section) is a high-performance source that installs directly into the Jaz stack providing a convenient alternative to a standalone source.

PX-2
Pulsed Xenon Light Source

Versatile UV Source

The PX-2 Pulsed Xenon Lamp is a high flash rate, short-arc xenon lamp for the UV (220-750 nm). It's great for applications requiring absorbance, reflection, fluorescence and phosphorescence measurements, and especially suited for measuring optically or thermally labile samples. The PX-2 operates at speeds up to 220 Hz, offers excellent pulse-to-pulse stability and has two trigger modes for software control of the flash rate.

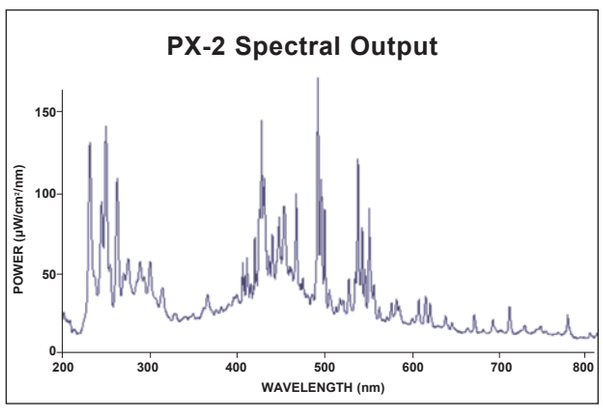
About the PX-2

Any external TTL positive pulse can be used to trigger the PX-2. With the PX-2 coupled to a USB Series spectrometer, you can easily synchronize operation of both the light and the detector. The spectrometer sampling can be altered so that a variable number of flashes are observed during each integration period.

The Multiple mode of light source operation is useful for absorbance and reflection applications because it ensures steady, consistent light exposure for each integration period.

In the Single mode of PX-2 operation, a single flash occurs during each integration period. The flash rate is modified by changing the integration period. Because it produces a pulsed signal, the PX-2 is less likely to contribute to solarization in optical fiber assemblies, which can occur when fibers are illuminated with signal <300 nm.

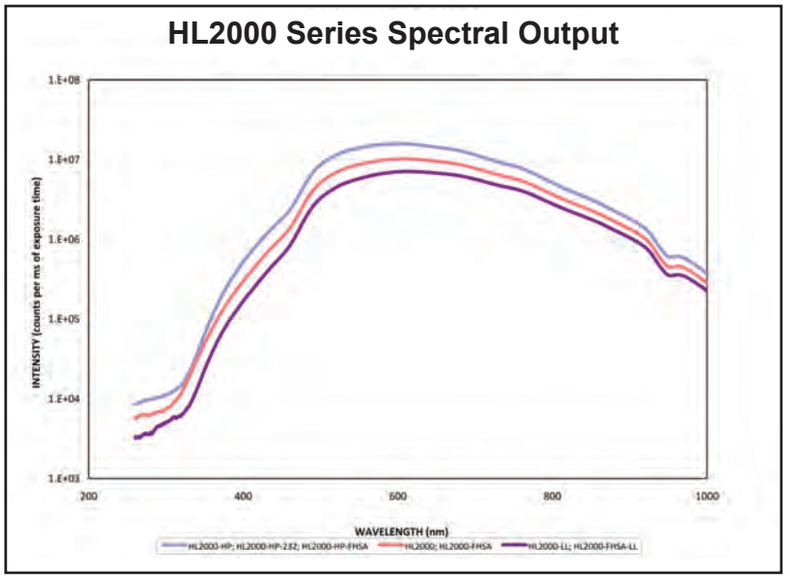
Specifications	
Spectral range:	220-750 nm
Approximate dimensions:	140 mm x 105 mm x 40 mm (LWH)
Power input:	1.3 A @ 11V @ 220 Hz
	100 mA @ 12V @ 10Hz
Trigger input:	External TTL positive pulse via 15-pin connector
Output:	45 microjoules per pulse maximum 9.9 watts average power from bulb (not the same as power coming out of fiber; see graph at right) 220 Hz pulse rate maximum
Pulse duration:	5 microseconds (at 1/3 height of pulse)
Lifetime:	10^9 pulses (estimated 230 days continuous operation at 50 Hz pulse rate)
Aperture:	3 mm
Connector:	SMA 905
Timing signals available:	Multiple mode: up to 220 Hz (varies with A/D sampling frequency); Single mode: varies with scan rate



Ordering Information	
Item	Description
PX-2	Miniature pulsed xenon light source for UV-VIS (220-750 nm)
PX-2-B	Spare bulb for PX-2

HL-2000

Tungsten Halogen Light Source



Measured with HR2000+ Spectrometer with 25 µm Slit and 400 µm Optical Fiber

Item	Description
HL-2000	Tungsten halogen light source, 1,500-hour bulb
HL-2000-LL	Long-life version (10,000-hour)
HL-2000-LL-LVF	Long-life version with slot for linear-variable filters
HL-2000-FHSA	Includes filter holder, attenuator and shutter
HL-2000-FHSA-LL	Long-life version (10,000-hour); includes filter holder, attenuator and shutter
HL-2000-HP	High-powered, 20 W version
HL-2000-HP-FHSA	High-powered, 20 W version with filter holder, attenuator and shutter
HL-2000-HP-LVF	High-powered, 20 W version with slot for linear-variable filters
HL-2000-HP-232R	High-powered, 20 W version, rack-mounted, with RS-232 control
HL-2000-B	Spare 1,500-hour bulb
HL-2000-B-LL	Long-life 10,000-hour spare bulb
HL-2000-HP-B	High-power spare bulb

The HL-2000 Tungsten Halogen Light Sources are versatile lamps that are optimized for the VIS-NIR (360-2500 nm) range. The HL-2000 is available in several versions, including a model (HL-2000-FHSA) that has a shutter for dark measurements, a slot that accepts filters up to 25.4 mm round or 50.8 mm square and an attenuator to control the intensity of the light source from 0-100%.

Smart Features

- Available with 10,000-hour, long-life bulb
- High-power version available that doubles your output power
- Fan cooled with shutter, TTL and manual attenuator functions
- RS-232 interface option to access shutter and attenuator

High-power Version

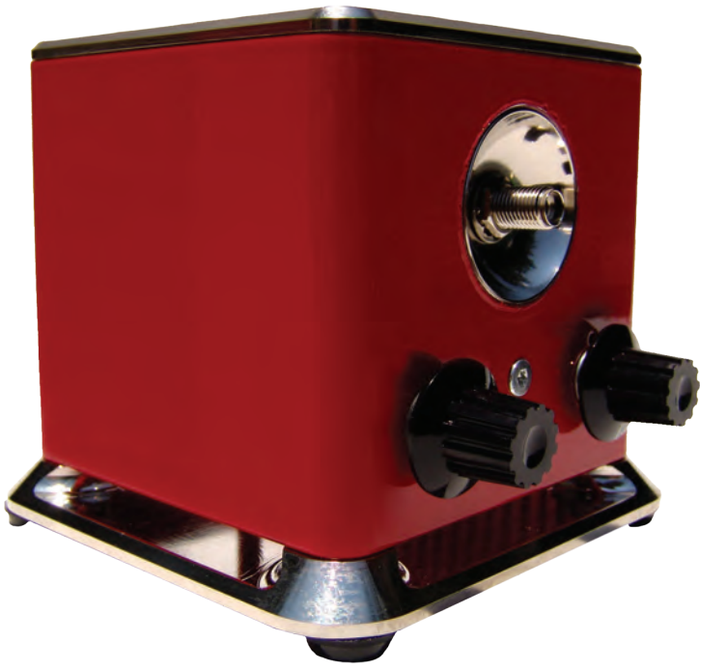
For applications requiring strong VIS-NIR output and using large-diameter optical fibers or fiber and probe bundles, a special high-power version of the HL-2000 is available. The bulb used in the HL-2000-HP is a 20-watt bulb. In addition, you can opt to control the intensity of the HL-2000-HP via an RS-232 module.

Specifications

HL-2000, HL-2000-LL Standard Sources	
Dimensions:	62 mm x 60 mm x 150 mm
Weight:	500 g
Bulb power consumption:	7 watts
Output to bulb:	1.4 A @ 5 VDC
Wavelength range:	360-2500 nm
Stability:	0.5%
Drift:	<0.3% per hour
Time to stabilize:	~5 minutes
Bulb lifetime:	1,500 hours
Bulb color temperature:	2,960 K
Temperature:	5 °C - 35 °C
Humidity:	5-95% at 40 °C

HL-2000-HP High-Power Sources	
Dimensions:	62 mm x 60 mm x 150 mm
Weight:	500 g
Bulb power consumption:	20 watts
Output to bulb:	1.66 A @ 12 VDC
Wavelength range:	360-2000 nm
Stability:	0.5%
Drift:	<0.3% per hour
Time to stabilize:	~5 minutes
Bulb lifetime:	2,000 hours
Bulb color temperature:	3,000 K
Temperature:	5 °C - 35 °C
Humidity:	5-95% at 40 °C

Cool Red
Infrared Light Source



The Cool Red works beautifully as a complement to mid-infrared analyzers or in any spectroscopy application where high-intensity infrared light is required.

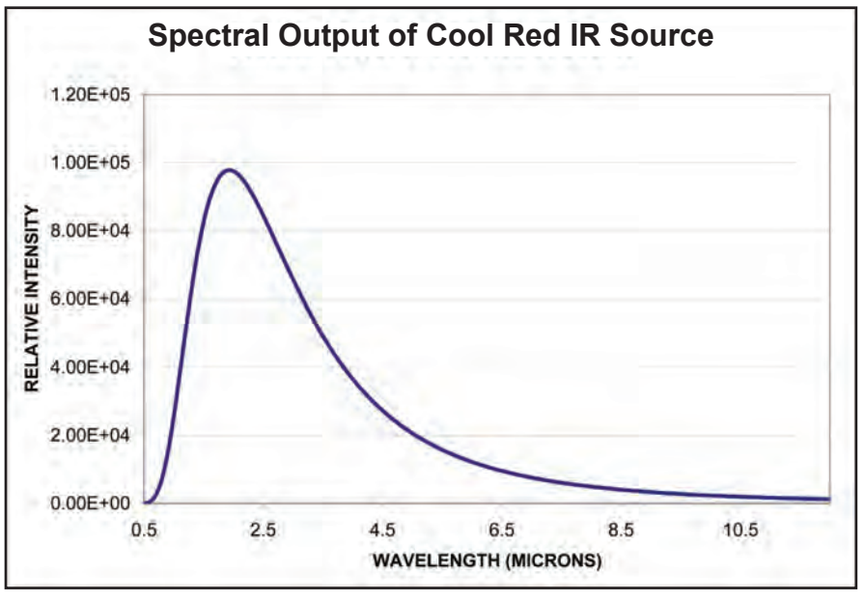
Cool Red is especially useful for applications in the region from 1000-5000 nm. For systems that require optical modulation, an integrated optical shutter can be modulated at frequencies of up to 200 Hz.

The shutter can be driven externally through a 15-pin digital interface. If no external drive is available, the shutter can be driven internally by an integrated adjustable square wave generator.

Frequency can be continually adjusted through the control knob on the front panel from 0.5 Hz to 200 Hz. The digital output for this signal can be taken from the same 15-pin interface and used to synchronize other devices.

Specifications

Lamp	
Material:	Silicon Nitride (Si3N4)
Temperature:	1500 ºK
Lifetime:	2,000 hours
Warm-up time:	12 seconds
Power:	50 Watts
Shutter	
Shutter frequency:	200 Hz
Additional Information	
Replacement lamps:	CR-Lamp-50W
Power Supply Requirements	
5 amps, 24 volts 5.5 mm OD/3 mm ID Universal input power supply included	
Dimensions	
127 mm x 127 mm x 114.3 mm	



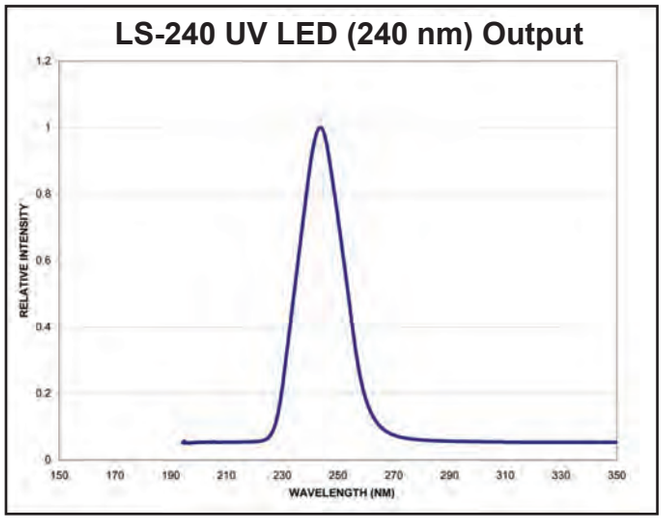
LLS Series

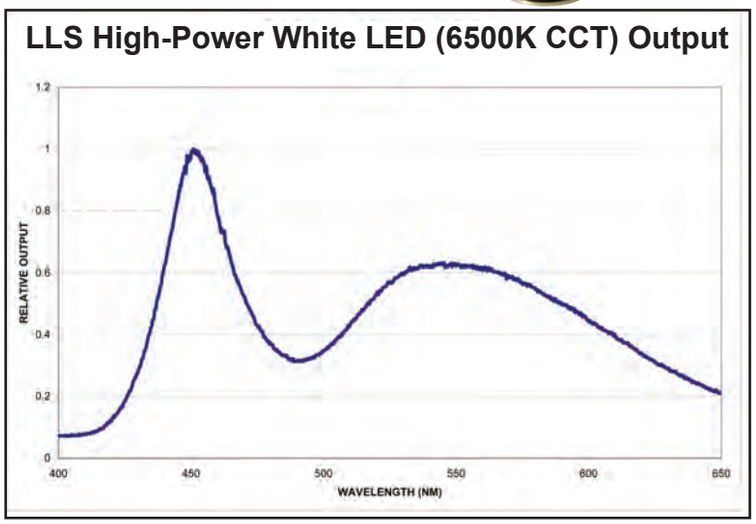
High-Performance UV and VIS LEDs

Our line of fiber-coupled LED light sources are ideal for fluorescence, spectroscopy and general fiber illumination applications. The LLS Series has a proprietary electronics design that provides stable high-current operation and allows the LEDs to run at high peak currents when in external trigger mode. Each unit is 89 mm x 89 mm x 76 mm (LWH) and weighs 340.2 g.

The Ultra LED high power light sources can be operated in continuous or external trigger modes. Included are the UVTOP® LEDs, which cover wavelengths from 240-400 nm.

LLS LEDs are available in nearly 50 different wavelength options. A partial listing of models is shown in the table below.





A Partial Listing of Available Models

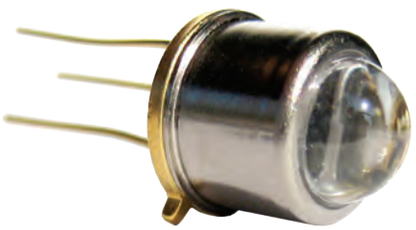
Part #	Wavelength	FWHM	Maximum Drive Current CW	Maximum Drive Current Pulsed	Maximum Duty Cycle in Pulsed Mode
LLS-240	240 nm	11 nm	30 mA	200 mA	1%
LLS-250	250 nm	12 nm	30 mA	200 mA	1%
LLS-270	270 nm	12 nm	30 mA	200 mA	1%
LLS-290	290 nm	12 nm	30 mA	200 mA	1%
LLS-310	310 nm	12 nm	30 mA	200 mA	1%
LLS-325	325 nm	12 nm	30 mA	200 mA	1%
LLS-345	345 nm	12 nm	30 mA	200 mA	1%
LLS-365	365 nm	9 nm	500 mA	1000 mA	50%
LLS-385	385 nm	10 nm	500 mA	1000 mA	50%
LLS-405	405 nm	14 nm	500 mA	1000 mA	50%
LLS-455	455 nm	20 nm	1500 mA	3000 mA	50%
LLS-470	470 nm	25 nm	1500 mA	3000 mA	50%
LLS-505	505 nm	30 nm	1500 mA	3000 mA	50%
LLS-530	530 nm	35 nm	1500 mA	3000 mA	50%
LLS-590	590 nm	14 nm	700 mA	1400 mA	50%
LLS-617	617 nm	20 nm	700 mA	1400 mA	50%
LLS-627	627 nm	20 nm	700 mA	1400 mA	50%
LLS-Warm White	VIS 3000K CCT	NA	1500 mA	3000 mA	50%
LLS-Neutral White	VIS 4100K CCT	NA	1500 mA	3000 mA	50%
LLS-Cool White	VIS 6500K CCT	NA	1500 mA	3000 mA	50%

LEDs
Small, Powerful, Reliable

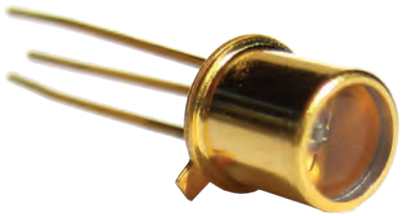
Our Deep UV LEDs are available in a wide range of wavelengths and package sizes. These devices are manufactured using AlGaN/GaN technology that enables a new generation of High Band-Gap Energy optoelectronics devices with output to 240 nm.

These small UV LEDs consume significantly less power than comparable UV technologies and come in several standard configurations. The Ball Lens is ideal for applications that require a small or focused spot of UV light. Flat and Hemispherical lens options are also available.

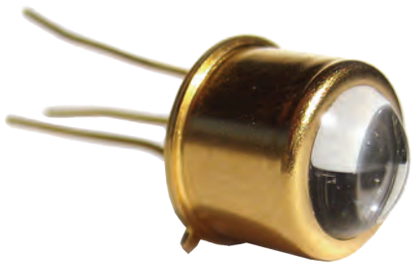
Ball Lens



Flat Lens



Hemispherical Lens



Please contact an Ocean Optics Applications Scientist for ordering information and item codes.

Electro-optical characteristics (UVTOP-280, Ta = 25 °C, Research Grade)						
Parameter:	Symbol	Unit	Minimum	Typical	Maximum	Condition
Forward voltage:	VF	V	5.5	7.5	9	IF=20 mA
Reverse current:	IR	µA	100	VR=5V		
Output UV power:	Pout	mW	0.5			IF=20 mA
Peak wavelength:	λp	nm	-10 nm	specified	+10 nm	IF=20 mA
Spectrum half width:	HW	nm	12	20	30	IF=20 mA

Parameter	Unit	Max. rated Value	Ambient Temp.
Power dissipation, DC:	mW	150	25 °C
Forward current, DC:	mA	30	25 °C
Pulse forward current:	mA	200	25 °C
Reverse voltage:	V	6	25 °C
Storage temperature::	°C	- 30 °C - +100 °C	- 30 °C - +100 °C

Multi-Channel LED Light Source
Four-Channel Module with Controller

Our Multi-Channel LED Light Source is designed to power up to four LED modules. The constant current drivers can each drive up to 2 amps continuously or 4 amps at 50% duty cycle. The user-changeable LED modules are automatically recognized and the drive current is adjusted accordingly. This module can work along with or be controlled through its USB interface.

The source has a timing controller that synchronizes the different channels. External events can be adjusted with a resolution of up to 10 ns. The duty cycle and pulse width of the LEDs can be programmed with great precision up to pulse widths of several seconds. Each LED channel has its own timer and the on/off function of each channel is independently controlled.

Variable triggering modules can be easily configured with Timing Genie Software. Once the timing setups are configured, you can store them onto your unit without the need for a computer.

When specifying a multi-channel LED system, you start with the driver electronics and housing as one component and then assign an LED for each of the channel lines. You'll also select a power supply and power cord.

Specifications	
Dimensions:	76.2 mm x 76.2 mm x 298.5 mm
Weight:	1.5 lb. (680.4 g)
Software:	Timing Genie for Windows and Java compatible SDK
PC interface:	USB 2.0
Trigger modes:	External, internal and free-running
Timing resolution:	10 ns
Drive capability per channel:	2.0 amps continuous or 4 amps at 50% duty cycle
LED modes:	Sequential, synchronized and free-running
Analog control resolution:	12 bit

DH-2000-CAL

UV-NIR Radiometric Calibration Source

The DH-2000-CAL Deuterium Tungsten Halogen Calibration Standard is a UV-NIR light source used to calibrate the absolute spectral response of a radiometric system. With the DH-2000-CAL and SpectraSuite Software, you can determine known absolute intensity values at wavelengths from 220-1050 nm.

The DH-2000-CAL is specifically calibrated for use with optical fibers or a cosine corrector. The calibration data includes absolute intensities for wavelengths between 220-1050 nm at the fiber entrance port for both a bare fiber and a CC-3-UV Cosine Corrector.

Features

- UV-NIR Calibration Source. For use in performing fast, radiometric calibrations from 220-1050 nm
- NIST-traceable Calibration from 220-1050 nm. Provides absolute spectral intensity in µW/cm2/nm at the fiber port
- Calibration Certificate. Calibration data is provided in paper and electronic formats for use with SpectraSuite Software

Included with the Lamp

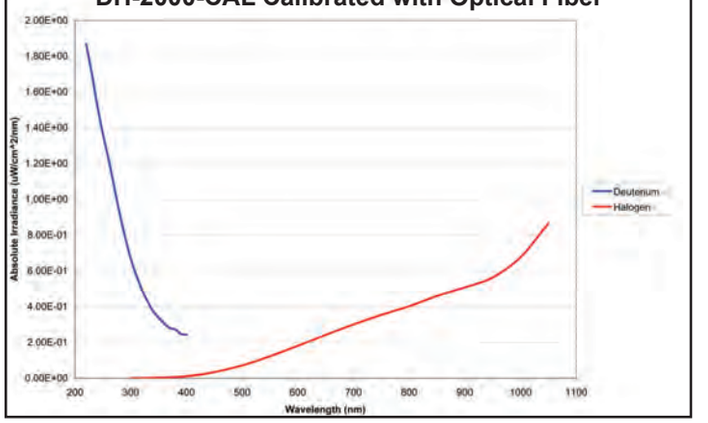
The DH-2000-CAL comes with the CC-3-UV Cosine Corrector. Also included are a calibration certificate and a diskette with a data file for use with our Spectra-Suite Software.

Other Calibration Services

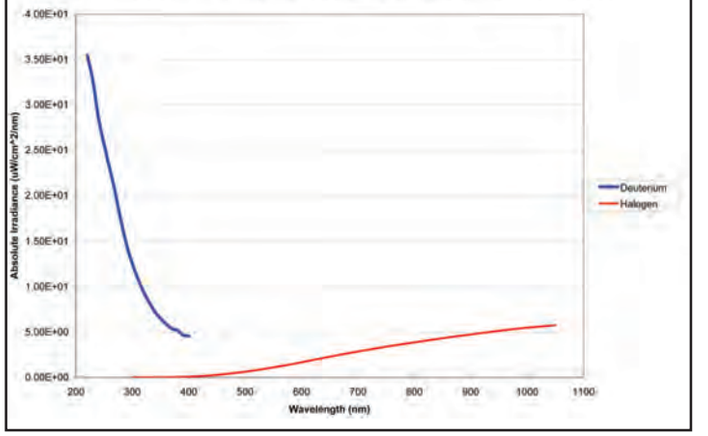
The DH-2000-CAL typically provides about 50 hours of operation before recalibration is necessary. Ocean Optics recalibrates these lamps in-house. Also, by using our SPEC-CAL-UV in-house calibration service, it is possible to have your UV spectrometer radiometrically calibrated without purchasing a DH-2000-CAL.

The calibration is typically good for about one year, provided the original calibration configuration is not disturbed.

DH-2000-CAL Calibrated with Optical Fiber



DH-2000-CAL Calibrated with Cosine Corrector



Specifications	
Dimensions:	150 mm x 135 mm x 319 mm
Weight:	6 kg
Power consumption:	25 W (deuterium); 20 W (tungsten halogen)
Calibrated range:	220-1050 nm
Calibration accuracy:	+/-5%
Calibration valid for:	50 hours
Lamp current:	Operating 85 V/0.3A
Lamp voltage:	350 V
Power requirements:	85-264 V 50/60 Hz
Current voltage drift:	<0.01% per hour
Current voltage stability:	<5 x 10^6 peak-to-peak (0.1-10.0 Hz)
Humidity:	5-95% without condensation at 40 °C
Operating temperature:	5 °C - 35 °C
Total power:	100 W
Power consumption:	190 W maximum
Warm-up time:	40 minutes (deuterium); 20 minutes (tungsten halogen)
Markings:	CE; VDI/VDE 0160; EN 61010

Models Available	
DH2000-CAL	NIST-traceable UV-NIR (220-1050 nm) calibration source
DH2000-RECAL	Recalibration service from 220-1050 nm
DH2000-CAL-EXT	Upgrade for extended range from 1050-2200 nm
DH2000-RECAL-EXT	Upgrade recalibration service from 1050-2200 nm

HL-2000-CAL

VIS-NIR Radiometric Calibration Source

The HL-2000-CAL Calibrated Tungsten Halogen Light Source can calibrate the absolute spectral response of a spectroradiometric system.

With this NIST-traceable light source and SpectraSuite Software, you can determine known absolute intensity values at wavelengths from 300-1050 nm. Calibration at wavelengths <380 nm may require special consideration. Contact an Applications Scientist for details.

Features

- NIST-traceable calibration from 300-1050 nm. Provides absolute spectral intensity in µW/cm2/nm at the fiber port
- Multiple calibration options. Source can be calibrated specifically for a bare fiber, a fiber plus cosine corrector, or an integrating sphere
- Calibration certificate. Calibration data is provided in paper and electronic formats, for use with SpectraSuite

Calibrated for Use with Fiber and Cosine Corrector

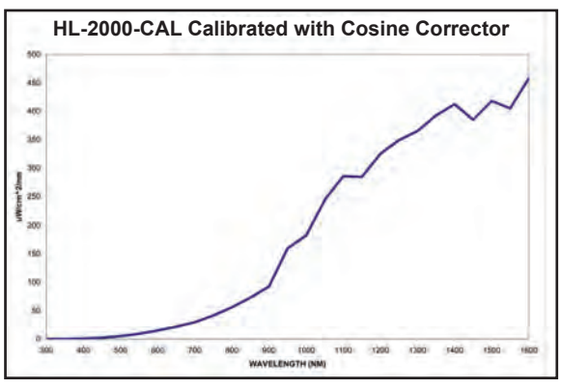
The HL-2000-CAL is designed for calibrating a system consisting of a spectrometer and an optical fiber or cosine corrector as the sampling optic. The calibration data for the HL-2000-CAL includes absolute intensities for wavelengths between 300-1050 nm.

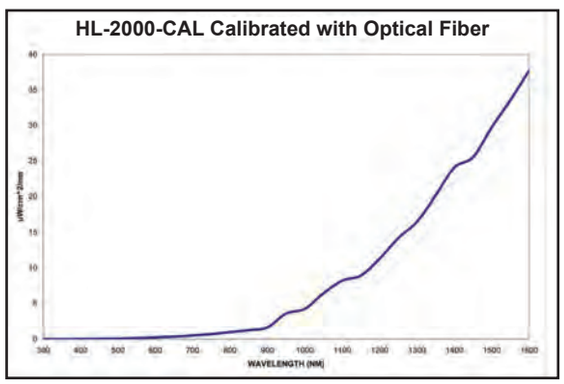
Calibrated for Use with Integrating Spheres

The HL-2000-CAL-ISP is designed for calibrating the absolute spectral response of your system when using the ISP-50-8-I Integrating Sphere as your sampling optic.

Included with the Lamp

The HL-2000-CAL comes with a regulated 12 VDC power supply. Also included is a calibration certificate and a diskette with data files for use with our irradiance software. A cosine corrector is available for an additional charge .





Specifications	
Spectral range (calibrated):	300-1050 nm (calibrated)
Power consumption:	600 mA @ 12 VDC
Power output:	6.5 watts
Bulb life:	900 hours (recommend recalibration after 50 hours of use)
Recalibration:	Required after ~50 hours of operation
Bulb color temperature:	3100 K
Output to bulb:	5 volts/1.3 amps
Output regulation:	0.2% voltage
Time to stabilized output:	~30 minutes
Connector:	SMA 905 for fiber; 6.35-mm barrel for cosine corrector; PTFE plug for integrating sphere

We also carry a high-power version for all your spectroscopy needs.

HL-2000-HP-CAL
Radiometrically Calibrated
HL-2000 High Power,
20W, 380-1050 nm

Spectrometer Wavelength Calibration Sources

Full Range of Emission Sources for Hundreds of Applications

We offer gas-discharge emission sources for spectrometer wavelength calibration that cover wavelengths ranging from ~250-2000 nm. With five different options – Mercury-Argon (HG-1), Krypton (KR-1), Neon (NE-1), Argon (AR-1) and Xenon (XE-1) – you can select a source with an optimum number of emission lines in your spectral region of interest. With more emission lines, correcting for baseline drift and related phenomena inherent to all spectrometers is more easily and reliably achieved. Also, many of the most intense emission lines are conveniently printed on each calibration source label.

Table of Emission Lines for Spectrometer Wavelength Calibration Sources

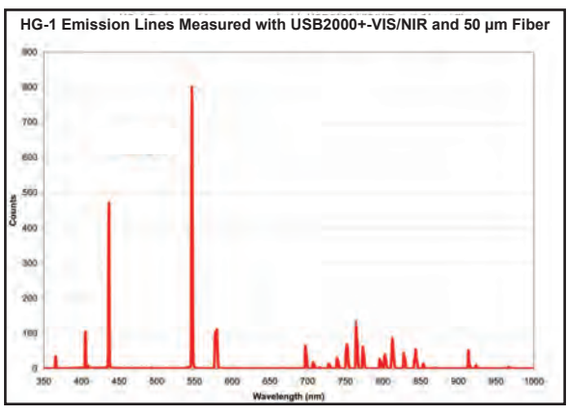
Peak	Lamp	Peak	Lamp	Peak	Lamp	Peak	Lamp	Peak	Lamp
253.652	Hg	480.702	Xe	692.947	Ne	892.869	Kr	1362.266	Ar
296.728	Hg	482.971	Xe	703.241	Ne	904.545	Xe	1363.422	Kr
302.150	Hg	484.329	Xe	717.394	Ne	912.297	Ar	1365.706	Xe
313.155	Hg	491.651	Xe	724.512	Ne	916.265	Xe	1367.855	Ar
334.148	Hg	492.315	Xe	733.930	Xe	922.450	Ar	1371.858	Ar
341.790	Ne	503.135	Ne	738.600	Xe	935.422	Ar	1382.572	Ar
342.391	Ne	503.775	Ne	739.379	Xe	965.779	Ar	1390.748	Ar
344.770	Ne	508.038	Ne	740.040	Xe	978.450	Ar	1409.364	Ar
345.076	Ne	511.367	Ne	743.890	Ne	979.970	Xe	1414.244	Xe
345.419	Ne	511.650	Ne	747.244	Ne	992.319	Xe	1442.679	Kr
346.052	Ne	540.056	Ne	748.887	Ne	1047.005	Ar	1473.281	Xe
346.658	Ne	546.074	Hg	753.577	Ne	1067.357	Ar	1473.444	Kr
347.257	Ne	556.222	Kr	754.404	Ne	1083.837	Xe	1504.65	Ar
349.806	Ne	557.029	Kr	755.979	Xe	1107.887	Ar	1517.269	Ar
350.121	Ne	576.441	Ne	758.468	Xe	1117.752	Ne	1520.310	Kr
351.519	Ne	576.960	Hg	758.741	Kr	1144.183	Ar	1532.934	Ar
352.047	Ne	579.066	Hg	760.155	Kr	1148.811	Ar	1537.204	Kr
359.353	Ne	582.015	Ne	764.391	Xe	1152.275	Ne	1541.839	Xe
360.017	Ne	585.249	Ne	768.525	Kr	1166.871	Ar	1598.949	Ar
363.366	Ne	587.096	Kr	769.454	Kr	1171.949	Ar	1605.328	Xe
365.015	Hg	588.189	Ne	780.265	Xe	1181.938	Kr	1620.872	Kr
368.573	Ne	594.483	Ne	785.482	Kr	1211.233	Ar	1647.29	Xe
370.122	Ne	597.553	Ne	788.132	Xe	1213.974	Ar	1656.023	Xe
404.656	Hg	602.000	Ne	791.343	Kr	1220.353	Kr	1672.815	Xe
407.783	Hg	607.433	Ne	796.734	Xe	1234.339	Ar	1689.676	Kr
431.958	Kr	609.616	Ne	805.726	Xe	1243.932	Ar	1694.058	Ar
435.833	Hg	612.884	Ne	805.950	Kr	1248.766	Ar	1704.288	Ar
436.264	Kr	614.306	Ne	806.134	Xe	1262.339	Xe	1755.350	Kr
437.612	Kr	616.359	Ne	810.436	Kr	1270.228	Ar	1763.882	Xe
439.997	Kr	621.728	Ne	819.006	Kr	1273.342	Ar	1785.738	Kr
445.392	Kr	626.649	Ne	823.163	Xe	1280.274	Ar	1790.45	Xe
446.369	Kr	630.479	Ne	826.324	Kr	1295.666	Ar	1800.223	Kr
450.235	Kr	633.442	Ne	826.652	Xe	1300.826	Ar	1809.09	Xe
452.186	Xe	638.299	Ne	829.811	Kr	1317.741	Kr	1816.733	Kr
462.420	Xe	640.225	Ne	837.761	Ne	1322.811	Ar	1832.53	Xe
466.849	Xe	650.653	Ne	849.536	Ne	1322.811	Ar	1959.94	Xe
469.097	Xe	653.288	Ne	866.794	Ar	1327.264	Ar	1984.638	Xe
469.804	Xe	659.895	Ne	877.675	Kr	1331.321	Ar	2190.851	Kr
473.415	Xe	667.828	Ne	878.375	Ne	1336.711	Ar		
479.262	Xe	671.704	Ne	881.941	Xe	1350.419	Ar		

Spectrometer Wavelength Calibration Sources

Compact Sources and Adapters

HG-1 Mercury Calibration Source

Our compact, low-cost HG-1 Mercury Argon Calibration Source is a spectral wavelength calibration source for UV-VIS-Shortwave NIR spectrophotometric systems. The HG-1 produces first order mercury and argon spectral lines from 253-922 nm and second order argon lines to 1700 nm for use in performing fast, reliable spectrometer wavelength calibrations. Easily identifiable mercury and argon spectral emission lines are printed on the HG-1 housing.



Output:	Low-pressure gas discharge lines of mercury
Spectral range:	253-1700 nm (253-922 nm first order emission lines)
Dimensions (in mm):	125.7 x 70 x 25.8
Power consumption:	250 mA at 12 VDC
Power requirements:	12 VDC wall transformer (included) or 9 VDC battery (additional)
Internal voltage:	600 volts at 30 kHz
Bulb life:	~ 3,500 hours (at 20 mA)
Amplitude stabilization:	~1 minute
Aperture:	3 mm
Connector:	SMA 905

Cuvette Wavelength Calibration Adapter

The PS-HG1-ADP Wavelength Calibration Adapter is a 1-cm square fixture that fits into a 1-cm pathlength sample chamber and connects to the AR-1 via optical fiber. (Wavelength calibration standard and fiber are sold separately).

The adapter is designed for performing a wavelength calibration for any spectrometer and 1-cm cuvette holder system, whether it's designed by Ocean Optics or another manufacturer.

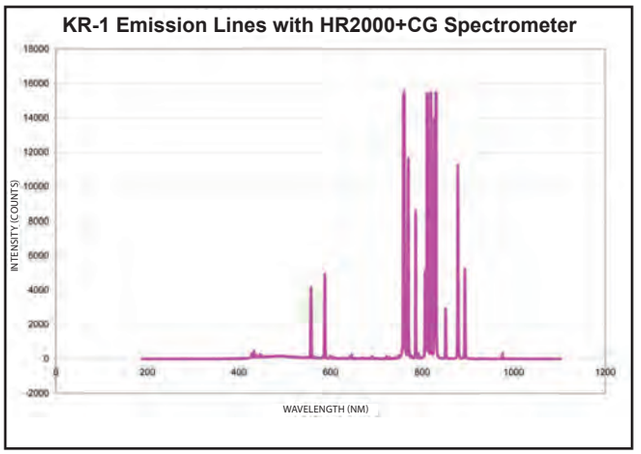
Item Code: PS-HG1-ADP

Spectrometer Wavelength Calibration Sources

Compact Sources with Well-Defined Emission Lines

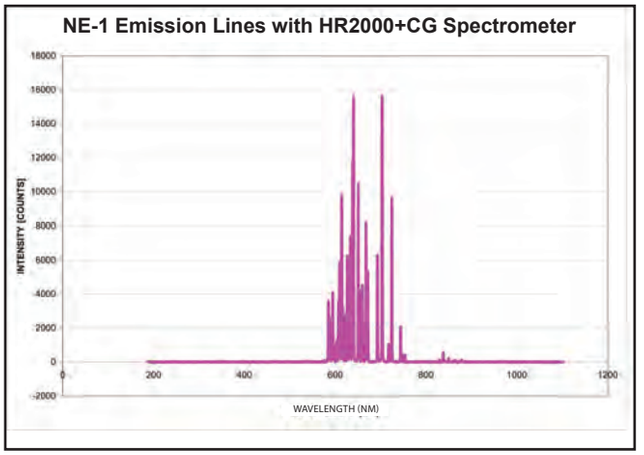
Our spectrometer wavelength calibration sources are available in more models covering more wavelengths than ever before. Those extra emission lines let you calibrate your spectrometer wavelength with greater precision and reliability. And, unlike radiometric sources that require NIST certification, these sources have atomic emission lines that are determined by quantum mechanics. Additionally, there are more emission lines for each source than may be printed on the product label.

KR-1 Krypton Calibration Source



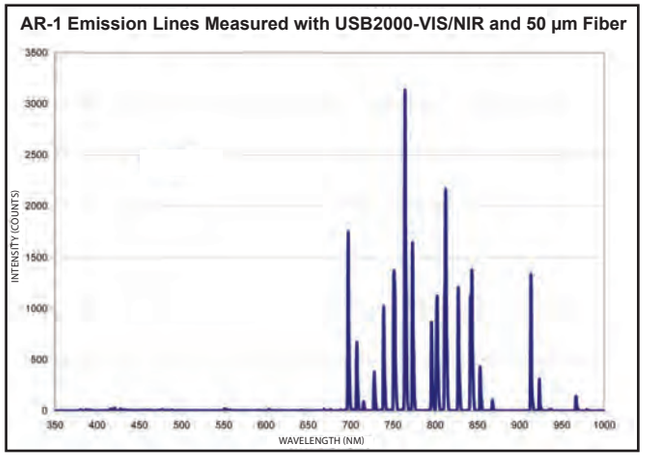
Output	Low-pressure gas discharge lines of Krypton
Spectral range:	427-893 nm
Dimensions (in mm):	125.7 x 70 x 25.8
Power consumption:	250 mA at 12 VDC
Power requirements:	12 VDC wall transformer (included) or 9 VDC battery (optional)
Bulb life:	Approx. 3500 hours (at 20 mA)
Internal voltage:	600 volts at 30 kHz
Aperture:	3 mm
Amplitude stabilization:	~ 1 minute
Connector:	SMA 905

NE-1 Neon Calibration Source



Output	Low-pressure gas discharge lines of Neon
Spectral range:	540-754 nm
Dimensions (in mm):	125.7 x 70 x 25.8
Power consumption:	250 mA at 12 VDC
Power requirements:	12 VDC wall transformer (included) or 9 VDC battery (optional)
Bulb life:	3500 hours (at 20 mA)
Internal voltage:	600 volts at 30 kHz
Aperture:	3 mm
Amplitude stabilization:	~ 1 minute
Connector:	SMA 905

AR-1 Argon Calibration Source

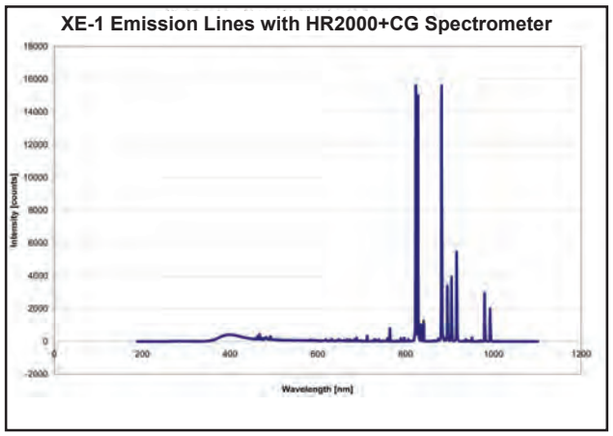


Output:	Low-pressure gas discharge lines of Argon
Spectral range:	696-1704 nm
Dimensions (in mm):	125.7 x 70 x 25.8
Weight:	40 g
Power consumption:	250 mA at 12 VDC
Power requirements:	12 VDC wall transformer (included) or 9VDC battery (optional)
Bulb life:	~ 3,500 hours (at 20 mA)
Internal voltage:	600 volts at 30 kHz
Aperture:	3 mm
Amplitude stabilization:	~1 minute
Connector:	SMA 905

Spectrometer Wavelength Calibration Sources

Compact Sources with Well-Defined Emission Lines

XE-1 Xenon Calibration Source



Output	Low-pressure gas discharge lines of Xenon
Spectral range:	916-1984 nm
Dimensions (in mm):	125.7 x 70 x 25.8
Power consumption:	250 mA at 12 VDC
Power requirements:	12 VDC wall transformer (included) or 9 VDC battery (optional)
Bulb life:	Approx. 3500 hours (at 20 mA)
Internal voltage:	600 volts at 30 kHz
Aperture:	3 mm
Amplitude stabilization:	~ 1 minute
Connector:	SMA 905

Technical Tip
Recalibration of Spectral Instruments

Proper analytical procedures require the use of standards or reference materials for performance monitoring of any spectral instrument. If such monitoring shows that the instrument is not performing according to its designed parameters, the instrument needs to be recalibrated to bring it back to peak performance and ensure good measurements and reliable results.

In electronic-based instruments, special software programs take care of the recalibration. These programs use sometimes complex mathematical algorithms to transform the actual measurements into standardized results by making minor adjustments to the electronics gain and baselines, data collection rates, power conditioning and other factors inherent to the instrument.

In simple terms, the recalibration is telling the instrument to go back to its original factory settings or at least to certain values considered to be part of the tolerances of the device. However, recalibration can only do so much. If this procedure fails, the instrument will need major adjustments that generally require the use of specialized tools and trained personnel.

With spectrometers, wavelength monitoring and recalibration requires the use of a reference light source that emits well-defined wavelengths. High purity gas or vapor lamps (light sources) are the primary standards recommended for testing wavelength accuracy. Light sources such as a mercury vapor lamp are recommended by testing organizations such as ASTM (E275-01 and E925-02), United States Pharmacopeia (USP) and British Pharmacopoeia (V.6.19).

Low-pressure mercury vapor lamps have a number of intense, narrow and well identified emission bands that cover the UV-VIS spectral range. Argon-filled and other similar lamps are used for monitoring and calibrating in the NIR spectral range. It is also common to use a combination of gases in order to manufacture reference light sources to cover extended spectral ranges.

A highly recommended practice before taking a measurement using a spectrometer is to first measure the reference light source. If the emission lines are detected at their specified wavelength, the actual experiment can follow. If there is drift between the expected values and the results, the instrument must be recalibrated and the calibration confirmed by measuring the reference source (monitoring again) with the spectrometer in Acquisition mode.

If the monitored results are satisfactory, it is recommended that the experimental measurements be taken relatively soon after the recalibration. Depending on the required accuracy of the results, the calibration step might be postponed or programmed to occur on a regular basis after developing a calibration procedure based on statistical data and method development for the application.

Light Source Accessories

Parts and Replacement Items

Item code	Description
Light Bulbs and Accessories	
CAL2000-B	Replacement bulb for CAL-2000 Spectrometer Wavelength Calibration Sources
DH-2000-BD	Deuterium Bulb for D-2000 and DH-2000, 215-400 nm, 1000 hrs
DH-2000-BH	Halogen Bulb for all DH-2000s, 360-2500-nm, 900 hrs, 3100K
DH-2000-DUV-B	Deep UV Deuterium Bulb, 190-2000 nm, 1000 hrs
DT-MINI-2-B	Bulb for DT-MINI-2 and DT-MINI-2-GS Light Source (yellow housing)
DT-MINI-B	Bulb for DT-MINI Light Source (blue/white housing)
HL-2000-B	Bulb for HL-2000, HL-2000-FHSA, 1500 hrs (red/black)
HL-2000-B-LL	Bulb for HL-2000-LL, 10,000 hrs
HL-2000-HP-B	Bulb for HL-2000-HP
HPX-2000-BM	Bulb module assembly for field replacement of HPX-2000 bulb
REPAIR-HPX-1	Service charge and bulb fee for factory replacement of HPX-2000 bulb
LS-1-B	Bulb for LS-1, 900 hrs, 3100K
LS-1-LL-B	Bulb for LS-1-LL, 360-2000 nm, 10,000 hrs, 2800K
PX-2-B	Bulb for PX-2 Lamp
ZGOGGLES	UV Goggles
USB-DT-B	Replacement bulb for USB-DT; requires factory installation
USB-ISS-UV-B	Replacement bulb for USB-ISS-UV-VIS; requires factory installation
USB-ISS-VIS-B	Replacement bulb for USB-ISS-VIS; requires factory installation
Power Supplies	
LED-PS+JAZ	Power supply for LLS LED sources when used with Jaz
WT-12V	Regulated 12 V universal power supply (1.5A, 110/220 VAC)
WT-12V-R	Regulated 12 VDC power supply (2.5 A, 110 V)
WT-12V-R-E	Regulated 12 VDC power supply 2.5 A, with European-version cord for connecting power supply to wall outlet
WT-24V	24 VDC power supply (110 V)
WT-15V-LLS-UV	15V, 0.4A Power Supply for High-Power UV LED Light Source - includes interchangeable plugs
WT-6V-LLS-VIS	6V, 3A Power Supply for High-Power VIS LED Light Source - includes interchangeable plugs
WT-9V-COOLRED-EU	24V, 6.25A Energy-Star Power Supply for COOL-RED, European (220 VAC) Power Cord
WT-9V-COOLRED-US	24V, 6.25A Energy-Star Power Supply for COOL-RED - US (110VAC) Power Cord
WT-9V-MCLS-AU	9V, 4A Energy-Star Power Supply for MCLS - includes Australian and US Power Cords
WT-9V-MCLS-EU	9V, 4A Energy-Star Power Supply for MCLS - includes European and US Power Cords
WT-9V-MCLS-UK	9V, 4A Energy-Star Power Supply for MCLS - includes UK and US Power Cords
WT-9V-MCLS-US	9V, 4A Energy-Star Power Supply for MCLS - includes US-Only Power Cord

Bulb for the HL-2000

The DH2000-BH tungsten halogen bulb used in all DH2000s

The DH2000-BD deuterium bulb used in all D-2000s and DH-2000s

Bulb module for the HPX-2000

Quick Tip: Jaz Light Source Accessories

For more information on spare bulbs, accessories and power supplies for Jaz light source modules, see pages 72-74. For most Jaz light sources, bulb replacement requires factory installation. An exception is the Jaz line of interchangeable LEDs. Contact an application scientist for details.

Sampling Accessories

Our modular components can be easily configured for absorbance, transmission, reflectance, fluorescence, emission or scattering experiments. These fiber optic sampling accessories create the optical interface of our modular spectrometer systems.

And, with so many sampling accessories to choose from, Ocean Optics can readily meet the demands of your unique application needs.

Tip

Collimating lenses are among our most versatile sampling accessories. Lenses convert divergent beams of radiation into a parallel beam and are optimized for UV-NIR wavelengths. With collimating lenses, you can adjust for variables such as FOV, collection efficiency, spatial resolution and lens transmission and acceptance angles.

Sampling Accessories

A Sea of Tools for Sample Handling

Your optimal choice of sampling accessory depends on the application. Are you measuring absorbance, reflectance or emission? Is your sample a solid or solution? Does it have a smooth, even surface or an irregular surface? Do you need to collect radiation from a particular field of view?

Those are just a few of the many questions that enter into your sampling accessory decision. And, much like your choice of spectrometer and optical bench accessories, the key question is a simple one: Why are you making the measurements?

Example Sampling Accessory Options: Absorbance

With an extensive line of sampling accessories – and the flexibility to switch among them with ease – you have many options for tackling your experiment. Consider absorbance: accessories run the gamut from standard labware such as cuvettes and cuvette holders to more sophisticated tools such as flow injection analysis devices. Here are some criteria to consider for your absorbance setup:

Where will you make the measurement?

If you can isolate the sample in a container such as cuvette or test tube, your options extend to cuvette holders and similar devices. If you need to make the measurement in situ – in a process stream, for example -- you'll need a transmission dip probe (see Fibers and Probes section) or flow cell that can be embedded into the sample stream.

What is the optical density of your sample?

The OD of your sample directly affects the pathlength of the device you'll need for your measurement. Cuvette holders, for example, are available with pathlengths of 1 cm and 10 cm. The more optically dense the sample, the shorter the pathlength that's required. On the other hand, low OD solutions require longer pathlengths. Use Beer's Law to help you determine the best pathlength.

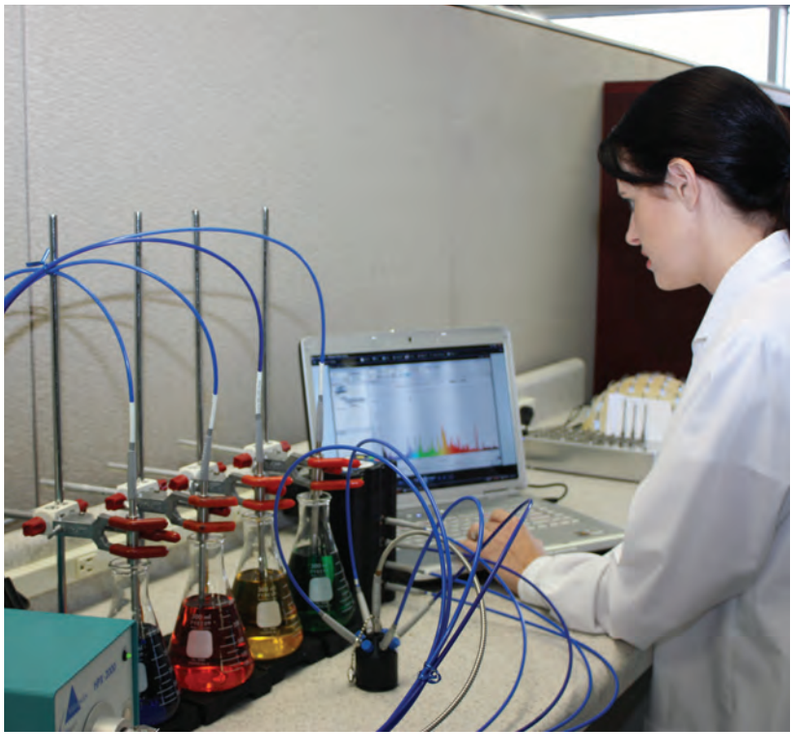
What is the sample volume?

The amount of sample you measure also affects your choice of sampling accessory. We offer microvolume-level cuvettes and pipetters for applications with sample volumes as low as 2 µl.

Does your sample require continuous flow?

We offer sampling accessories such as flow cells that can be coupled with pumps, tubing and fittings to stream sample fluids for absorbance and other measurements.

That's just absorbance. We also offer nearly 500 sampling accessories for reflectance, emission, fluorescence and other measurements. Our Applications Scientist can help you choose the best option for your application.

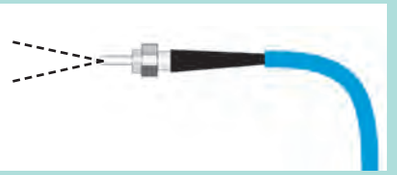


What's Your Field of View?

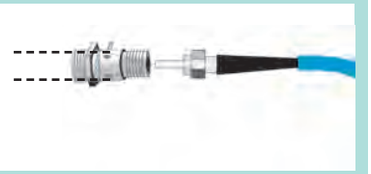
Four of our devices are used to control field of view (FOV) and aperture:

1. Optical Fiber (25° FOV, aperture = fiber diameter)
2. Collimating Lens (0° - 45° FOV, aperture = 3 mm)
3. Cosine Corrector (180° FOV, aperture = 3.9 mm)
4. Integrating Sphere (360° FOV, aperture = 25 mm)

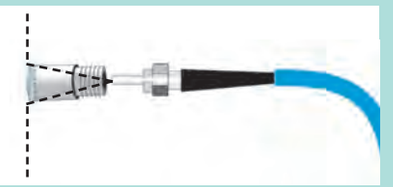
Optical Fiber: 25°



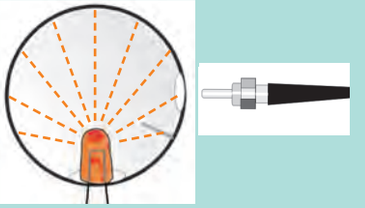
Adjustable Collimating Lens: ~0-45°



Cosine Corrector: ~180°



Integrating Sphere: 360°



Technical Tip

The divergence **(α)** of a beam focused using a single lens is: **tan(α) = d/f** where **f** is the focal length of the lens and **d** is the aperture of the spectrometer.

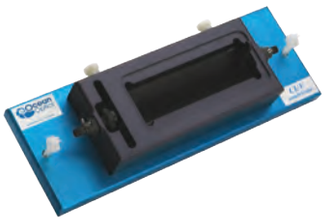
Sampling Accessories

Choosing Your Accessory by Measurement Type

We proudly offer a full range of Sampling Accessories that help you obtain accurate, reliable measurements in virtually any environment.

Absorbance and Transmission

1-cm Cuvette Holder
See Page 110

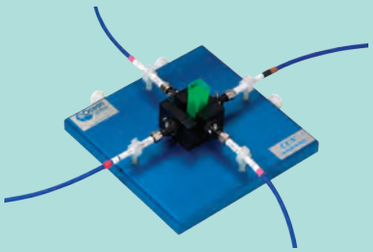


10-cm Cuvette Holder
See Page 110

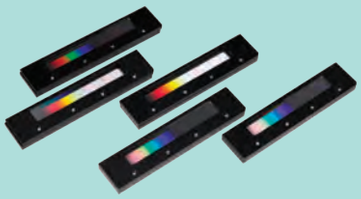
Longpass Flow Cells
See Page 116

Cuvettes
See Page 113

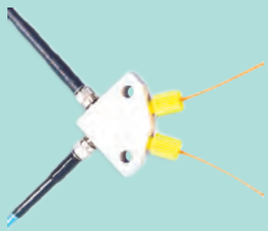
Fluorescence



4-way Cuvette Holder
See Page 110



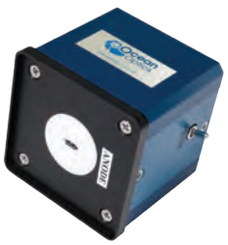
Linear Variable Filters
See Page 127



Flow Cells
See Page 114

Emission

Cosine Correctors
See Page 118



LED Power Supply
See Page 118

Integrating Spheres
See Page 119

Collimating Lenses
See Page 108

Reflectance

Diffuse Reflectance Standards
See Page 125

Integrating Spheres
See Page 120

Multifunction Reflection Stage
See Page 123

Sampling Accessories
Collimating Lenses

74-Series Lens Fixtures
Our 74-Series Collimating Lens Fixtures are the common fiber optic-coupled lens fixtures used throughout our extensive line of sampling accessories. They feature an inner barrel threaded for SMA 905 Connectors.

74-UV Collimating Lens

(200-2000 nm) The 74-UV has an f/2 fused silica lens for 200-2000 nm. When focused for collimation, beam divergence is 2° or less, depending on fiber diameter. The 74-UV can be adjusted for UV-VIS or VIS-NIR setups.

74-90-UV Collimating Lens

(200-2000 nm) The 74-90-UV features a mirror located under its cap that reflects light from the collimating lens to 90°. The mirror is coated with a UV-enhanced aluminum substrate that is >80% reflective from 200-2000 nm.

74-VIS Collimating Lens

(350-2000 nm) The 74-VIS has a BK7 lens suitable for the VIS-NIR. These single-lens systems have the disadvantage of chromatic aberration, due to dispersion or variation in refractive index with wavelength.

74-ACR Collimating Lens
(350-2000 nm) The 74-ACR has two optical elements cemented together to form an achromatic doublet, optimized to correct for spherical and chromatic aberrations.

74-DA Collimating Lens

(200-2000 nm) The 74-DA Direct-attach Collimating Lens screws on to a spectrometer's SMA 905 Connector for increased light throughput. The lens collects collimated light in a straight path of open air and focuses it onto a spectrometer's slit.

COL-UV-30 Collimating Lens

(200-2000 nm) This 74-series Collimating Lens is our largest-diameter lens – 30 mm – and couples to SMA 905 connectors for simple use.

84-Series Lens Fixtures

(200-2000 nm) The 84-Series Collimating Lens is designed for coupling larger free-space beams to optical fibers. The fiber is coupled to the assembly with an inner 17.85 mm threaded barrel. The barrel positions the fiber ~100 mm from the lens surface and is turned to achieve a fine focus.

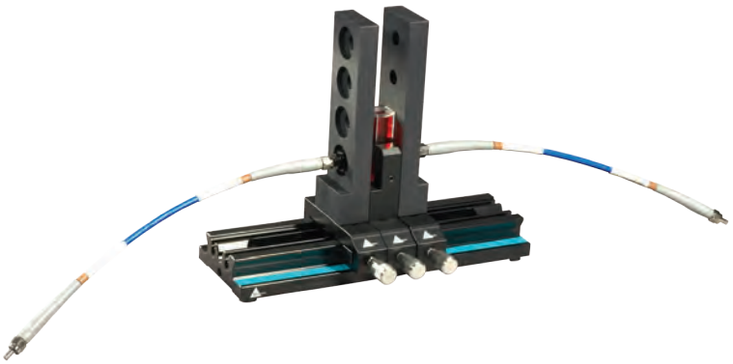
Item	Diameter	Focal Length	Material	Range	Operating Temp	Connector
74-UV	5 mm	10 mm	f/2 fused silica Dynasil	200-2000 nm	150 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread
74-90-UV	5 mm	10 mm	f/2 fused silica Dynasil	200-2000 nm	120 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread
74-VIS	5 mm	10 mm	f/2 BK7 glass	350-2000 nm	150 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread
74-ACR	5 mm	10 mm	f/2 BaF10 and FD10 fused silica	350-2000 nm	150 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread
74-DA	5 mm	10 mm	f/2 fused silica Dynasil	200-2000 nm	150 °C	SMA 905, 1/4-36 internal thread, 3/8-24 external thread
COL-UV-30	30 mm	30 mm	f/2 fused silica Suprasil	200-2000 nm	200 °C	SMA 905, 6.35-mm ferrule, 1/4-36 external thread
84-UV-25	25.4 mm	100 mm	f/2 fused silica Dynasil	200-2000 nm	70 °C	SMA 905, 6.35-mm ferrule, 1/4-36 external thread

Sampling Accessories
Collimating Lenses

ACH-CUV-VAR
Adjustable Collimating Lens and Cuvette Holder

The ACH-CUV-VAR Adjustable Collimating Lens and Cuvette Holder is two products in one: a fixture for positioning collimating lenses at various heights or for holding extra-large or especially thick samples, and a holder for accepting cuvettes for transmission measurements.

As a lens holder, the ACH-CUV-VAR has an anodized aluminum base and adjustable mount bars with 3/8-24 threaded holes for collimating lenses (two 74-UV Collimating Lenses are included). The bars can be adjusted to accept samples up to ~150 mm thick and the base is marked in 1-mm intervals as a pathlength guide. The ACH-CUV-VAR has a cuvette holder component that fits securely between the two mount bars and can accept cuvettes up to ~150-mm wide.



OPM-SMA
Optical Post Mount

The OPM-SMA is a fixture for mounting 74-Series Collimating Lenses and SMA 905-terminated optical fibers. The OPM-SMA consists of a 1.5-inch OD disk with 3/8-24 threads for use with lenses and an adapter for use with SMA 905-terminated optical fibers. A special adapter that holds an SMA 905-terminated optical fiber flush against one surface of the OPM-SMA is included. The OPM-SMA also includes 8-32 (Imperial) and M6 (metric) threads for attachment to an optical post.

OPM-M
Optical Post Mount Assemblies

We offer four stainless steel optical posts (in 25.4-mm, 50.8-mm, 76.2-mm and 101.6-mm heights) to attach to the OPM-SMA. These posts have a 12.7 mm OD and screw into optical breadboards via a 1/4"-20 (M6) tapped hole in the bottom of each post. The posts also have a removable 8-32 (M4) threaded stud.

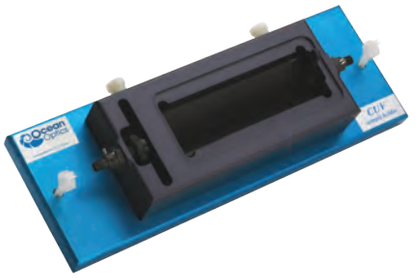
Item Codes: OPM-1, OPM-2, OPM-3, OPM-4

Specification	OPM-SMA	OPM-M
Dimensions (in mm):	38.1 OD x 10.2 width	30 mm OD x 6.5 width
Weight:	130 g (including post)	220 g (including post)
Collimating lens included:	No	No
Threads:	3/8-24 (lens holder) 8-32 (bore for mounting)	3/8-24 (lens holder) M4 (bore for mounting)
Material:	Black anodized Al (mount) and stainless steel (post)	Black anodized Al (mount) and stainless steel (post)

Sampling Accessories
Cuvette Holders

CUV-UV
Holder for 1-cm Cuvettes
The CUV-UV Cuvette Holder for 1-cm pathlength cuvettes couples via SMA 905-terminated optical fibers to Ocean Optics high-sensitivity miniature fiber optic spectrometers and light sources to create small-footprint spectrophotometric systems for absolute absorbance measurements of aqueous solutions. This compact cuvette holder is optimized for UV-VIS-NIR. (~200-2000 nm) applications.

CUV-UV-10
Holder for 10-cm Cuvettes
The CUV-UV-10 Cuvette Holder for 10-cm pathlength cuvettes couples via SMA 905-terminated optical fibers to Ocean Optics high-sensitivity miniature fiber optic spectrometers and light sources to create small-footprint spectrophotometric systems for absorbance/transmission measurements of aqueous solutions and gases. This compact cuvette holder is optimized for UV-VIS-NIR. (~200-2000 nm) applications.



CUV-ALL
4-way Holder for 1-cm Cuvettes
The CUV-ALL-UV 4-way Cuvette Holder for 1-cm pathlength cuvettes is equipped with fiber optic couplings at each of four quartz f/2 collimating lenses, which couple to optical fibers to either read or illuminate the sample. When used with Ocean Optics modular spectrometers and light sources, CUV-ALL-UV Cuvette Holders can measure absorbance, fluorescence, scattering or any combination of these optical phenomena.

CUV-FL-DA
Direct-attach Cuvette Holder
The CUV-FL-DA Cuvette Holder attaches directly to Ocean Optics light sources and couples via SMA 905-terminated optical fibers to our spectrometers, creating an incredibly small-footprint spectrophotometric system for fluorescence and relative absorbance experiments. The CUV-FL-DA, optimized for UV-VIS-NIR (200-2000 nm) applications, holds 1-cm square cuvettes.

74-MSP
Mirror Screw Plugs
Designed for use with our fluorescence cuvette holders, our Mirror Screw Plugs are inserted into a collimating lens port on the cuvette holder to redirect energy back to the sample or back into a collimating lens. This increases signal collection for fluorescence measurements.

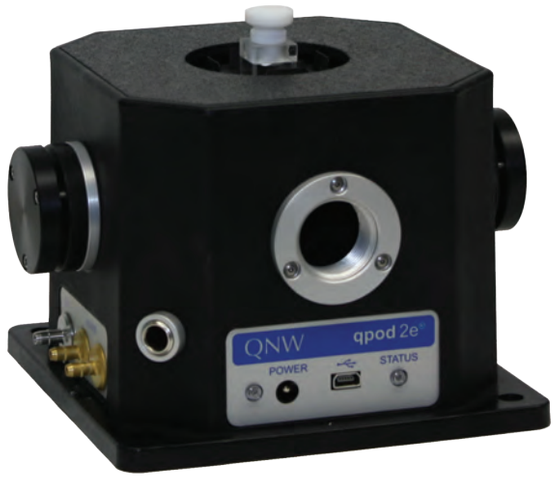
Specifications	CUV-UV	CUV-UV-10	CUV-ALL-UV	CUV-FL-DA
Dimensions:	58 mm x 140 mm x 38 mm	97 mm x 147 mm x 40 mm	147 mm x 147 mm x 40 mm	57 mm x 61 mm x 29 mm
Weight:	230 g	1.4 kg	540 g	80 g
Pathlength:	1 cm	10 cm	1 cm	1 cm
Z dimension:	15 mm	15 mm	15 mm	15 mm
Filter slot:	Up to 6 mm, screw clamp	Up to 6 mm, wheel clamp	Up to 6 mm, screw clamp	Up to 6 mm, screw clamp
Water input fittings:	3.175 mm (1/8") NPT	3.175 mm (1/8") NPT	3.175 mm (1/8") NPT	NA
Collimating lens:	2 each 74-UV	2 each 74-UV	4 each 74-UV	2 each 74-UV
Fiber termination:	SMA 905	SMA 905	SMA 905	SMA 905

Sampling Accessories
Temperature-Regulated Cuvette Holders

CUV-QPOD-2e
Temperature-Controlled Cuvette Holder

The qpod™ is a temperature-regulated sample compartment for fiber optic spectroscopy that controls the temperature of standard 1-cm square cuvettes to +/-0.05 ºC. The unit includes a Peltier controller, magnetic stirrer and fused silica focusing lenses, and has SMA 905 connectors for easy coupling to Ocean Optics spectrometers and accessories. The qpod is built for cuvettes with a Z-dimension of 8.5 mm.

When combined with Ocean Optics spectrometers and accessories, the qpod is especially useful for absorbance and fluorescence measurements that require stringent control of the sample's temperature. Each unit is calibrated against a NIST-traceable thermometer; performance data is provided.



Here are some typical applications:

- DNA melting and annealing
- Protein thermodynamics
- Fluorophore characterization
- Enzyme kinetics
- On-line thermocycling of biological particles

Features

- Rapid and precise temperature control over a wide range of temperatures from -30 ºC to +105 ºC +/- 0.05 ºC (controllable to even lower temperatures under special conditions)
- Calibrated against a NIST-traceable thermometer with performance data provided
- Designed for standard 1 x 1 cm square cuvettes or standard microcuvettes
- All optical components have focusing and position adjustments to maximize light throughput
- Light-tight cover with access cap providing a means of holding a thermistor probe in the cuvette

The qpod was conceived by our channel partner Quantum Northwest as an improvement on its CUV-TLC-Series Temperature-regulated Cuvette Holders.

Available Items

Item	Description
CUV-QPOD-ABSKIT	Temperature Controlled Sample Compartment - Absorbance
CUV-QPOD-2E-ABSKIT	Temperature Controlled Sample Compartment -- Absorbance; USB/Bluetooth interface
CUV-QPOD-FLKIT	Temperature Controlled Sample Compartment - Fluorescence
CUV-QPOD-2E-FLKIT	Temperature Controlled Sample Compartment -- Fluorescence; USB/Bluetooth interface
CUV-QPOD-MPKIT	Temperature Controlled Compartment - Absorbance and Fluorescence
CUV-QPOD-2E-MPKIT	Temperature Controlled Sample Compartment -- Absorbance and Fluorescence; USB/Bluetooth interface
CUV-QPOD	Temperature Controlled Sample Compartment - No Optics
CUV-QPOD-CL-UV	Collimating Lens for qpod Absorbance
CUV-QPOD-IL-UV	Imaging Lens for qpod Fluorescence
CUV-QPOD-MP	Mirror Plug for qpod Sample Compartment
CUV-QPOD-POL	Polarizer for qpod Sample Compartment
CUV-QPOD-FH	Holder for 12.5 mm Diameter Optical Filter for qpod
CUV-QPOD-SER	Serial Interface for qpod External Computer Control
CUV-QPOD-16.10-Q	Micro-volume (10 ul) transmission cuvette
CUV-QPOD-16.100F-Q	Micro-volume (100 ul) fluorescence cuvette
CUV-QPOD-16.10F-Q	Micro-volume (10 ul) fluorescence cuvette
CUV-QPOD-Q-02SH	Oxygen holder for the qpod sample compartment
CUV-QPOD-THERM	Thermistor for the qpod sample compartment

Technical Tip

Proper use of cuvettes can help avoid measurement errors. For example, cuvettes always should be used in the same orientation. Most cuvettes have index marks as a guide. Also, it's important not to touch the optical surfaces of the cuvette. Oils from your skin, particles from wiping tissues and other contaminants can affect the readings.

For open-top square cuvettes, perhaps the most effective approach is to use a slender transfer or Pasteur pipette to add and remove fluids. The tiny tip allows for suction of fluid from the corners, minimizing the carry-over volume. The typical procedure is to rinse the cuvette with the next sample to be analyzed at least three times. If the residual fluid is less than 10% of the wash fluid (it's more likely to be 1% or less), the carry-over is reduced to 1/1000. It is important that the pipettes also be washed with the sample and not be allowed to touch or scratch the inside optical surfaces.

Sampling Accessories
Integrated Sampling Systems

These Integrated Sampling Systems are direct-attach cuvette holder and light source combinations created specifically for our USB2000+ and USB4000 Spectrometers (page 14). Both systems receive power and control signals though a connector on the spectrometer.

USB-ISS-UV-VIS
Integrated Sampling System

The USB-ISS-UV-VIS Integrated Sampling System is a direct-attach sample holder and deuterium tungsten halogen light source (200-1100 nm) combination for 1-cm square cuvettes. The USB-ISS-UV-VIS allows you to adjust the intensity of the bulb via software. The sampling system has an electronic shutter for taking dark measurements and comes with a 5-volt power supply.

USB-ISS-VIS
Integrated Sampling System

The USB-ISS-VIS Integrated Sampling System has a violet LED-boosted tungsten source (390-900 nm) and a sample holder that bolts to the front of a USB4000 or USB2000+ Spectrometer. The spectrometer provides the power and control signals for the light sources. The USB-ISS-VIS holds 1-cm cuvettes.

ISS-UV-VIS
Integrated Sampling System

The ISS-UV-VIS Integrated Sampling System is a combination RF deuterium source with a tungsten bulb in a housing connected to a holder for 1-cm cuvettes. This sampling system couples to an Ocean Optics spectrometer with optical fiber to create a small-footprint system for relative absorbance. This sampling system is best used with Ocean Optics' 300 µm solarization-resistant optical fiber.

ISS-2
Integrated Sampling System

The ISS-2 Integrated Sampling System is a fully integrated 1-cm cuvette holder and tungsten halogen light source for relative absorbance measurements. It couples to Ocean Optics spectrometers with optical fiber to create a small-footprint system for VIS-NIR (~360-1100 nm) applications.

Specifications	USB-ISS-UV-VIS	USB-ISS-VIS	ISS-UV-VIS	ISS-2
Dimensions (mm):	198 x 105.1 x 40.6	40.7 x 88.8 x 34.1	198 x 104.9 x 40.9	155 x 50 x 53.3
Weight:	200 g	130 g	400 g	240 g
Power consumption:	1.8 A @ 5 VDC	160 mA @ 5 VDC	420 mA @ 12 VDC	600 mA @ 12 VDC
Wavelength range (source):	~200-1100 nm (Typical)	390-900 nm (Typical)	~200-1100 nm (Typical)	~360-1100 nm (Typical)
Pathlength:	1 cm	1 cm	1 cm	1 cm
Cuvette shape:	Square	Square	Square	Square
Light source:	Deuterium tungsten	Tungsten and violet LED	Deuterium tungsten	Tungsten
Bulb life (hours):	800 (deut.); 2,000 (tung.)	2000 (tungsten); 45,000 (LED)	800 (deut.); 2,000 (tung.)	900
Time to stabilized output:	~30 minutes	~5 minutes	~30 minutes	~30 minutes
Filter slot:	None	None	None	6.35 mm
Recommended optical fibers:	None	None	QP400-025-SR	QP400-2-UV-VIS
Spectrometers:	USB2000+ and USB4000	USB2000+ and USB4000	All	All
"Z" dimension:	15 mm	15 mm	15 mm	15 mm

Sampling Accessories
Plastic and Quartz Cuvettes and More

Disposable Cuvettes

Our CVD-Series Disposable Cuvettes are a low-cost, zero-maintenance alternative to quartz cuvettes. They feature a 1-cm pathlength, 220-900 nm or 350-900 nm wavelength range coverage and a variety of fill volumes.

Quick tip: You can use a single cuvette for your measurements, but take care to rinse the cuvette thoroughly with the next sample being analyzed in order to eliminate cross-over contamination. Oils from your skin, particles from wiping tissues and other contaminants also can affect the readings. In addition, proper positioning of cuvettes is important. The cuvettes are marked with an arrow indicating the transmission path; the user consistently must position the cuvette with the arrow facing the light source.

CVD-VIS1M

CVD-UV1U

CVD-UV1S

Item Code	Range	Material	Volume	Window (in mm)	Clear Sides*	Cover Needed	Quantity
CVD-UV1S	220-900 nm	Plastic	1.5 - 3.0 mL	4.5 x 23	4	Square	100 Pack
CVD-UV1S-SAM	220-900 nm	Plastic	1.5 - 3.0 mL	4.5 x 23	4	Square	8 Pack
CVD-UV1U	220-900 nm	Plastic	70 µL - 1.8 mL	2 x 3.5	2	Round	100 Pack
CVD-UV1U-SAM	220-900 nm	Plastic	70 µL - 1.8 mL	2 x 3.5	2	Round	8 Pack
CVD-VIS1S	350-900 nm	Polystyrene	1.5 - 3.0 mL	5 x 23	4	Square	100 Pack
CVD-VIS1M	350-900 nm	Polystyrene	2.5 – 4.0 mL	10 x 35	2	Square	100 Pack

*Cuvettes with 4 clear sides are suitable for fluorescence measurements.

Quartz Cuvette Cells

We offer several popular high-purity quartz cuvettes including macro, semi-micro, flow and cylindrical cells. These Quartz Cuvette Cells are suitable for use from 200-2700 nm.

Item	Description	Windows	Path	Lid	Exterior (mm)	Volume
CV-Q-10	Standard	2 clear	10 mm	Teflon cover	12.5 x 12.5 x 45	3.5 mL
CVFL-Q-10	Fluorescence	4 clear	10 mm	Teflon stopper	12.5 x 12.5 x 45	3.5 mL
CVS-Q-10	Self-masking	2 clear	10 mm	Teflon stopper	12.5 x 12.5 x 48	1.4 mL
CVF-Q-10	Flow cell	2 clear	10 mm	M6 screws	12.5 x 12.5 x 35	0.42 mL
CV-Q-100	Cylindrical	2 clear	100 mm	Teflon stopper	22 OD x 102.5	28.2 mL

SpecVette Cuvettes

SpecVette™ Cuvettes are UV-transparent, short pathlength, disposable cuvettes especially designed for use with the HR4000 and HR2000+ High-resolution Spectrometers. Economical and disposable, SpecVettes eliminate cross-contamination and reduce analyte consumption. SpecVettes are sold in packs of 25, with or without the universal adapter. Sample packs are also available. SpecVettes are a product of ALine, Inc.

CSV-6-SP	CSV-250-25	CSV-250-25-A	CSV-500-25	CSV-500-25-A	CSV-1000-25	CSV-1000-25-A
6-piece sample pack with adapter, 2 each: 250 µm pathlength, 500 µm pathlength and 1000 µm pathlength	25-pack, 250 µm pathlength	25-pack with adapter, 250 µm pathlength	25-pack, 500 µm pathlength	25-pack with adapter, 500 µm pathlength	25-pack, 1000 µm pathlength	25-pack with adapter, 1000 µm pathlength

Sampling Accessories

Flow Cells for Flow Injection Analysis

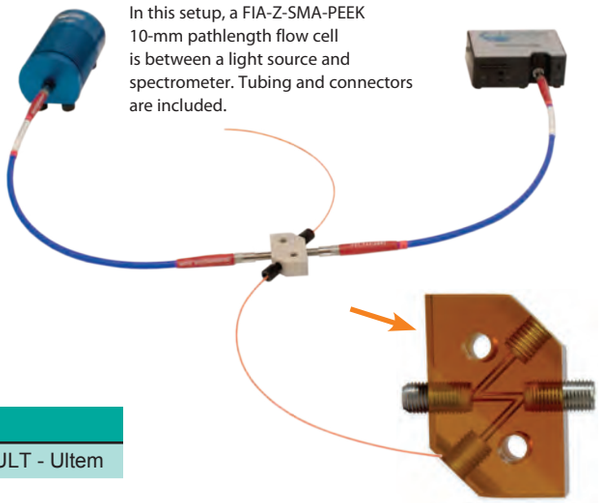
We offer a variety of optical flow cells with a Z configuration. For measuring the optical absorbance of fluids, couple Z cells directly to our spectrometers to monitor chemical or biological processes and immunoassays.

In our FIA-Z-SMA Flow Cells, standard optical fibers (available separately) connect to the SMA 905 fittings to transmit and receive light through the central axis of the Z. The FIA-Z-SMA cells use silica windows as wetting surfaces at each fiber optic junction and are available in PEEK polymer, Plexiglas, Stainless Steel, Teflon and Ultem.

The FIA-Z-CELL Flow Cells are different from the FIA-Z-SMAs; instead of windows they use optical fibers in 1.58-mm ferrules, a design that allows you to slide the ferrules in and out of the cell to adjust the optical pathlength from 0-10 mm.

Item Code: FIA-Z-CELL-####

Specifications	
Cell materials:	PEEK, Plexiglas, Teflon, Stainless Steel, Ultem
Inner diameter:	1.5 mm
Window material:	UV-grade fused silica
Window thickness:	1 mm
Wavelength range:	200-2000 nm
FIA connectors:	1/4-28 fittings (included)
Fiber connectors:	SMA 905 for FIA-Z-SMA cells; 1.58 mm stainless steel ferrules for FIA-Z-CELL cells



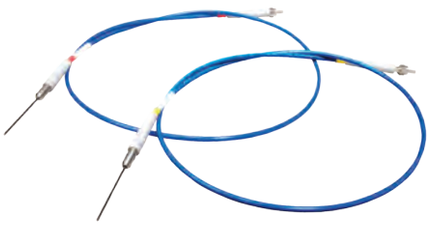
In this setup, a FIA-Z-SMA-PEEK 10-mm pathlength flow cell is between a light source and spectrometer. Tubing and connectors are included.

Available Items

Note: Item Code Extensions indicate:				
PEEK – PEEK	PLEX – Plexiglas	SS – Stainless Steel	TEF – Teflon	ULT - Ultem

10 mm Pathlength	20 mm Pathlength	50 mm Pathlength	100 mm Pathlength
FIA-Z-SMA-###	FIA-Z-SMA-20-###	FIA-Z-SMA-50-###	FIA-Z-SMA-100-###

Our standard fibers are designed for the FIA-Z-SMA cells.



The FIA-P400-SR and FIA-P200-SR fiber assemblies have ferrules for use with the FIA-Z-CELL cells.

This FIA-Z-SMA-100-ULT is a 100 mm pathlength cell made out of Ultem.

Fibers for Use with FIA Cells

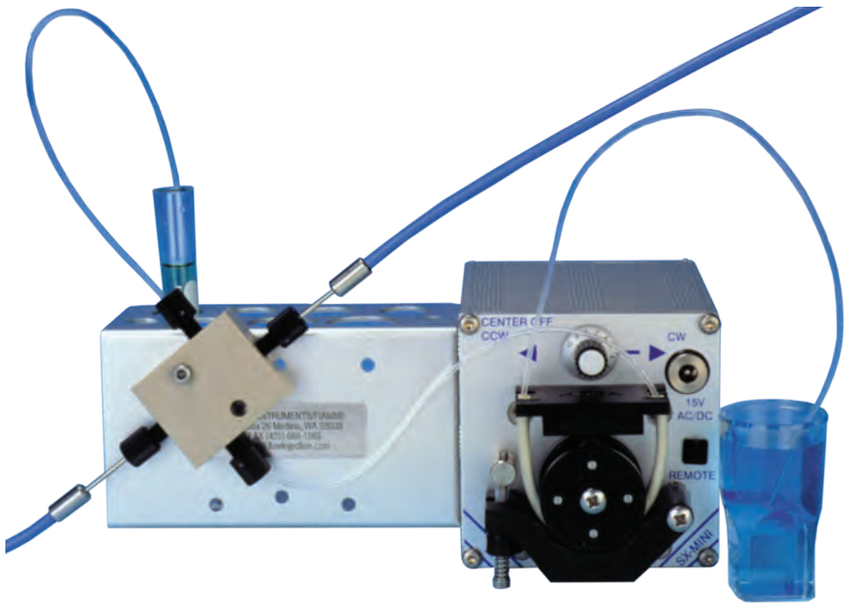
A FIA-Z-SMA requires two 200 µm or 400 µm diameter fiber assemblies. Your application may require optical fibers that are optimized for a specific wavelength range. The FIA-Z-CELL requires two fiber assemblies with ferrule terminations.

Item	Description	Use With
P400-2-UV-VIS	400 µm fiber assembly with SMA 905 connectors	FIA-Z-SMA
P200-2-UV-VIS	200 µm fiber assembly with SMA 905 connectors	FIA-Z-SMA
FIA-P400-SR	400 µm fiber assembly with ferrule terminations	FIA-Z-CELL
FIA-P200-SR	200 µm fiber assembly with ferrule terminations	FIA-Z-CELL

Sampling Accessories
Fluid Analysis Systems

Our FIA-1000-Z Flow Cell Kit is a convenient, low-cost fluid handling system that couples to Ocean Optics high-sensitivity miniature spectrometers and light sources for fast, quantitative analysis of solutions.

The FIA-1000-Z system consists of a two-channel peristaltic pump, a 1-cm pathlength fiber optic flow cell, a fittings kit and Windows-based operating software. A pair of optical fibers or special bifurcated assembly (priced separately) completes the package.



High-throughput Z-cell Option

The FIA-Z-SMA-PEEK-LENSED is a 10 mm Z-type flow cell that includes two collimating lenses and special SMA 905 adapters that increase the UV-VIS throughput of the flow cell by up to 10x compared with the standard Z-cell.

The high-throughput cell can be used as part of any system that has an Ocean Optics spectrometer configured for optical absorbance measurements, but is especially attractive as part of a multichannel Jaz system configured for chromatographic applications.

The FIA-Z-SMA-PEEK-LENSED cell has good resistance to a wide range of organic and inorganic materials. Its lens material is UV-grade fused silica with response from 200-900 nm. By adding accessories such as the FIA-PUMP-C and a pair of QP450-1-XSR 450 µm extreme solarization resistant optical fibers, you can create a system comparable to the FIA-1000-Z Flow Cell Kit.

Specifications

Criteria	
Spectral range:	260-2000 nm
Cell materials:	PEEK, Plexiglas, Teflon, Stainless Steel or Ultem
Inner diameter:	1.5 mm
Window material:	UV-grade fused silica
Pathlength:	10 mm
Fiber connectors:	SMA 905
Tubing:	1/16" Teflon, ~3 m
Tubing connectors:	1/4-28
Pump dimensions:	105 mm x 105 mm x 185 mm
Pump weight:	2100 g
Flow rate:	0.5-2.0 mL/minute/channel (depending on RPM and tubing diameter)
Pressure rating:	25 psi

Available Items

Item	Description
FIA-1000-Z	Z-SMA flow cell with peristaltic pump. Includes operating software with code for computer control of pump. User specifies cell material: Teflon, Plexiglas, Stainless Steel, PEEK polymer or Ultem.
FIA-ZSMA	Replacement Z-SMA flow cell for FIA-1000-Z. User specifies cell material: Teflon, Plexiglas, Stainless Steel, PEEK polymer or Ultem.
FIA-ZSMA-100	Z flow cell w/SMA 905, 100 mm pathlength
FIA-ZSMA-50	Z flow cell w/SMA 905, 50 mm pathlength
FIA-ZSMA-20	Z flow cell w/SMA 905, 20 mm pathlength
FIA-ZSMA-ML	Z flow cell with SMA 905 connector, microliter volume. User specifies cell material: Teflon, Plexiglas, Stainless Steel, PEEK polymer or Ultem.
FIA-ZSMA-ML-100	Z flow cell w/SMA 905, microliter volume 100 mm path
FIA-ZSMA-ML-50	Z flow cell w/SMA 905, microliter volume 50 mm path
FIA-ZSMA-ML-20	Z flow cell w/SMA 905, microliter volume 20 mm path
FIA-Z-CELL	Adjustable replacement cell for use with FIA-1000-Z. Connects to fiber optics w/ferrule termination. Standard cell materials are Plexiglas, Stainless Steel, Teflon, Ultem or PEEK.
FIA-P200-SR	Custom 200 µm ferrule-termination fiber optic for use with FIA-Z-CELL; requires 2 fibers.
FIA-P400-SR	Custom 400 µm ferrule-termination fiber optic for use with FIA-Z-CELL; requires 2 fibers.
FIA-PUMP-C	Replacement peristaltic pump (computer-controlled) for FIA-1000 flow cells

Sampling Accessories
Fluid Analysis

SpectroPipetter Microcell

The PIP-10-2 SpectroPipetter Microcell is a combination micropipetter and 10-mm pathlength microcell for low-volume sampling. The SpectroPipetter conveniently couples to Ocean Optics high-sensitivity fiber optic spectrometers and compact light sources for rapid measurement of microliter-level solutions. It requires only 2 µL of sample for a spectral measurement and is especially handy for applications such as protein analysis, DNA experimentation and forensic toxicology.

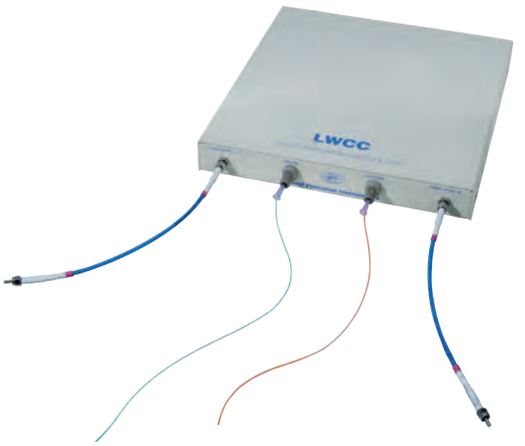
Specifications

Sample cell pathlength: 10 mm
Sample cell volume: 2.0 µL
Wavelength range: UV-VIS through Shortwave NIR (~240-1100 nm)

PIP-10-2	PIP-UCK	PIP-UCK-CS
Micropipetter and 1-cm pathlength microcell sampling device	Micropipetter cleaning kit	Cleaning solution

Longpass Flow Cells

LPC Longpass Flow Cells couple to Ocean Optics spectrometers and light sources for simple, efficient measurement of low-volume or low-concentration aqueous samples. These liquid waveguide capillary cells are available in pathlengths ranging from 50-500 cm, with internal sampling volumes ranging from 125 µL for a 50 cm pathlength cell to 1,250 µL for a 500 cm pathlength cell. Cells are responsive from ~230-800 nm, with higher starting wavelengths for the longer pathlength versions.



The LPC Flow Cells were developed by our partner World Precision Instruments as fiber-coupled alternatives to standard cuvettes. Units can be directly connected to a pump or fluid injection analysis system or filled with a syringe. The LPCs are ideal for various kinds of flow analysis and water monitoring.

Also available are very low-volume LPC flow cells ideal for micro-volume solution measurements such as DNA and RNA quantification, protein determination and nutrient analysis. These cells are available in 10 mm, 50 mm and 100 mm pathlengths, with sample volumes of 2.4 µL, 12 µL and 24 µL, respectively.

LPC Specifications	LPC-050CM	LPC-100CM	LPC-250CM	LPC-500CM
Optical pathlength:	50 cm	100 cm	250 cm	500 cm
Internal volume:	125 µL	250 µL	625 µL	1250 µL
Fiber connection (SMA 905):	500 µm	500 µm	500 µm	500 µm
Noise [mAU]:	<0.1	<0.2	<0.5	<1.0
Maximum pressure:	100 PSI	100 PSI	100 PSI	100 PSI
Wetted material:	PEEK, Fused Silica, PTFE			
Liquid input standard:	10-32 Coned Port Fitting			

Micro Cell Specifications	LPC-10MM	LPC-50MM	LPC-100MM
Optical pathlength:	10 mm	50 mm	100 mm
Internal volume:	2.4 µL	12 µL	24 µL
Wavelength range (most efficient):	~230-800 nm	~230-800 nm	~230-800 nm
Fiber connection (SMA 905):	500 µm	500 µm	500 µm
Maximum pressure:	1000 PSI	1000 PSI	1000 PSI
Refractive index @ 280 nm:	<7 mAU	<15 mAU	Not reported
Wetted material:	PEEK, Fused Silica, PTFE		

Longpass Flow Cell Options

Item Code	Description
LPC-050CM	Liquid Waveguide Capillary Cell, 50 cm pathlength
LPC-100CM	Liquid Waveguide Capillary Cell, 100 cm pathlength
LPC-250CM	Liquid Waveguide Capillary Cell, 250 cm pathlength
LPC-500CM	Liquid Waveguide Capillary Cell, 500 cm pathlength
LPC-10MM	Liquid Waveguide Capillary Cell, 10 mm pathlength
LPC-50MM	Liquid Waveguide Capillary Cell, 50 mm pathlength
LPC-100MM	Liquid Waveguide Capillary Cell, 100 mm pathlength

Sampling Accessories
Fluid Analysis

CFV-Series FluoroVettes

Our FluoroVettes are ultra low-volume, disposable cells for nano-molar range fluorescence detection. These UV-transparent cuvettes require only 50 µl of fluid and slide neatly into a 1-cm cuvette adapter for use in setups with a spectrometer and cuvette holder.

The design of our FluoroVettes makes them quite suitable for a variety of applications including real-time monitoring of chemical or biological agents for competitive displacement assays, high-sensitivity quantification of double-stranded DNA and ELISA assay development.

Here are some other possible applications:

- Assay development with quantum dots
- Protein conformation analysis
- Cell marker identification
- Enzyme inhibitors using FRET assays

Specifications

Volume	
Dead volume:	2 µL
Dead volume (tubing interface):	Depends on length of tubing at inlet side of FluoroVette; typical ID is 0.030", OD is 0.063" (1/16"); length of tubing is 1.5" on each side
Contained volume:	50 µL (+/- 1 µL)
Dimensions	
Height x width:	50 mm x 9 mm
Thickness:	1 mm
Materials	
Zeonor Film:	50 mm (0.002") (UV-transparent to 220 nm)
Black Delrin:	0.75 mm (0.030")
Bonding:	Medical-grade acrylic solvent for bonding Delrin to Zeonor
Compatibility:	Ethanol (up to 99.5%), Isopropyl alcohol (up to 91% water), aqueous buffers with or without detergents
Incompatibility:	Acetone or aliphatic solvents such as hexane
Connectors	
For CFV-PIP-SP:	Acrylic
For CFV-PUMP-SP:	Polysulfone
For tube connection:	Translucent FEP for tubing; glue is a solvent-less UV-curing medical-grade adhesive

Available Items

Item Code	Description
CFV-PIP-SP	10 pack Pipettor UV-transparent FluoroVettes with adapter
CFV-PUMP-SP	5 pack Pump UV-transparent FluoroVettes with adapter
CFV-PIP	10 pack Pipettor UV-transparent FluoroVettes
CFV-PUMP	5 pack Pump UV-transparent FluoroVettes
CFV-ADP-2	Universal adapter for 1 cm x 1 cm fluorescence sample holder with 2-way 90 degree viewing
CFV-ADP-4	Universal adapter for 1 cm x 1 cm sample holder with 4-way viewing
CSV-6-SP	Sample pack of 6 SpecVettes - 2 x 1 mm, 2 x 0.5 mm, and 2 x 0.25 mm + Adapter

Note: There are two types of FluoroVettes. The CFV-PIP-SP has an inlet port for loading the sample into the FluoroVette with a standard 20-200 µL pipetter and ordinary tips, making it a snap to fill and perform measurements. The CFV-PUMP-SP has tubing barbs at the inlet and outlet ports so the FluoroVette can be used in continuous or flow injected measurements using a syringe or peristaltic pump.

Sampling Accessories
Cosine Correctors

CC-Series Cosine Correctors

Our Cosine Correctors couple to optical fibers and spectrometers for relative and absolute spectral intensity measurements, emission applications and evaluation of light sources.

When the CC-3 and CC-3-UV-S are screwed onto the end of an optical fiber, the cosine corrector and optical fiber become an irradiance probe. The probe couples to one of our spectrometers to measure the intensity of light normal to the probe surface. The CC-3-DA screws directly onto the SMA 905 Connector of our spectrometers, creating a complete spectroradiometric system and eliminating the need for an optical fiber.

Please note that the native response of Spectralon covers a wider range than what we report here. Our specifications reflect its use with our spectrometers as a light collector.

Available Items	CC-3	CC-3-UV-S	CC-3-UV-T	CC-3-DA
Diffusing material:	Opaline glass	Spectralon	PTFE	Spectralon
Typical range:	350-1000 nm	200-1700 nm	200-1100 nm	200-1100 nm
Dimensions:	6.35 mm OD	6.35 mm OD	6.35 mm OD	12.7 mm OD
Field of View:	180°	180°	180°	180°

Power Supply and Controller for LEDs

The LED-PS Power Supply works with our spectrometers and the FOIS-1 Fiber Optic Integrating Sphere for spectroradiometric and color measurements of LEDs. The LED-PS unit has easy-to-reach electrical connectors for mounting LEDs that are 9.52-mm diameter or smaller with 2.77-mm lead spacing.

The LED-PS Power Supply provides three useful functions. The LED-PS holds the LED in place, powers the LED, and displays the LED's drive current. The drive current is adjustable, with a digital display to indicate the current level. Use the adjustable drive current feature to increase or decrease an LED's current up to 50 mA. With the LED-PS-NIST, the current meter is calibrated against a NIST-traceable standard.

Specifications	
Dimensions:	56.8 mm x 56.8 mm x 56 mm
Weight:	170 g
Power consumption:	Up to 100 mA @ 12 VDC; depends on setting
LED drive current:	12-50 mA with 0.1 mA resolution
Drive current accuracy:	± 1.0%
LED mount:	2.77 mm lead spacing, PTFE base

Available Items

Item	Description
LED-PS	Power Supply and Controller for LEDs
LED-PS-NIST	NIST-traceable Power Supply and Controller for LEDs
LED-PS-RECAL	Recalibration services for your LED-PS-NIST
FOIS-1	Fiber Optic Integrating Sphere

Sampling Accessories
Integrating Spheres

ISP-I Integrating Spheres

Our ISP-I Integrating Spheres are convenient sampling optics that couple to our spectrometers and optical fibers to measure spectral output of LEDs, lasers and other light sources from 200-2500 nm.

Each fiber optic integrating sphere consists of a proprietary PTFE-based, sintered diffusing material in diameters of 30, 50 or 80 mm. This provides a Lambertian surface with >98% reflectivity in the visible range for irradiance measurements. Sample port sizes of 6 mm for the 30 mm sphere and 8 mm for the 50 mm and 80 mm spheres are available.

Available Items

Item Code	Description	Sample Port
ISP-30-6-I	Integrating sphere, 59 mm diameter, 58 mm high	6 mm
ISP-50-8-I	Integrating sphere, 80 mm diameter, 78 mm high	8 mm
ISP-80-8-I	Integrating sphere, 107 mm diameter, 117 mm high	8 mm
ISP-LED-ADP	Holds in place 3, 5 or 8 mm LED for reproducibility; for use with ISP-50-8-1	N/A
ISP-50-I-USB	ISP-50-8-I with connector for directly attaching to a spectrometer	8 mm
ISP-80-I-USB	ISP-80-8-I with connector for directly attaching to a spectrometer	8 mm
ISP-PORT-1	Custom sample port machining of 8, 10, or 12 mm diameter	8, 10 or 12 mm
ISP-PORT-2	Custom sample port machining of 14,16 or 20 mm diameter	14, 16 or 20 mm

Specifications	
Dimensions:	ISP-30-6-I: 59 mm diameter, 58 mm height ISP-50-8-I: 80 mm diameter, 78 mm height ISP-80-8-I: 107 mm diameter, 117 mm height
Weight:	330 g (ISP-30); 730 g (ISP-50); 1,650 g (ISP-80)
Spectral range:	200-2500 nm
Sphere diameter:	30 mm, 50 mm or 80 mm
Sample port diameter:	6 mm (ISP-30); 8 mm (ISP-50 and ISP-80)
Sphere coating:	Proprietary PTFE-based diffusing material
Reflectivity:	>98% (400-1500 nm); >95% (250-2500 nm)
LED adapter:	For 3-mm, 5-mm or 8-mm LEDs

FOIS-1 Fiber Optic Integrating Sphere

The FOIS-1 is a compact sampling optic that collects light from emission sources such as LEDs and lasers and can be used to measure light fields with a 360° field of view.

The compact FOIS-1 measures just 56.8 mm x 62.4 mm x 38.1 mm and weighs only 240 g -- yet it is durable enough for use for many types of applications. The interior of the FOIS-1 is made from Spectralon, a white diffusing material that provides a highly Lambertian reflecting surface.

The FOIS-1 is easy to operate. Simply connect an optical fiber (the read fiber) from the FOIS-1's SMA 905-terminated output port to the SMA termination of the spectrometer. The emission source is then inserted into the 0.375" input port of the FOIS-1. Or the setup can be configured so that the light energy from the emission source can enter the input port.

Specifications	
Effective spectral range:	250-2500 nm
Dimensions:	56.8 mm x 62.4 mm x 38.1 mm
Weight:	240 g
Sample port aperture:	9.5 mm
Sphere coating:	Spectralon
Top cap mounts:	(2) 8-32 threaded holes (hardware not included) (1) 1/4"-20 threaded hole in center (screw/adapter included)
Side mounts:	SMA 905 connector for coupling optical fiber to the spectrometer 8-32 threaded hole for post mounts
Connector:	SMA 905

Sampling Accessories
Spheres for Reflectance

ISP-REF Integrating Sphere for Reflectance

The ISP-REF Integrating Sphere is designed for applications requiring even surface illumination for reflectance measurements -- such as in determining the color of flat surfaces.

The ISP-REF is 1.5" in diameter and features a transfer optic assembly for restricting the fiber viewing angle, a 0.4" aperture sample port and a built-in tungsten-halogen light source with 12 VDC adapter. The sphere is coated with Spectralon®, a white diffusing material that provides a highly Lambertian reflecting surface. A simple switch allows users to manipulate the sampling optic for the inclusion (I) or exclusion (E) of specular reflectance.

The ISP-REF Integrating Sphere is small and compact -- measuring just 54 mm x 57 mm x 83 mm (LWH) and weighing 865 g – yet, it is durable enough for use outside the laboratory.

Item Codes: ISP-REF Illuminated Integrating Sphere, ISP-REF-B Replacement Bulb for ISP-REF

Specifications	
Spectral range (of illumination source):	360-1000 nm
Dimensions:	54 mm x 57 mm x 83 mm (LWH)
Sphere diameter:	38.1 mm
Weight:	865 g
Sample port aperture:	10.32 mm
Sphere coating:	Spectralon (doped with Barium Sulfate)
Reflectivity:	>98% (400-1500 nm) >95% (250-2000 nm)
Reflectance measurements:	Specular included or excluded
Bulb life:	900 hours
Bulb color temperature:	3100 K
Connector:	SMA 905

ISP-R Integrating Spheres for Reflectance

The ISP-R Integrating Spheres are distinguished by their compact size and sturdy design. All ISP-R spheres have two SMA 905 ports. The excitation input is angled at 8° and collimates the fiber input before introduction into the sphere. The output port is angled at 90° (to connect to a spectrometer). A gloss-trap version comes with two cylindrical inserts coated with either a black absorbing material (for excluding the specular component of the reflection) or with the same material as the sphere (to include the specular component). This insert fits into a hole angled at 8° at the top of the sphere.

Specifications	ISP-REF	ISP-30-6-R	ISP-50-8-R	ISP-80-8-R	ISP-50-8-R-GT
Dimensions:	54 mm x 57 mm x 83 mm	59 mm dia., 58 mm high	80 mm dia., 78 mm high	107 mm dia., 117 mm high	80 mm dia., 78 mm high
Weight:	864.7 g	330 g	730 g	1,650 g	743.3 g
Power consumption:	600 mA @ 12 VDC (lamp)	None	None	None	None
Spectral range:	360-2000 nm	200-2500 nm	200-2500 nm	200-2500 nm	200-2500 nm
Sphere diameter:	38.1 mm	30 mm	50 mm	80 mm	50 mm
Sample port diameter:	10.32 mm	6 mm	8 mm	8 mm	8 mm
Sphere coating:	Spectralon	PTFE material	PTFE material	PTFE material	PTFE material
Reflectance:	Diffuse or specular and diffuse	Specular and diffuse	Specular and diffuse	Specular and diffuse	Diffuse or specular and diffuse
Reflectivity:	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)
Bulb:	900-hour bulb; 3100 K color temp.	None	None	None	None

Sampling Accessories
Spheres for Reflectance

Reflectance/Transmittance Spheres

The RT and RTC Spheres from Labsphere are basic measurement tools that can be used to measure the reflectance or transmittance of light through a wide variety of sample media. These spheres feature 25.4 mm diameter ports to accommodate sample and reference beams as well as port plugs required for a 9° single beam geometry.

RTC Spheres add further versatility with a center-mounted sample holder so users are able to measure reflectance and transmittance versus incident angle of radiation. Five ports accommodate a sample and reference beam with a center mount stage located at the top of the sphere, and a 12.7 mm detector port located at the bottom of the sphere assembly.

Item Codes: LAB-RT-060SF, Reflectance/Transmittance Integrating Sphere; 6"; includes 0° sample holder and accessories
LAB-RTC-060SF, Reflectance/Transmittance Integrating Sphere; 6"; includes 0° and 8° sample holders, center mount and accessories

Specifications	RT-060-SF	RTC-060-SF
Sphere diameter:	152. 4 mm (6")	152. 4 mm (6")
Sphere coating:	Spectraflect®	Spectraflect®
Optimum spectral range:	250-2500 nm	250-2500 nm
Detector port diameter:	12.7 mm (0.5")	12.7 mm (0.5")
Sample and reference ports:	5	5
Sample and reference ports (diameters):	25.4 mm (1") for all	25.4 mm (1") for three and 31.75 mm (1.25") for two
Center-mount sample holder:	NA	Jaw and clip styles
Sphere mount:	1/4-20 boss mounting post and base assembly	Adjustable H-frame assembly

Sampling Accessories
Light Modification

MonoScan2000

The MonoScan2000 is a computer-controlled scanning monochromator with a 300-700 nm wavelength range. The rapid system scans one nanometer in 15-20 milliseconds and covers its entire range within three seconds. The MonoScan2000 is compatible with all Ocean Optics spectrometers, light sources, accessories and optical fibers.

A light source directs light via optical fiber to a sample, interacts with the sample and sends light to the MonoScan2000. The monochromator captures the incoming light and transmits it via fiber to a single-element detector (such as a photodiode) one wavelength at a time. The MonoScan2000 allows a high optical throughput and provides an intense spectral signal. The MonoScan2000 has the ability to scan through a wavelength range you select via software. Because the MonoScan2000 has no slit, the diameter size of the optical fiber determines the optical resolution of the system. When using 200 µm fibers, for example, optical resolution is <3 nm (FWHM).

Item Code: MONOSCAN2000

Specifications	
Dimensions:	112 mm x 132 mm x 145 mm
Weight:	1.1 kg
Wavelength range:	300-700 nm
Optical resolution:	Depends on the diameter of the optical fiber; ~4 nm (FWHM) using a 400 µm diameter optical fiber
Holographic grating:	1250 lines/mm, blazed at 350 nm
Accuracy:	<0.5 nm
Repeatability:	0.2 nm
Transition speed:	A scan from 300 nm to 700 nm takes ~3 seconds A one nanometer step takes ~15-20 milliseconds
Dispersion:	~10 nm per mm
Optical throughput:	>50% with a 1000 µm fiber at 350 nm >30% with a 1000 µm fiber at 500 nm
Grating scan angle:	14.8° (300-700 nm)
Computer interface:	USB and RS-232
Power requirement:	12 VDC max. 1.2A (WT-12V-E)
Gearbox ratio:	1:261

Hydra Fiber-Coupled Light Mixer

Hydra from Ocean Optics is a fiber-coupled light mixer that features nine SMA 905 connectors. Each connector can be used as input for light or an output.

Light coming into the Hydra's SMA connectors are mixed homogeneously inside the Hydra's chamber. The intensities of the outgoing light are at the same level with a matching of better than 1%.

The physical properties of the Hydra are based on Spectralon® diffuse reflectance material and offer high reflection efficiency (better than 90%) over a wavelength range from 200-2500 nm.

The Hydra is a compact 60 mm x 45 mm. The unit's integrating sphere is 20 mm in diameter. Use Hydra to harness up to eight light sources and accurately mix light intensities to fit your application's requirements.

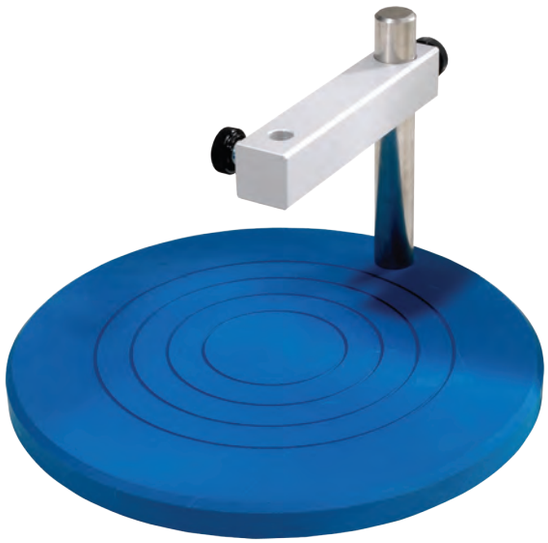
Item Code: HYDRA

Specifications	
Dimensions:	60 mm ht x 45 mm diameter
Integrating sphere:	20 mm diameter
Integrating sphere coating:	Spectralon
Integrating sphere reflectivity:	>90% from 200-2500 nm
Connectors:	(9) SMA 905

Sampling Accessories
Reflection and Transmission Stages

Reflectance Stage

Our Single-Point Reflection stage is a probe holder that is perfect for reflection measurements of optical layers and other substrates (up to 150 mm in diameter). The probe holder accommodates fiber optic probes up to 6.35 mm in diameter and slides up and down a stainless steel post for adjustment to heights as great as ~63.5 mm.



The Stage has an anodized base plate, scored in concentric circles of varying diameters, that act as a guide when positioning round samples.

Item Code: STAGE

Reflection-Transmission Stage

The Stage-RTL-T is a unique and versatile sampling system for performing transmission and reflection measurements in numerous configurations. When combined with Ocean Optics spectrometers and light sources, the Stage-RTL-T is ideal for applications ranging from materials analysis of coatings, plastics, glass and semiconductor wafers to characterization of biological samples such as plants, animal tissue and fruit.

The Stage-RTL-T includes a variable rail to which various additional sampling fixtures can be attached. In addition to the rail, the Stage-RTL-T comes with a sample plate, adapter, a pair of 74-UV collimating lenses and a light trap.

Here are some of the ways you can utilize the Stage-RTL-T:

- Attach any Ocean Optics reflection probe with ¼" (6.35 mm) OD and position the rail to measure an extensive range of sample shapes and sizes.

- With the generic adapter, position the collimating lenses to measure transmission at a perpendicular angle or reflection at a 45-degree angle. The adapter also will accommodate Ocean Optics reflection probes with ¼" (6.35 mm) OD.

- Add an optional ISP-RTL-ADP adapter to accommodate our 30 mm and 50 mm ISP-series integrating spheres. This allows the user to take diffuse reflection and transmission measurements.

The optical components in the Stage-RTL-T are responsive from 200-2500 nm, making them feasible for the full range of Ocean Optics UV, Visible and NIR spectrometers and light sources. The system's anodized aluminum plates and rails and its stainless steel posts and post holders are sturdy and dependable.

Item Code: STAGE-RTL-T

Specifications	STAGE	STAGE-RTL-T
Dimensions:	152.4 mm diameter (base) 101.6 mm diameter (sample area)	206.3 mm diameter (base) 152.4 mm diameter (sample area)
Weight:	620 g	4.5 kg
Height:	Adjustable 63.5 mm	Adjustable to 400 mm
Materials:	Anodized aluminum plate, stainless steel post and post holder	Anodized aluminum

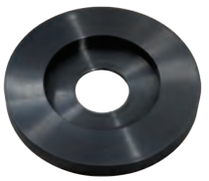
Sampling Accessories
Specular Reflectance Standards

We offer three Specular Reflectance Standards for use in measuring the reflectance of surfaces with high or low specular reflectivity. Each consists of a 31.7-mm outer diameter optical reflectance material in a protective aluminum receptacle with screw-on top. The superior coatings on the substrates are environmentally stable and can withstand high temperature and mechanical stresses.

STAN-SSH
The STAN-SSH High-reflectivity Specular Reflectance Standard is a mirrored, fused-silica standard that can be used as a reference when measuring surfaces with high specular reflectance values such as optical substrates, optical coatings, machined metals and semiconductor materials. The STAN-SSH provides high reflectance across the range from 800-2500 nm.

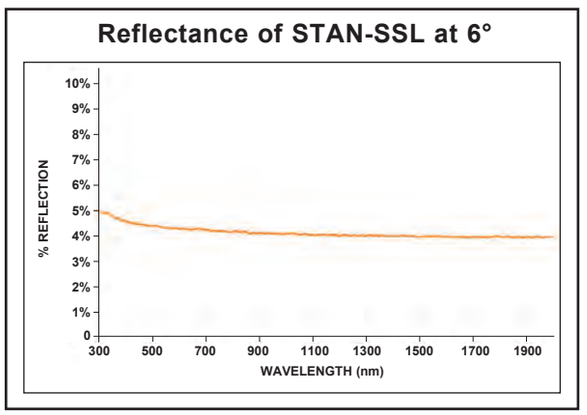
STAN-SSH-NIST
The NIST-traceable STAN-SSH-NIST is calibrated to a NIST master (NIST part number NIST38060S, s/n 99G16) and is spectrally flat to <5% from 250-2500 nm. With the shipment of the NIST-traceable version, the customer will receive a certificate of calibration, a data sheet with the reflectance values as a function of wavelength and a diskette that contains calibration data that can be transferred to Ocean Optics SpectraSuite Operating Software.

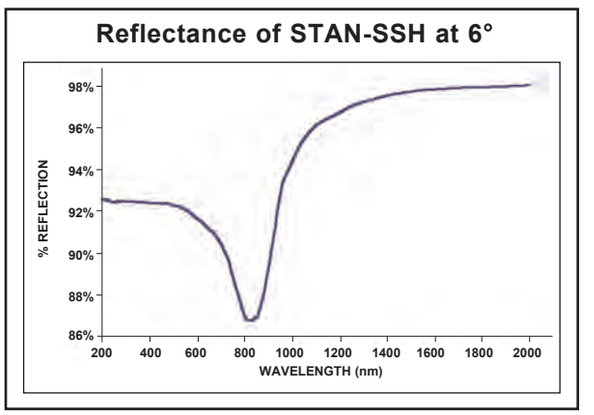
STAN-SSL
The STAN-SSL Low-reflectivity Specular Reflectance Standard is a black glass standard that can be used as a reference when measuring surfaces with low specular reflectance values such as thin film coatings, anti-reflective coatings, blocking filters and substrates. The coated surface of the STAN-SSL provides ~4.0% reflectance across the 200-2500 nm wavelength range.



STAN-HOLDER
This convenient accessory option keeps your standard securely in place during measurements and helps preserve its coating.

Specifications	STAN-SSH	STAN-SSH-NIST	STAN-SSL
Substrate dimensions:	31.75 mm outer diameter x 6.35 mm height	31.75 mm outer diameter x 6.35 mm height	31.75 mm outer diameter x 6.35 mm height
Housing dimensions:	38 mm outer diameter x 19 mm height	38 mm outer diameter x 19 mm height	38 mm outer diameter x 19 mm height
Weight:	40 g	40 g	40 g
Reflectance material:	Front-surface protected aluminum mirror on fused silica substrate	Front-surface protected aluminum mirror on fused silica substrate	Schott ND9 glass
Reflectivity:	~87-93% (200-1000 nm) ~93-98% (1000-2050 nm)	~87-93% (200-1000 nm) ~93-98% (1000-2050 nm)	~5% (200-950 nm) ~4% (950-2500 nm)





Sampling Accessories
Diffuse Reflectance Standards

WS-1 Diffuse Reflectance Standard

The WS-1 Diffuse Reflectance Standard is made of PTFE, a diffuse white plastic that provides a Lambertian reference surface for reflectance experiments. The WS-1 comes in an anodized aluminum housing, and is hydrophobic, chemically inert and very stable, even in deep-ultraviolet applications. It is >98% reflective from 250-1500 nm and >95% reflective from 250-2200 nm.

Item Code: WS-1

WS-1-SL White Reflectance Standard with Spectralon

The WS-1-SL is a diffuse reflectance standard from Labsphere and is made from their patented diffuse reflectance material, Spectralon. Spectralon is hydrophobic and is thermally stable to 350 °C. The durable material provides highly accurate, reproducible data.

Item Code: WS-1-SL

Specifications	WS-1	WS-1-SL
Dimensions:	38 mm diameter housing	32 mm OD, 10 mm thick tile
Weight:	30 g	30 g
Spectral range:	250-2000 nm	250-2500 nm
Housing:	Aluminum	Delrin holder, protective cover
Reflectivity:	>98% (250-1500 nm) >95% (250-2200 nm)	99% (400-1500 nm) >96% (250-2000 nm)

Sampling Accessories
Spectralon Standards from Labsphere

Spectralon® material is distinguished by its high diffuse reflectance values (>99% over a range from 400-1500 nm and >95% from 250-2500 nm) and is available in components such as reflectance, color and fluorescence standards.

Diffuse reflectance standards are highly Lambertian, with reflectance values ranging from 2%-99%. Color standards come in various color sets and are an excellent choice for developing consistent reproduction in manufacturing applications. Fluorescence standards use various combinations of Spectralon and inorganic fluors and are photochemically stable compared with their organic counterparts.

Available Reflectance and Color Standards	
LAB-RSS-040-010	Diffuse reflectance standard set, 1", 2%, 50%, 75%, 99% reflectance values
LAB-RSS-08-020	Diffuse reflectance standard set, 2", 2%, 5%, 10%, 20%, 40%, 60%, 80%, 99% reflectance values
LAB-SRS-02-010	Diffuse reflectance standard, 1", 2% reflectance value
LAB-SRS-10-010	Diffuse reflectance standard, 1", 10% reflectance value
LAB-SRS-20-010	Diffuse reflectance standard, 1", 20% reflectance value
LAB-SRT-50-020	Diffuse reflectance target, UV-NIR, 2", 50% reflectance value, single centerpoint calibration
LAB-SRT-99-020	Diffuse reflectance target, UV-NIR, 2", 99% reflectance value, single centerpoint calibration
LAB-SRT-MS-050	Diffuse reflectance target, multi-step, 250-2500 nm, 5" x 5", 12%, 25%, 50%, 99% reflectance values, single centerpoint calibration
LAB-CSS-04-010	Diffuse color standards set, 1", Red-Green-Blue-Yellow
LAB-CSS-04A-010	Diffuse color standards set, 1", Orange-Purple-Violet-Cyan
LAB-CSS-12-010	Diffuse color standards set, 1", RGBY and OPVC, 2%, 20%, 50%, 99% reflectance values

Available Fluorescence Standards	
LAB-USFS-500-010	Fluorescence standards set, includes five fluors, uncalibrated
LAB-USFS-200-010	Fluorescence standards, 1", Blue/White Fluor #200, uncalibrated
LAB-USFS-205-010	Fluorescence standards, 1", Blue Fluor #205, uncalibrated
LAB-USFS-210-010	Fluorescence standards, 1", Green Fluor #210, uncalibrated
LAB-USFS-336-020	Fluorescence standards, 1", Orange Fluor #336, uncalibrated
LAB-USFS-461-010	Fluorescence standards, 1", Blue/White Fluor #461, uncalibrated

Sampling Accessories
Filter Holders

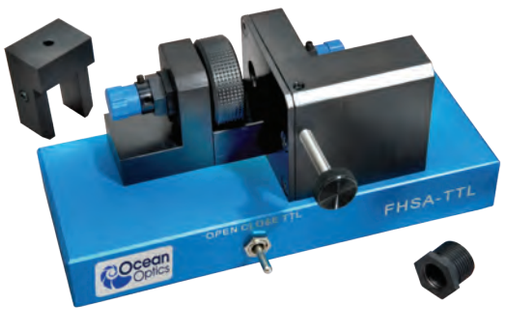
FHS-UV In-Line Filter Holder

The FHS-UV In-Line Filter Holder is a low-cost spectrophotometric accessory for fast, convenient absorbance/transmission measurements of optical and other filters.

The FHS-UV In-Line Filter Holder features a pair of 74-UV 5-mm diameter f/2 collimating lenses that maximize light throughput, as well as a manual light-block wheel for dark readings. The Filter Holder acts as a simple yet effective device for measuring filters. It also provides a convenient place to accommodate filters for optical setups.

FHSA-Series Filter and Cuvette Holders

With our FHSA Filter and Cuvette Holders, you can configure the holders to sample either cuvettes or filters. Use FHSAs to measure transmission of a 1-cm square cuvette or filter up to 7 mm thick. Plus, FHSAs interface to your PC, allowing you to control many of their functions via the included software.



With the FHSA-TTL, you have manual control of attenuation (adjustable 0-100%) and manual or software control of a shutter.

Specifications	FHSA-TTL	FHS-UV
Dimensions:	150 mm x 50 mm 50 mm	50.6 mm x 140 mm x 43.1 mm
Weight:	490 g	240 g
Power consumption:	100 mA @ 12 VDC	None
Maximum filter size:	7 mm thick	25 mm diameter round; up to 6 mm thick
Wavelength range:	200-2000 nm	200-2000 nm
Cuvette dimensions:	10 mm x 10 mm	NA
Shutter frequency:	5 Hz/60 dB maximum	NA
Shutter response time:	7 µsec	NA

INLINE-FH Filter Holder for Optical Fibers

Our INLINE-FH is an in-line filter holder that accommodates filters up to 8 mm in diameter and 3 mm in thickness. This filter holder includes two collimating lenses and connects to two fibers for in-line filtering. Filter options are similar to the 25.4 mm square filters listed on page 128. Please consult an Applications Scientist for assistance.

The FH-SMA allows you to mount filters or diffusers at the end of the SMA 905-terminated optical fibers. The FH-SMA accepts 8 mm diameter filters in thicknesses of 1-7 mm.

Specifications	FH-SMA	INLINE-FH
Dimensions:	16 mm diameter	15 mm diameter
Weight:	10 g	20 g
Filter size:	8 mm diameter, 1-7 mm thick	8 mm diameter, 3 mm thick
Material:	Anodized aluminum	Stainless steel (collimating lenses have anodized housings)

Sampling Accessories
Linear Variable Filters

We've combined our patented high-pass and low-pass technology to create an exceptional Linear Variable Filter line that features an adjustable center wavelength and bandpass. Each filter delivers an outstanding transmission band (~90%) and blocking band (99.8%).

Our LVF Filters have interference coatings applied to 57 mm x 10 mm quartz substrates and are particularly useful for spectrally shaping the excitation energy from broadband sources used for fluorescence.

Slide Carriers

These off-the-shelf filters are epoxied into slide carriers that allow you to move the transmission or blocking band throughout each filter's wavelength range.

Single High-pass and Single Low-pass Filter

The LVF-H High-pass Filter is a single filter that blocks light at 98.8% until a transition wavelength that varies along its length. At that point, the LVF-H passes light better than 90%. The LVF-L Low-pass Filter is a single filter that passes light at 88% until a transition wavelength that varies along its length.

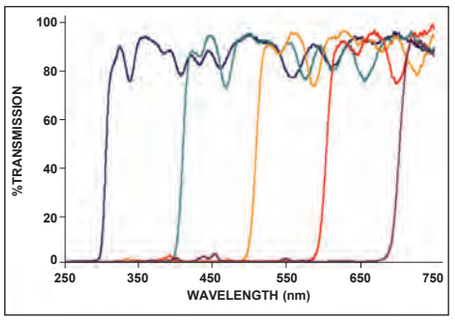
Double High-pass and Double Low-pass Filters

The benefit of having double filters versus a single filter is that the optical density of the blocking band increases to 99.96%. However, the transmission band is reduced to 80%.

High-pass and Low-pass Variable Bandpass Filters

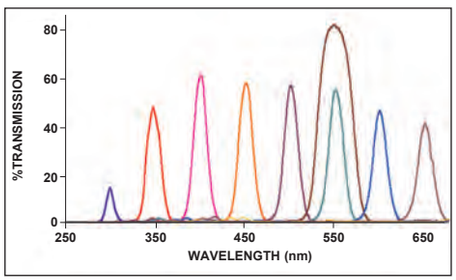
By fastening together a high-pass filter and a low-pass filter, we created a variable bandpass notch filter that allows you to adjust the center wavelength and the bandwidth. We preset the transmission bandwidth at ~25 nm FWHM, but adjusting four screws allows you to slide the filters against one another to create a wider or narrower transmission bandwidth.

LVF-H High-pass Filter



The transition wavelength from blocking to transmission band varies according to the filter's position in front of the collimating lens.

LVF-HL Variable Bandwidth Filter



These spectra were taken with an LVF-HL to show how a transmission bandwidth can be set throughout the filter's range (300-750 nm).

Item	Description
LVF-H	A single high-pass filter for 300-750 nm
LVF-L	A single low-pass filter for 300-750 nm
LVF-HH	Two LVF-H high-pass filters epoxied together for 300-750 nm
LVF-LL	Two LVF-L low-pass filters epoxied together for 300-750 nm
LVF-HL	An LVF-H high-pass filter and LVF-L low-pass filter fastened together to create an adjustable bandpass linear variable filter
LVF-UV-H	A single high-pass filter for 230-500 nm
LVF-UV-L	A single low-pass filter for 230-500 nm
LVF-UV-HH	Two LVF-UV-H high-pass filters epoxied together for 230-500 nm
LVF-UV-LL	Two LVF-UV-L low-pass filters epoxied together for 230-500 nm
LVF-UV-HL	An LVF-UV-H high-pass filter and LVF-UV-L low-pass filter fastened together to create an adjustable bandpass linear variable filter
LVF-CUV-ADP	Adapter for use with cuvette holders, to clamp filter slides into place
CVD-DIFFUSE	Teflon diffuser for cuvette holder-LVF setups, to redirect excitation energy to spectrometer
FHS-LVF	In-line system with two collimating lenses that accommodates slide carriers for straight-through (absorbance/transmission) measurements
LVF-KIT	Consists of the LVF-HL, LVF-CUV-ADP, FHS-LVF, and CVD-Diffuse
LVF-UV-KIT	Consists of the LVF-UV-HL, LVF-CUV-ADP, FHS-LVF and CVD-Diffuse

Sampling Accessories
Accessories for Linear Variable Filters

FHS-LVF
The FHS-LVF is an in-line filter holder that is used in absorbance and transmission applications. This in-line LVF holder features two collimating lenses with SMA 905 connectors. Its slot accommodates the LVF slide carrier. Screws hold the FHS-LVF in place. For absorbance/transmission measurements only.

Item Code: FHS-LVF

LVF-CUV-ADP
The LVF-CUV-ADP is an adapter piece that fits onto our 1-cm cuvette holders and holds the LVF slide carrier. The cuvette adapter slides over the top of the cuvette holder and includes screws to clamp the LVF's slide carrier into place. The LVF-CUV-ADP comes with a cover to block out ambient light and can accommodate both single-filter and double-filter slide carriers

Item Code: LVF-CUV-ADP

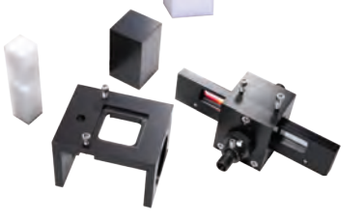
CVD-DIFFUSE
The CVD-DIFFUSE is a 1-cm cuvette-shaped piece of Teflon with a 45° surface at the measurement height. Use it in a fluorescence cuvette holder-with-filters configuration to redirect the excitation energy into the spectrometer. This facilitates setting the filter position or selecting the wavelength passed by the filter.

Item Code: CVD-DIFFUSE

Packages
Select one of the following packages for a convenient, all-in-one filter solution.

Item Code: LVF-KIT includes: LVF-HL, LVF-CUV-ADP, FHS-LVF, CVD-DIFFUSE

Item Code: LVF-UV-KIT includes: LVF-UV-HL, LVF-CUV-ADP, FHS-LVF, CVD-DIFFUSE



Sampling Accessories
Absorbing Glass Filters

High-Pass Filters
We offer our OF2 filters for installing into the optical path of your spectrometer setup. These high-pass filters are transmissive approximately 50% of the normal cutoff wavelength, >99% at wavelengths 50 nm higher than the cutoff and less than 0.1% at 50 nm lower than the cutoff. High-pass filters are used to block second orders, test for stray light and block excitation energy in fluorescence or Raman experiments.

Available Items		
OF2-WG305	pass >305 nm	square 25.4 x 25.4 x 3 mm
OF2-GG375	pass >375 nm	square 25.4 x 25.4 x 3 mm
OF2-GG395	pass >395 nm	square 25.4 x 25.4 x 3 mm
OF2-GG475	pass >475 nm	square 50.8 x 50.8 x 3 mm or square 25.4 x 25.4 x 3 mm
OF2-OG515	pass >515 nm	square 25.4 x 25.4 x 3 mm
OF2-OG550	pass >550 nm	square 25.4 x 25.4 x 3 mm

Balancing Filters
Our Balancing Filters absorb energy in some regions while transmitting in others. The BG34 filter, for example, reduces the intensity of light at 600 nm from a tungsten halogen bulb while transmitting all of the light at the blue and red regions, where detector sensitivity is lower.

Available Items		
OF2-FG3	enhance blue and red	square 25.4 x 25.4 x 3 mm
OF2-BG34R	enhance blue and red	round 12.7 mm OD

Bandpass Filters
These filters transmit a particular wavelength range while rejecting energies higher and lower than the selected range.

Note: Some of 25.4 mm square filters may be available in dimensions suitable for use with the INLINE-FH filter holder (page 126). Consult an Applications Scientist for details.

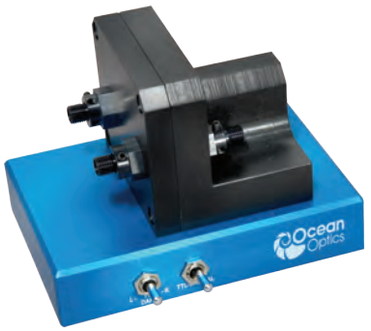
Available Items		
OF2-KG3	>325 nm and <700 nm	square 25.4 x 25.4 x 3 mm
OF2-U360	>340 nm and <380 nm	square 25.4 x 25.4 x 3 mm
OF2-RG780	>780 nm and 50% transmission <2.7 µm	square 25.4 x 25.4 x 3 mm

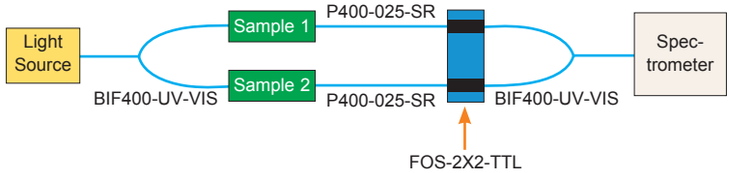
Sampling Accessories
Routing Control and More

Fiber Optic Dual Switch with TTL Line

The FOS-2X2-TTL Fiber Optic Dual Switch was designed to provide you with flexibility in routing, splitting and controlling light. The FOS has two light channels. You can opt to have one light channel open at a time or have both closed. The FOS is useful for monitoring the drift of the light source or for measuring two samples with one spectrometer channel and one light source. The diagram below is an example of how the FOS can be utilized. In this setup, the FOS eliminates the need for a second spectrometer channel.

Item Code: FOS-2X2-TTL





In this setup, light enters a Bifurcated Optical Fiber Assembly and then splits into two arms, one for each sample. Light interacts with each sample and travels through another fiber assembly, each into its own port in the FOS. Another Bifurcated Assembly collects the light from the FOS and sends it to the spectrometer. Here you would switch the shutter on the FOS from one light channel to another in order to get clean data from each sample. Without the FOS, you would need another spectrometer channel to monitor the two samples.

Electronic TTL Shutter

In spectrometer setups, the INLINE-TTL TTL-driven shutter allows you to block the light path without disturbing the experiment -- for example, by turning the light source on and off. The laser-cut shutter is installed between two collimating lenses, which attach to two optical fibers. The INLINE-TTL is driven by a small board with a TTL input. Included is a cable for interfacing to a spectrometer.

Item Code: INLINE-TTL-S

Specifications	
Dimensions:	140 mm x 50 mm x 50 mm
Weight:	~600 g
Shutter-Input:	TTL maximum 5 Hz
Power requirements:	12 VDC (power supply included)
Power consumption:	100 mA maximum
Maximum frequency:	5 Hz

Field of View Control

The Gershun Tube Kit (GER-KIT) controls the field of view of our SMA 905-terminated optical fiber. It also directly attaches to a spectrometer with an SMA 905 Connector. User-interchangeable apertures provide many different fields of view from 1° to 28°. When the GER-KIT is used with our optical fiber, the field of view cannot exceed the optical fiber's 25° field of view if you are measuring radiance.

Item Code: GER-KIT

Specifications	
Material:	Black anodized aluminum
Interior:	Bead-blasted surface to reduce off-axis reflections
Connection:	Directly attaches to one of our spectrometers or couples to an SMA 905-terminated optical fiber with included adapter barrel
Apertures:	1°, 3°, 8°, 10° and 14° apertures included, providing 1°, 2°, 3°, 6°, 8°, 10°, 14°, 16°, 20° and 28° fields of view

Sampling Accessories
Filtering Light

MPM-2000 Optical Multiplexer

Our MPM-2000 Fiber Optic Multiplexers take light to your spectrometer or from a light source (connected to one of the input ports) and distribute it to either 8 or 16 outputs. The light is distributed through the output ports in sequential order with switching times between channels of less than 150 milliseconds. These precision instruments are ideal for process environments where multiple locations need to be measured with a single spectrometer channel or light source.

High-Precision

All versions of our MPM-2000 include a DC motor that provides excellent speed control without sacrificing power. An included encoder converts movement into a digital pulsed output. Each channel in the MPM-2000 has a collimating lens that connects to an internal optical fiber system. Plus, the MPM-2000 provides accurate measurements with superior repeatability of 99%.

Software Controlled

Our MPM-2000 Multiplexers interface easily with your PC via an RS-232 port and come with software and drivers for complete PC control. The MPM-2000's software allows you full control of the switching order, switching delay time and system calibration.

Specifications	
Dimensions (600 µm version):	400 mm x 170 mm x 130 mm
Dimensions (400 µm version):	200 mm x 170 mm x 130 mm
Wavelength range:	250-800 nm – UV-VIS 350-2000 nm – VIS-NIR
Optical throughput:	>60% when using standard 400 µm fibers @ 650 nm
Motor:	Direct-current
Repeatability:	>99%
Switching time:	150 ms between adjacent positions
Interface:	RS-232 (optional USB)
Power requirement:	24 VDC, 1.2 A (includes WT-24V-E power supply)
Connectors:	SMA 905

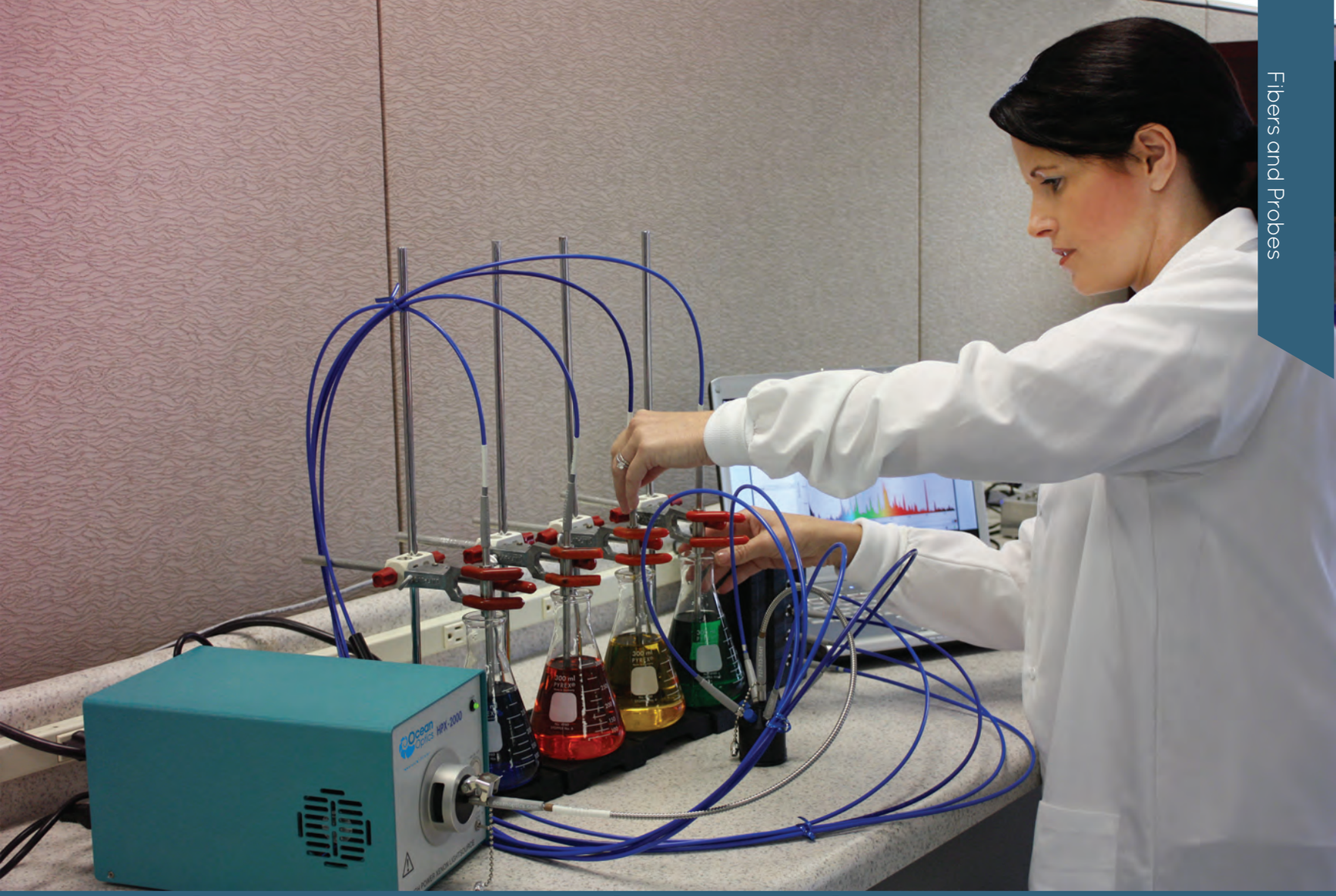
Available Items	
MPM-2000-UV-VIS400-1X16	1x input 16x output channels, RS-232 controlled, 24VDC. 400 µm fiber
MPM-2000-UV-VIS400-2X8	2x input 8x output channels, RS-232 controlled, 24VDC. 400 µm fiber
MPM-2000-VIS400-1X16	1x input 16x output channels, RS-232 controlled, 24VDC. 400 µm fiber
MPM-2000-VIS400-2X8	2x input 8x output channels, RS-232 controlled, 24VDC. 400 µm fiber
MPM-2000-VIS600-1X16	1x input 16x output channels, RS-232 controlled, 24VDC. 600 µm fiber
MPM-2000-VIS600-2X8	2x input 8x output channels, RS-232 controlled, 24VDC. 600 µm fiber
MPM-2000-UV-VIS600-1X16	1x input 16x output channels, RS-232 controlled, 24VDC. 600 µm fiber
MPM-200-UV-VIS600-2x8	2x input 8x output channels, RS-232 controlled, 24VDC. 600 µm fiber

Fiber Optic Variable Attenuator

Our FVA-UV Fiber Optic Variable Attenuator is an opto-mechanical device that helps you control the amount of light transmitted between two fibers. Fibers screw into either side of the FVA-UV via SMA 905 connectors with collimating lenses that project light across a metal disk in which a slit has been cut. The width of the slit varies as a function of manually adjusted radial position. Rotating the disc varies the attenuation from 0-100% uniformly across a 200-2000 nm wavelength range.

Item Code: FVA-UV Fiber Optic Variable Attenuator, FVA-ADP Adapter for FVA-UV

Specifications	
Dimensions:	38.1 mm x 59.4 mm x 40 mm
Weight:	90 g
Assembly ports:	3/8-24 threads for collimating lenses
Wheel lock:	6-32 nylon thumbscrew
ADP adapter:	Directly attaches to a light source with a collimating lens
Connector:	SMA 905



Fibers and Probes

Ocean Optics provides the most flexible line of optical fibers available. We craft our standard and custom fiber assemblies to provide you years of reliable, accurate results. You can depend on Ocean Optics for everything from one-off patch cords and custom assemblies to OEM builds for virtually any application you can imagine.

Our fiber accessories, fixtures and fiber assembly kits allow you to easily connect or manipulate fibers and integrate them into the most challenging application setups.

Tip

To get the most from your Ocean Optics optical fiber, it's important to use special care in handling. Never bend or wind fibers tightly and always store in a cool, dry place.

Fibers and Probes

The Most Flexible Line in the Industry

Anatomy of an Assembly

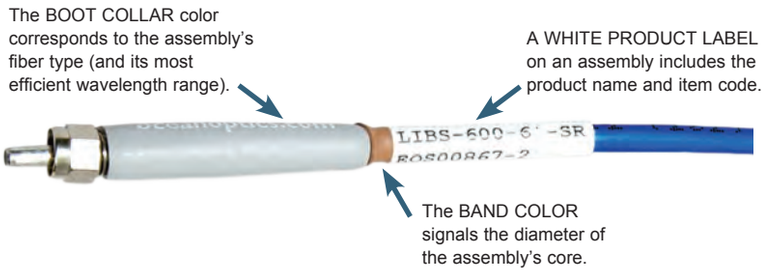
At the fiber's core is pure silica; it's the diameter of the core that you need to consider when purchasing an optical fiber assembly. (The core diameter is often in the product's item code. For example, the QP600-UV-VIS has a 600 µm diameter silica core).

Surrounding the core is a doped-fluorine silica cladding. A buffer material is then applied. A buffer coats the core and cladding , strengthens the fiber and reduces stray light even further. In most assemblies polyimide is used as the buffer; other assemblies use aluminum or acrylate. Then a jacketing is applied over the core, cladding and buffer to protect the fiber and provide strain relief.

For off-the-shelf Premium-grade "Q" Optical Fiber Assemblies, the standard jacketing is stainless steel silicone monocoil. There are several other jacketing options when creating a custom assembly. Precision SMA 905 Connectors terminate the assembly and are precisely aligned to the spectrometer's slit to ensure concentricity of the fiber. Finally, captive end caps protect the fiber tips against scratches and contaminants.

Assembly Identifiers

Our optical fiber and probe assemblies are clearly and cleanly labeled in three ways so that you always know the following about your assembly: its name, its core diameter, and its most efficient wavelength region.



Band Colors

The assembly's band color lets you know the fiber type and the most efficient wavelength range in which your fiber will work.

A color band tells you the diameter fiber with which you are working.

8 µm	Purple
50 µm	Blue
100 µm	Green
200 µm	Yellow
300 µm	Gray
400 µm	Red
500 µm	Orange
600 µm	Brown
1000 µm	Clear

Boot Color	Fiber Type	Most Efficient Wavelength Range	Premium-grade Optical Fiber Assembly for each Fiber Type
Gray	UV-VIS XSR Solarization-resistant	180-800 nm	
Gray	UV/SR-VIS High OH content	200-1100 nm	
Blue	UV-VIS High OH content	300-1100 nm	
Red	VIS-NIR Low OH content	400-2100 nm	
Black	Fluoride	300-4500 nm	

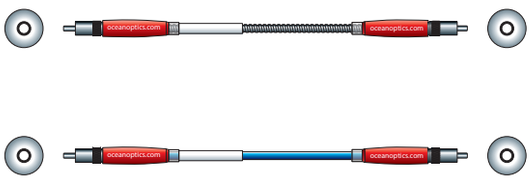
Note: An additional option for mid-IR wavelengths (2000-6000 nm) is Chalcogenide fiber. Standard assemblies are available.

Fibers and Probes: Overview

Standard Assemblies and Probes

From these half-dozen standard fiber designs, you can tackle an extensive range of absorbance, emission and reflectance spectroscopy needs. All Ocean Optics fibers have SMA 905 terminations for connecting to our spectrometers and accessories. Custom configurations, multiple-fiber bundles and special ferrule designs are also available.

Patch Cord Assemblies

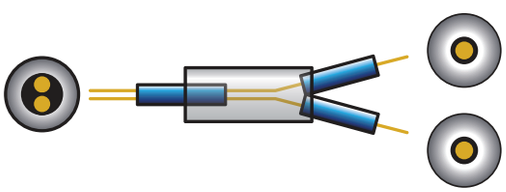


Our patch cord assemblies consist of a single fiber. Our standard, premium-grade options are available with stainless steel BX (top drawing) or silicone monocoil jacketing and PVDF.

Round to Keyed Linear Fiber

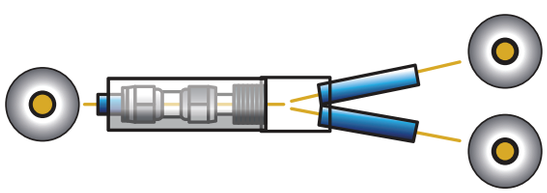
At one end of this seven-fiber assembly, the fibers are aligned linearly to more efficiently direct light into the optical bench and onto the detector. The collection end of the fiber has a six fibers-around-one design.

Bifurcated Fiber



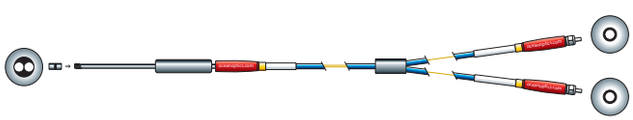
Bifurcated assemblies have two fibers side-by-side in the common end and break out into two legs at the other end. Each leg can be UV-VIS or VIS-NIR or mixed.

Splitter



A splitter comprises three fibers – two fibers at one end that deliver light into the third fiber at the common end. All the fibers are epoxied together at the nexus of the assembly.

Transmission Dip Probe



We offer several versions of this standard two-fiber transmission probe, designed for immersion in process streams and solutions. Various pathlength tips are available.

Premium Reflection Probe

Our standard reflection probe arrangement has seven optical fibers – six illumination fibers around one read fiber – in a stainless steel ferrule. Additional configurations are available.

Fibers and Probes: Overview

Transmission Characteristics of UV-VIS Options

Ocean Optics offers fiber material types with wavelength ranges to best match your application. On these pages are the attenuation curves for each of the fiber types we offer. High OH, or high water content fiber, is optimized for transmission in the UV-VIS. For work in the UV, especially <300 nm, our XSR and UV/SR-VIS fibers are a fine choice. These silica-core fibers are doped with fluorine to mitigate the solarizing effects of UV radiation. An Applications Scientist can provide additional assistance.

Transmission Efficiency of Optical Fibers

Transmission efficiency is the ratio of light energy exiting an optical fiber to the energy that is projected onto the other end. Transmission of light by optical fibers, however, is not 100% efficient. Energy is lost by reflection when light is launched into the fiber and at the other end when it exits the fiber. This is called Fresnel reflection and occurs when light travels across an interface between materials with different refractive indices.

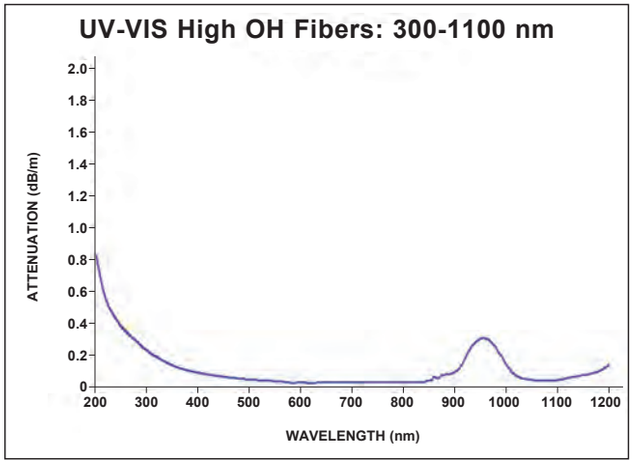
Ideally, light would travel inside the fiber by total internal reflection without any loss of energy. However, several factors can degrade the light during transmission and cause attenuation or absorption of light in the fiber.

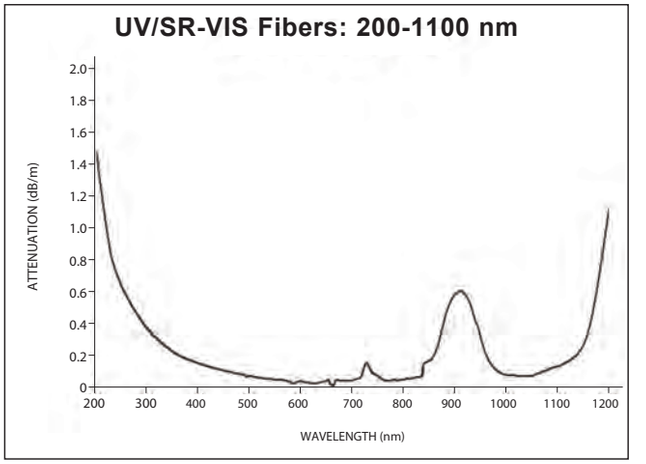
One reason for degradation of light is the presence of tiny imperfections in the fiber material, causing light at lower wavelengths to scatter. The fiber is also not completely transparent at all wavelengths. For example, high OH fiber is designed to transmit as much light as possible in the UV. However, the extra water has an absorption band that leads to dips in transmission efficiency in the NIR. To achieve good transmission in the NIR, the fiber material must be low OH.

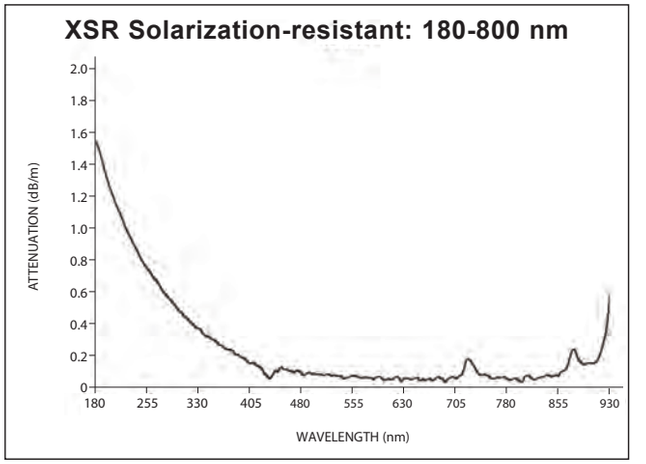
Another loss in transmission efficiency results from the evanescent field. When the light bounces off the interface between the core and cladding inside the fiber, its electric field penetrates the cladding. If the cladding material absorbs the light, the fiber will lose some of its energy.

Bending of fibers also contributes to attenuation. As the fiber is bent, it changes the angle at which light rays are striking the surface between the core and cladding. If the fiber is bent enough, light that had been below the critical angle will now exceed the critical angle and leak out of the fiber. Most of the bending occurs where a flexible fiber meets a rigid connector. To spread the bending along the length of the fiber, strain relief boots are added to the connectors.

Ocean Optics builds its fibers into assemblies that are cleaved, epoxied into precise SMA 905 or other connectors and polished with a very fine lapping film to reduce Fresnel reflection. The fiber is encased in mechanical sheathing to protect it and to provide good strain relief at the ends. As a result, the improvement in performance between Ocean Optics premium assemblies and ordinary telecom grade assemblies is quite significant.



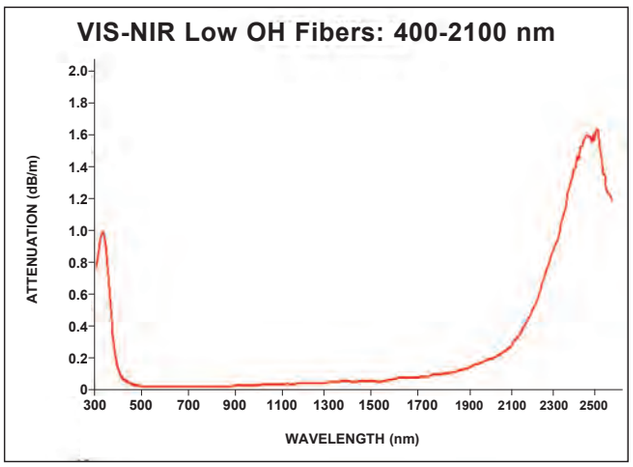


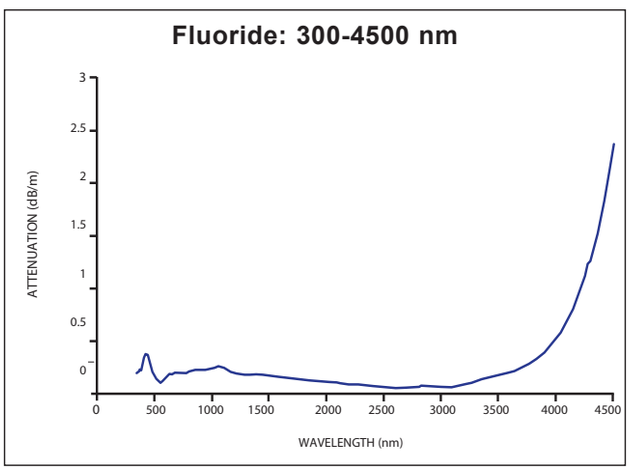


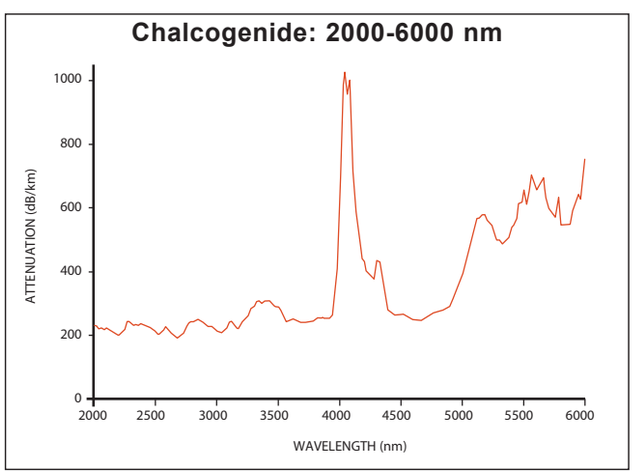
Fibers and Probes: Overview

Transmission Characteristics of VIS-NIR and Mid-IR Options

Ocean Optics offers several options for applications at higher wavelengths. For most Visible and Shortwave NIR setups, our low OH VIS-NIR fibers are a convenient, affordable option. If your work takes you farther into the NIR and mid-IR, consider our fluoride and chalcogenide fiber options. ZBLAN heavy-metal fluoride fibers are responsive to 4500 nm and distinguished by excellent IR transmittance performance. Chalcogenide fibers are responsive from 2000-6000 nm and characterized by low optical loss and great flexibility.



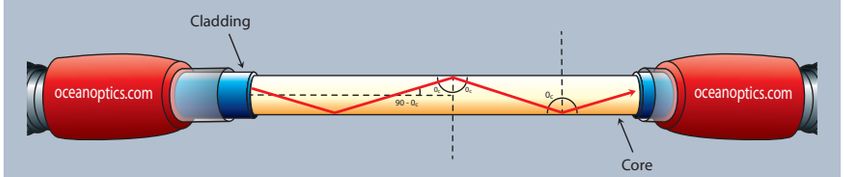




Numerical Aperture of Optical Fibers

Optical fibers are designed to transmit light from one end of the fiber to the other with minimal loss of energy. The principle of operation in an optical fiber is total internal reflection. When light passes from one material to another, its direction is changed. According to Snell's Law, the new angle of the light ray can be predicted from the refractive indices of the two materials. When the angle is perpendicular (90º) to the interface, transmission into the second material is maximum and reflection is minimum. Reflection increases as the angle gets closer to parallel to the interface. At the critical angle and below the critical angle, transmission is 0% and reflection is 100% (see figure below).

Light Passing Through an Optical Fiber



Snell's Law can be formulated to predict critical angle and also the launch or exit angle θ_{max} from the index of refraction of the core (n1) and cladding (n2) materials. The angle also depends on the refractive index of the media (n). Equation (1)

$$n \sin \theta_{max} = \sqrt{n_1^2 - n_2^2}$$

The left side of the equation is called the numerical aperture (NA) and determines the range of angles at which the fiber can accept or emit light.

Ocean Optics fibers have a numerical aperture of 0.22. If the fiber is in a vacuum or air, this translates into an acceptance angle θ_{max} of 12.7° (full angle is ~25°). When light is directed at the end of an optical fiber all the light rays or trajectories that are within the +/-12.7° cone are propagated down the length of the fiber by total internal reflection. All the rays that exceed that angle pass through the cladding and are lost. At the other end of the fiber, light exits in a cone that is +/- 12.7°.

There are many types of fibers available, with a variety of numerical apertures. While a fiber with a larger numerical aperture will collect more light than a fiber with a smaller numerical aperture, it is important to look at both ends of the system to ensure that light exiting at a higher angle can be used. In optical sensing, one end is gathering light from an experiment and the other is directing light to a detector. Any light that does not reach the detector will be wasted.

Premium Grade Optical Fiber Assemblies

Our premium-grade fibers are durable, high quality fibers optimized for spectroscopy and enhanced with extra strain relief for use even in demanding environments. We have a full range of standard patch cords and can customize assemblies (see pages 138-139 for options). Also available are assemblies (see table at bottom) consisting of multiple fibers stacked in a linear arrangement at one end to deliver light more efficiently into the spectrometer.

Premium-Grade Assemblies				Assembly Length					Jacketing				Bend Radius	
Wavelength Range	Item Code	Core Diameter	Buffer/ Coating	0.25 m	0.5 m	1 m	1.5 m	2 m	Silicone monocoil	Stainless-steel BX	PVDF Furcation	PEEK	LTBR	STBR
UV-VIS High OH Content 300-1100 nm	QP50-2-UV-VIS QP50-2-UV-BX	50 µm	Polyimide					X	X	 X			4 cm	2 cm
	QP100-2-UV-VIS QP100-2-UV-BX	100 µm	Polyimide					X	X	 X			4 cm	2 cm
	QP200-2-UV-VIS QP200-2-UV-BX	200 µm	Polyimide					X	X	 X			8 cm	4 cm
	QP400-1-UV-VIS QP400-1-UV-BX QP400-2-UV-VIS QP400-2-UV-BX	400 µm	Polyimide			X X		 X X	X X	 X X			16 cm	8 cm
	QP600-025-UV-VIS QP600-025-UV-BX QP600-1-UV-VIS QP600-1-UV-BX QP600-2-UV-VIS QP600-2-UV-BX	600 µm	Polyimide	X X		 X X		 X X	X X X	 X X X			24 cm	12 cm
	QP1000-2-UV-VIS QP1000-2-VIS-BX	1000 µm	Acrylate					X X	X	 X			40 cm	20 cm
VIS-NIR Low OH content 400-2100 nm	QP8-2-VIS-NIR	8 µm	Acrylate					X	X				4 cm	2 cm
	QP50-2-VIS-NIR QP50-2-VIS-BX	50 µm	Polyimide					X X	X	 X			4 cm	2 cm
	QP100-2-VIS-NIR QP100-2-VIS-BX	100 µm	Polyimide					X X	X	 X			4 cm	2 cm
	QP200-2-VIS-NIR QP200-2-VIS-BX	200 µm	Polyimide					X X	X	 X			8 cm	4 cm
	QP400-1-VIS-NIR QP400-1-VIS-BX QP400-2-VIS-NIR QP400-2-VIS-BX	400 µm	Polyimide			X X		 X X	X X	 X X			16 cm	8 cm
	QP600-025-VIS-NIR QP600-025-VIS-BX QP600-1-VIS-NIR QP600-1-VIS-BX QP600-2-VIS-NIR QP600-2-VIS-BX	600 µm	Polyimide	X X		 X X		 X X	X X X	 X X X			24 cm	12 cm
	QP1000-2-VIS-NIR QP1000-2-VIS-BX	1000 µm	Acrylate					X X	X	 X			40 cm	20 cm
Fluoride 300-4500 nm	P450-0.5-FLUORIDE P450-1.5-FLUORIDE P450-1-FLUORIDE	450 µm	Acrylate		X	X	 X				X X X		15 cm	8 cm
Chalcogenide 2000-6000 nm	P500-0.5-CHAL P500-1-CHAL	500 µm	Fluoropolymer and PVC		X	X						X X	7.5 cm	7.5 cm

Keyed SMA Optical Fiber Assemblies

Keyed SMA Optical Fiber Assemblies, Round to Keyed Linear				Assembly Length					Jacketing					
Wavelength Range	Item Code	Core Diameter	Buffer/ Coating	0.25 m	0.5 m	1 m	1.5 m	2 m	Silicone monocoil	Stainless-steel BX	PVDF Furcation	PEEK	LTBR	STBR
300-1100 nm	PL100-2-UV-VIS	100 µm ± 3 µm	Polyimide					x	x				4 cm	2 cm
400-2100 nm	PL100-2-VIS-NIR	100 µm ± 3 µm	Polyimide					x	x				4 cm	2 cm
300-1100 nm and 400-2100 nm	PL100-2-MIXED	100 µm ± 3 µm	Polyimide					x x	x x				4 cm	2 cm
300-1100nm and 400-2100 nm	PL200-2-MIXED	200 µm ± 4 µm	Polyimide					x	x				8 cm	4 cm

Note: Fiber bend radius is expressed as Long Term (LTBR) and Short Term (STBR).

Bifurcated Optical Fiber Assemblies

Premium-grade bifurcated assemblies have two fibers in the common end of the assembly that break out into separate legs. Splitters comprise three fibers epoxied at the nexus of a Y-shaped assembly and have lower transmission efficiency than bifurcated fibers.

Premium-grade Bifurcated Optical Fiber Assemblies				Assembly Length	Jacketing		Bend Radius	
Wavelength Range	Item Code	Core Diameter	Buffer/ Coating	2 m	Silicone monocoil	Stainless-steel BX	LTBR	STBR
VIS-NIR Low OH content 400-2100 nm	QBIF50-VIS-NIR	50 µm	Polyimide	X	X			
	QBIF200-VIS-NIR QBIF200-NIR-BX	200 µm	Polyimide	X X	X	 X	8 cm	4 cm
	QBIF400-VIS-NIR QBIF400-NIR-BX	400 µm	Polyimide	X X	X	 X	16 cm	8 cm
	QBIF600-VIS-NIR QBIF600-NIR-BX	600 µm	Polyimide	X X	X	 X	24 cm	12 cm
UV-VIS High OH Content 300-1100 nm	QBIF50-UV-VIS	50 µm	Polyimide	X	X		4 cm	2 cm
	QBIF200-UV-VIS	200 µm	Polyimide	X	X		8 cm	4 cm
	QBIF400-UV-VIS	400 µm	Polyimide	X	X		16 cm	8 cm
	QBIF600-UV-VIS	600 µm	Polyimide	X	X		24 cm	12 cm
300-1100 nm and 400-2100 nm (Mixed)	QBIF200-MIXED	200 µm	Polyimide	X	X		8 cm	4 cm
	QBIF400-MIXED	400 µm	Polyimide	X	X		16 cm	8 cm
Splitter Optical Fiber Assemblies								
VIS-NIR Low OH content 400-2100 nm	SPLIT200-VIS-NIR	200 µm	Polyimide	X	X		8 cm	4 cm
	SPLIT400-VIS-NIR	400 µm	Polyimide	X	X		16 cm	8 cm
UV-VIS High OH Content 300-1100 nm	SPLIT200-UV-VIS	200 µm	Polyimide	X	X		8 cm	4 cm
	SPLIT400-UV-VIS	400 µm	Polyimide	X	X		16 cm	8 cm

Solarization Resistant Optical Fiber Assemblies

We offer two types of solarization-resistant fiber assemblies, which prevent transmission degradation in the UV: polyimide-buffer fibers for applications <300 nm and aluminum-buffer fibers that offer enhanced UV transmission (signal will transmit to 180 nm) and resistance to UV degradation.

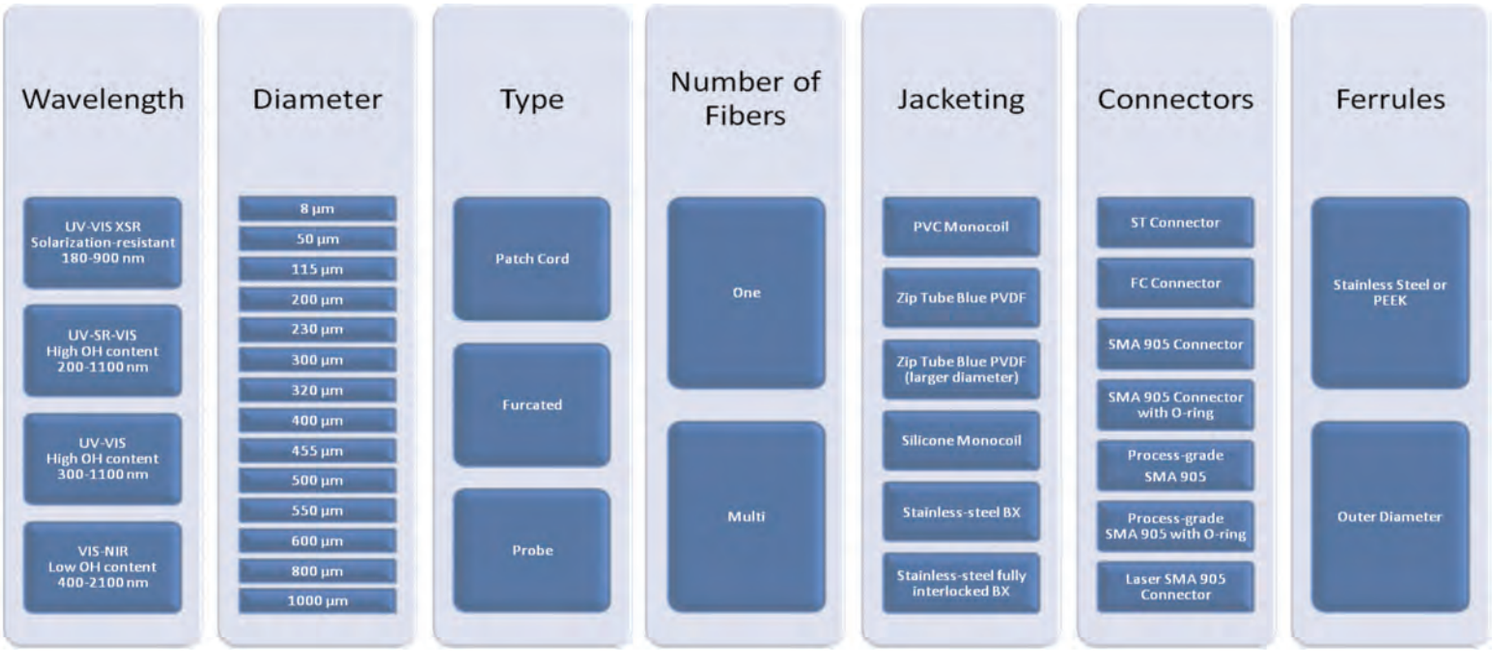
Extreme Solarization-Resistant				Assembly Length					Jacketing		Bend Radius	
Wavelength Range	Item Code	Core Diameter	Buffer/ Coating	0.25 m	0.5 m	1 m	1.5 m	2 m	Silicone monocoil	Stainless-steel BX	LTBR	STBR
UV/SR-VIS High OH content 200-1100 nm	QP200-2-SR-BX	200 µm	Polyimide					X		X	8 cm	2 cm
	QP300-1-SR QP300-1-SR-BX	300 µm	Polyimide			X X			X	 X	12 cm	6 cm
	QP400-025-SR QP400-025-SR-BX QP400-2-SR QP400-2-SR-BX	400 µm	Polyimide	X X				 X X	X X	 X X	16 cm	8 cm
	QP600-025-SR QP600-025-SR-BX QP600-1-SR QP600-1-SR-BX QP600-2-SR QP600-2-SR-BX	600 µm	Polyimide	X X		 X X		 X X	X X X	 X X X	24 cm	12 cm
UV-VIS XSR Solarization-resistant 180-900 nm	QP115-025-XSR-BX QP115-1-XSR-BX QP115-2-XSR-BX	115 µm	Aluminum (Primary)	X		X		 X		X X X	4 cm	2 cm
	QP230-025-XSR-BX QP230-1-XSR-BX QP230-2-XSR-BX	230 µm	Aluminum (Primary)	X		X		 X		X X X	4 cm	2 cm
	QP455-025-XSR-BX QP455-1-XSR-BX QP455-2-XSR-BX	455 µm	Aluminum (Primary)	X		X		 X		X X X	8 cm	4 cm
	QP600-025-XSR-BX QP600-1-XSR-BX QP600-2-XSR-BX	600 µm	Aluminum (Primary)	X		X		 X		X X X	24 cm	12 cm

Note: Fiber bend radius is expressed as Long Term (LTBR) and Short Term (STBR).

Fibers and Probes

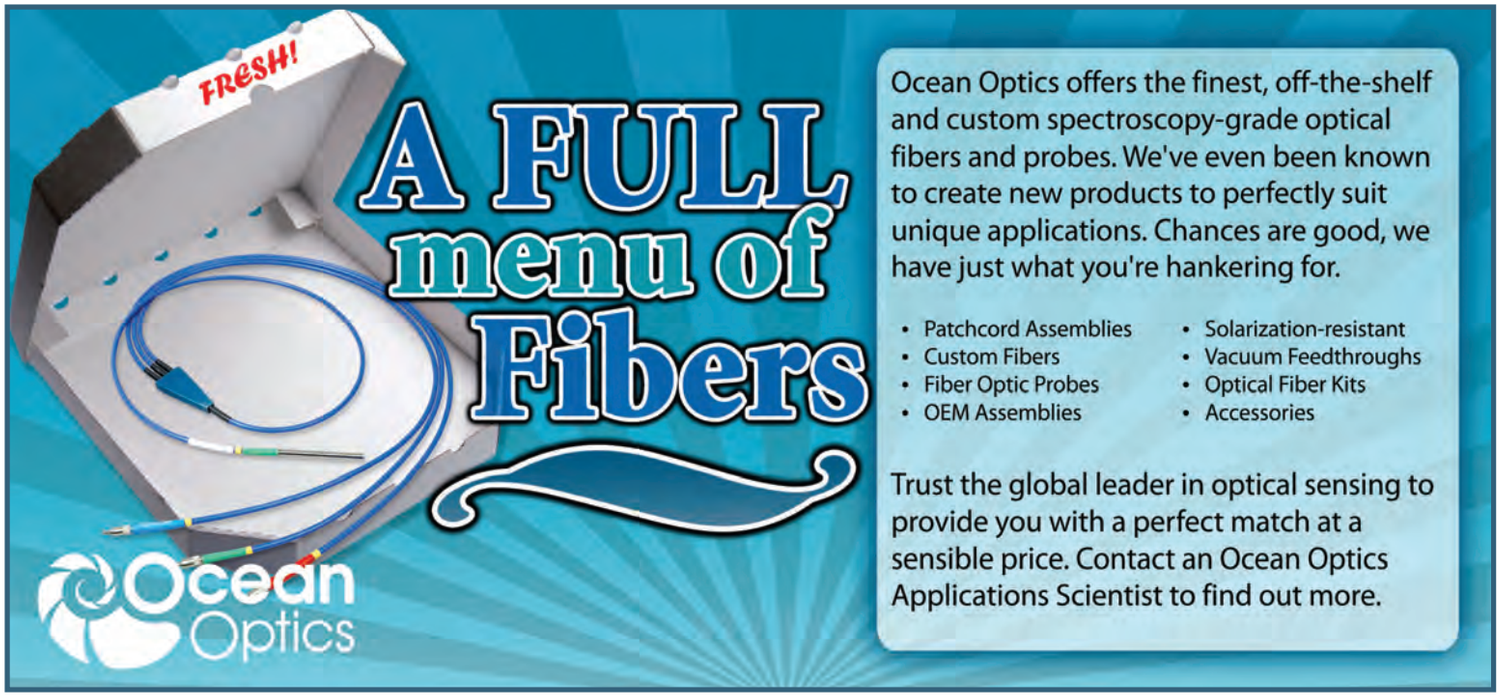
Custom Fiber and Probe Assemblies

Custom Fibers



After selecting the best fiber type, you should consider the diameter size of the pure silica core needed inside of your assembly. We offer several diameter sizes, and can recommend the appropriate assembly based on these criteria:

1. How much light do you need for your application? Reflection and fluorescence applications generally need more light, and larger diameter fibers are often better choices than smaller diameter fibers. For a laser application, however, we may suggest a smaller diameter fiber.
2. What is the entrance aperture size of your spectrometer? Make sure that your fiber diameter size and the entrance aperture to your spectrometer are compatible and are configured properly for your application needs.
3. If you have too much light in your setup, are there ways you can attenuate the light? We believe that it's better to have too much light than not enough.



Fibers and Probes
Custom Fiber and Probe Assemblies

Custom Option: Jacketing Options

The fiber assembly jacketing is designed to protect the fiber and provide strain relief. But we have jacketing options that can do so much more. We offer multiple jacketing options; our most popular selections are listed below.

Item		Description	Chemical Resistance	Steam Sterilizable	Mechanical Tolerance	Length Limits
1	PVC Monocoil	PVC covering SS monocoil only	Poor	No	Good	6 m
2	Zip Tube Blue PVDF	Best for budget-conscious applications; standard in Laboratory-grade Assemblies	Poor	No	Good	50 m
3	Zip Tube Blue PVDF	Best for budget-conscious applications; larger diameter than #2	Poor	No	Good	50 m
4	Silicone Monocoil	High-end jacketing; standard in Premium-grade Assemblies (sIlicone covering SS monocoil)	Good	Yes	Good	20 m
5	Stainless-steel BX	OEM applications only; optional polyolefin heatshrink overcoat	Good	Yes	Poor	4 m
6	Stainless-steel fully interlocked BX	Excellent stainless steel jacketing supports longer lengths of fiber; optional polyolefin heatshrink overcoat	Good	Yes	Excellent	40 m

Custom Option: Connectors and Connector Adapters

Our fiber assemblies are available with several connector options. For an upgrade fee that includes the cost of the custom connector and labor, we will replace the standard SMA 905 Connector (included in the assembly price) with any custom connector from the list below. When ordering custom connectors, please specify the diameter size of the optical fiber to which it will be attached. You also can order connectors separately.

Item	Description
CONN-ST	Stainless-steel ST Connector
CONN-FC	Stainless-steel FC Connector
CONN-QSMA	Premium-grade SMA 905 Connector (standard in Premium-grade assemblies)
CONN-SMA	Laboratory-grade SMA 905 Connector (standard in Laboratory-grade assemblies)
CONN-QSMA-O	Premium-grade SMA 905 Connector with O-ring
CONN-SMA-O	Laboratory-grade SMA 905 Connector with O-ring

Custom Option: Ferrules for Probe Assemblies

Description	Length
1/4” (6.35 mm) diameter stainless-steel dip probe often used in solution transmission measurements	3” (76.2 mm)
1/4” (6.35 mm) diameter PEEK dip probe used in harsh environments for solution transmission measurements	3” (76.2 mm)
1/4” (6.35 mm) diameter stainless-steel ferrule used in reflection measurements	3” (76.2 mm)
1/4” (6.35 mm) diameter PEEK ferrule used in harsh environments	3” (76.2 mm)
1/8” (3.2 mm) diameter stainless-steel ferrule	3” (76.2 mm)
1/16” (1.59 mm) diameter stainless-steel ferrule	2” (51 mm)
1/4” (6.35 mm) diameter stainless-steel ferrule with angled window	2” (51 mm)
Fiber-to-lens ferrule that comes with a collimating lens	2” (51 mm)

Reflection/Backscattering Probes

Our Reflection Probes are ideal for measuring diffuse or specular reflectance from solid surfaces or backscattering and fluorescence in solutions and powders. Probes are available in lab-grade (R-series) and premium-grade (QR-series) versions. Choose from nearly 40 standard options or customize a probe by selecting different lengths and other features.

Standard Reflection/Backscattering Probes			Fiber Bundle	Probe Ferrule		Jacketing				
Wavelength Range	Item Code	Core Diameter	6 illumination fibers around 1 read fiber	6.35 mm OD x 76.2 mm	3.18 mm OD x 74.3 mm	Silicone monocoil	Stainless-steel BX	Zip tube blue PVDF	LTBR	STBR
VIS-NIR Low OH content 400-2100 nm	QR200-7-VIS-NIR	200 µm	X	X		X			8 cm	4 cm
	R200-7-VIS-NIR		X	X				X		
	QR400-7-VIS-NIR	400 µm	X	X		X			16 cm	8 cm
	R400-7-VIS-NIR		X	X				X		
	QR400-7-VIS-BX		X	X			X			
	R400-7-VIS-BX		X	X			X			
	QR600-7-VIS-NIR	600 µm	X	X		X			24 cm	12 cm
	R600-7-VIS-125F		X		X			X		
	QR600-7-VIS-125F		X	X		X				
	QR600-7-VIS125BX		X	X			X			
UV-VIS High OH Content 300-1100 nm	QR200-7-UV-VIS	200 µm	X	X		X			8 cm	4 cm
	R200-7-UV-VIS		X	X				X		
	QR400-7-UV-VIS	400 µm	X	X		X			16 cm	8 cm
	R400-7-UV-VIS		X	X				X		
	QR400-7-VIS-BX		X	X			X			
	R400-7-VIS-BX		X	X			X			
	QR400-7-UV-BX		X	X			X			
	QR600-7-UV-VIS	600 µm	X	X		X			24 cm	12 cm
	R600-7-UV-125F		X		X			X		
	QR600-7-UV-125F		X		X	X				
	QR600-7-UV125BX		X		X		X			
UV/SR-VIS High OH content 200-1100 nm	QR200-7-SR	200 µm	X	X		X			8 cm	2 cm
	R200-7-SR		X	X				X		
	QR300-7-SR	300 µm	X	X		X			12 cm	6 cm
	R300-7-SR		X	X				X		
	QR400-7-SR	400 µm	X	X		X			16 cm	8 cm
	R400-7-SR		X	X				X		
	QR400-7-SR-BX		X	X			X			
	R400-7-SR-BX		X	X			X			
	QR600-7-SR-125F	600 µm	X	X		X			24 cm	12 cm
	R600-7-UV-125F		X		X			X		
	QR600-7-SR125BX		X		X		X			
	R600-7-SR-125F		X		X			X		
	QR600-7-UV-125F		X		X	X				
	QR600-7-UV125BX		X		X		X			
	QR600-7-VIS-125F		X		X	X				
	QR600-7-VIS-125BX		X		X		X			
UV-VIS XSR Solarization-resistant 180-900 nm	QR230-7-XSR	230 µm	X	X		X			4.6 cm	2.3 cm
	QR450-7-XSR	450 µm	X	X		X			9.0 cm	4.5 cm

Our most typical reflection probe design has a tightly packed 6-around-1 fiber bundle to ensure parallel orientation of the fibers.

Reflection probes couple to our spectrometers and light sources to measure reflection and fluorescence from solid surfaces or backscattering and fluorescence in liquids and powders. Sample applications include color and appearance measurements of solid surfaces such as filters and biological samples and backscattering measurements of milk, bulk powders and dyes. Also, we offer a 200 µm reflection probe in the same 6-around-1 design, but with a 76.2 mm PEEK ferrule for applications (such as corrosive environments) where non-metallic probes are necessary.

Item Code: RP200-7-UV-VIS

Reflection/Backscattering Probes

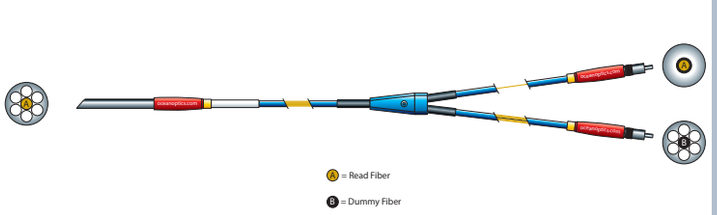
Reflection Probes with Reference Leg			Fiber Bundle	Probe Ferrule		Jacketing			
Wavelength Range	Item Code	Core Diameter	6 illumination fibers around 1 read	6.35 mm OD	3.18 mm OD	Silicone monocoil	Zip tube blue PVDF	LTBR	STBR
VIS-NIR Low OH content 400-2100 nm	QR200-7-REF-VIS-NIR R200-7-REF-VIS-NIR	200 µm	X X	X X		X	 X	8 cm	4 cm
UV-VIS High OH Content 300-1100 nm	QR200-7-REF-UV-VIS R200-7-REF-UV-VIS	200 µm	X X	X X		X	 X	8 cm	4 cm
Reflection/Backscattering Probes for Expanded Wavelength Coverage									
UV-VIS and VIS-NIR 300-1100 nm and 400-2100 nm	QR200-12-MIXED R200-12-MIXED	200 µm	6 UV-VIS and 6 VIS-NIR illumination fibers around 1 UV-VIS and 1 VIS-NIR fibers	X X		X	 X	8 cm	4 cm
Angled Probes for Solutions and Powders									
VIS-NIR Low OH content 400-2100 nm	QR200-7-ANGLE-VIS R200-7-ANGLE-VIS	200 µm	X X	X X		X	 X	8 cm	4 cm
	QR400-7-ANGLE-VIS R400-7-ANGLE-VIS QR400-ANGLE-VIS	400 µm	X X X	X X X		X X	 X	16 cm	8 cm
UV-VIS High OH Content 300-1100 nm	QR200-7-ANGLE-UV R200-7-ANGLE-UV	200 µm	X X	X X		X	 X	8 cm	4 cm
	QR400-7-ANGLE-UV R400-7-ANGLE-UV QR400-ANGLE-UV	400 µm	X X X	X X X		X X	 X	16 cm	8 cm

Reflection/Backscattering Probes for Expanded Wavelength Coverage

The QR200-12-MIXED has 14 fibers -- six UV-VIS and six VIS-NIR illumination fibers, plus one UV-VIS and one VIS-NIR read fiber (see bundle photo at left). It couples easily to a dual-channel spectrometer in which each channel is set for a different wavelength range.

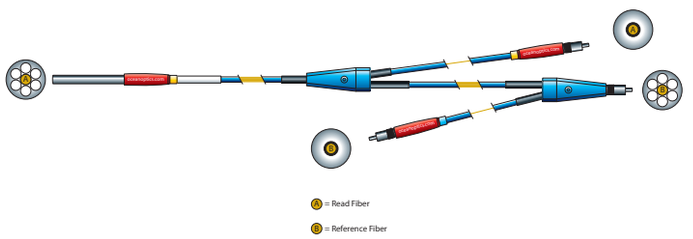
Item Code: QR200-12-MIXED

Angled Reflection Probe



Our Angled Reflection Probes have a 6-around-1 fiber design with a 30º window to remove specular effects when the probe is immersed in liquids or powders.

Reflection Probe With Reference Leg



In this design, an additional fiber leg is added to the probe to monitor an illumination or reference source. This is useful where the changing output of the source needs continuous monitoring.

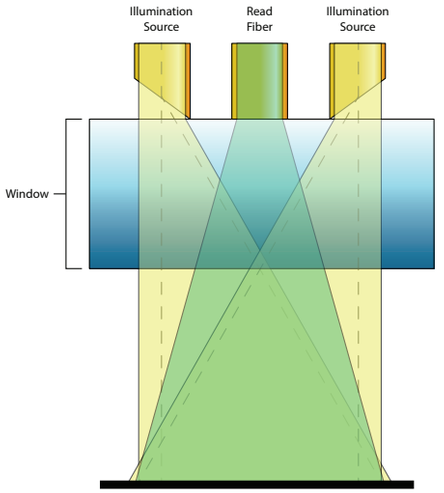
QF600-8-VIS-NIR

The Fluorescence Probe that Excels

Novel Design Maximizes Fluorescence Signal

The QF600-8-VIS-NIR Fiber Optic Fluorescence Probe has a unique optical design that allows users to control the depth of sampling and to optimize the region of overlap between excitation and emission fibers. The probe uses 1 flat fiber for detection and 7 angled fibers that direct excitation energy to the region in front of the detection fiber. An adjustable window facilitates choosing the depth of overlap. The probe works with liquids or solids. Custom options are available. Select different fiber wavelength range options or solarization-resistant fiber, as well as different connectors and jacketing. Custom length probes are also available. Replacement tips can be purchased separately.

Item Code: QF600-8-VIS-NIR



Item	Specifications
Fiber profile:	Step-index multimode
Fiber core:	Low OH silica
Fiber cladding:	Doped silica
Fiber buffer:	Polyimide
Fiber assembly jacketing:	Silicone monocoil
Fiber diameter:	600 µm
Fiber assembly length:	2.0 meters (+/- 5%)
Fiber bundle:	7 angled polished fibers around 1 flat polished fiber
Operating temperature:	-50 °C to 80 °C (fiber assembly); -50 °C to 200 °C (probe tip)
Numerical aperture:	0.22 +/-0.02 (before angle polishing)
Wavelength range:	VIS/NIR (400-900 nm)
Probe ferrule:	6.35 mm (¼") OD x 76.2 mm (3.0") stainless steel
Connectors:	Premium SMA 905

FL-400

Flame-resistant Fiber Probe

Fiber core diameter:	400 µm
Assembly length:	20 cm (8")
Fiber core/cladding:	Silica
Fiber core/cladding diameter:	400 µm/440 µm
Fiber jacketing:	Gold
Fiber buffer/ tube diameter:	510 µm/0.9 µm
Fiber bundle:	1 single-strand, multi-mode read fiber
Wavelengths covered:	300-1100 nm
Probe sleeve (ferrule):	Stainless steel
Flame loop:	Nickel chromium 24 AWG
Temperature range:	-269° C to 750° C
Numerical aperture:	0.22
Fiber termination:	SMA 905

The FL-400 is a heat-resistant fiber optic probe that couples to Ocean Optics miniature fiber optic spectrometers to measure in situ emission spectra of samples such as dissolved metals and high-temperature plasmas.

High-temperature Fiber

The FL-400 Flame-resistant Fiber Probe consists of a high-temperature 400 µm gold-jacketed UV-VIS optical fiber in an 8-inch-long stainless steel sleeve. The probe is connected with a splice bushing to a standard SMA-terminated patch cord, which couples to the spectrometer to measure emission spectra.

Spectroscopy Teaching Tool

The FL-400 Flame-resistant Fiber Probe is especially beneficial as an emission spectroscopy teaching tool for use with Ocean Optics' CHEM4-series of low-cost, UV-VIS teaching-lab spectrophotometers. Use the probe in two ways:

- By introducing it into emission sample environments up to 750 °C
- By attaching the nickel wire loop at the probe tip so that users can observe flame emission spectra of samples such as sodium, potassium, calcium and copper

Item Code: FL-400

Transmission Dip Probes

General Purpose Probes for the Lab and Other Environments

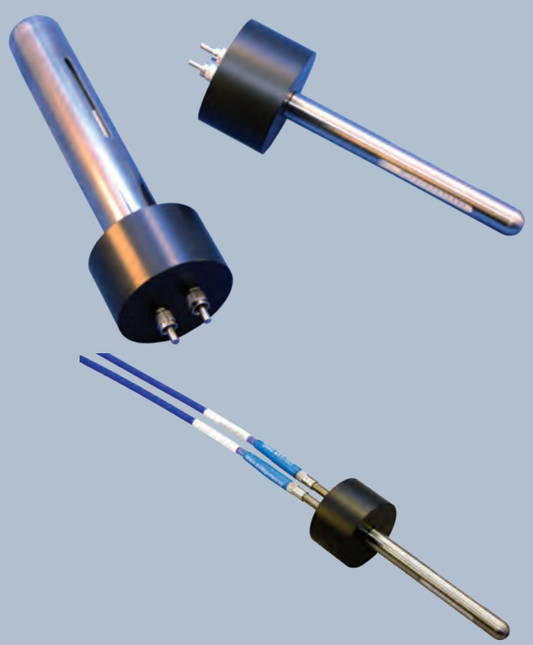
Our T300-RT and T200-RT Transmission Dip Probes couple to our spectrometers and light sources to measure absorbance and transmission in solutions. These probes are especially useful for embedding into process streams for real-time sample monitoring.

Item Code: T300-RT, T200-RT

Item	Specifications
Fiber type:	T300: 300 µm solarization-resistant or VIS-NIR optical fiber; T200: 200 µm VIS-NIR optical fiber
Outer diameter:	6.35 mm
Probe length:	127 mm
Fiber length:	2 meters
Breakout:	1.0 meters from the end of the probe
Optics:	Fused silica
Probe wetted materials:	Stainless steel, fused silica, Epotek 353ND
Pathlength:	2, 5 or 10 mm
Internal materials:	Second surface aluminum mirror
Pressure:	100 psi
Fiber jacketing:	PVC Monocoil - PVDF zip tube
Probe sleeve:	Stainless steel (300 series)
Connector:	SMA 905
Operating temperature:	Up to 100 ºC without sleeve

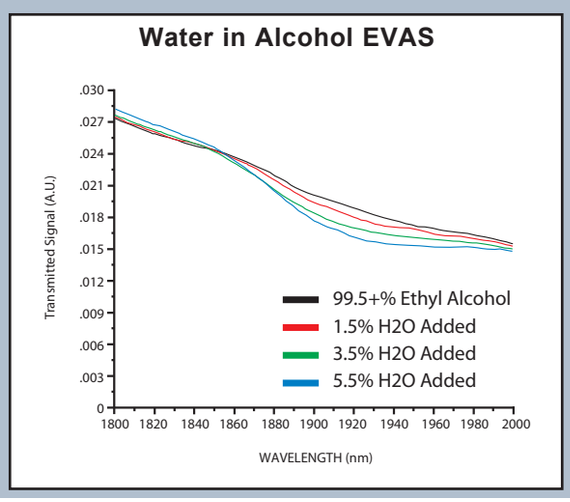
EVAS Probe

The Evanescent Wave Absorption Sensor



The EVAS evanescent wave absorption sensor consists of a sapphire fiber wound around a vertical PTFE shaft. The ends of the fiber are tapered up to facilitate the coupling of light into and out of the probe. The design permits the adjustment of the interaction length by more than an order of magnitude to accommodate the optical analysis of spectral features with widely different absorption coefficients. The EVAS is especially well suited for measurements in turbid fluids.

Item Code: EVAS-PROBE-50, EVAS-PROBE-65

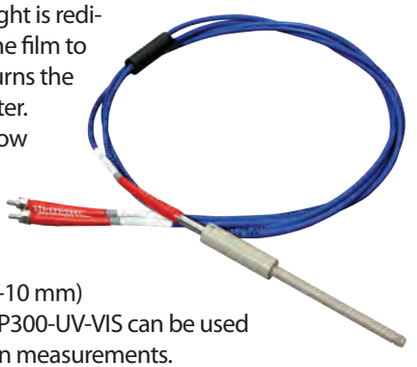


Transmission Probes

Transmission Dip Probes for Hostile Environments

The TP300-UV-VIS Transmission Dip Probe couples to our spectrometers and light sources to measure the absorbance and transmission of solutions in harsh environments.

Also, the TP300-UV-VIS Probe is a chemically inert PEEK transmission probe that can be equipped with a tip (RT-PH) for mounting transmissive pH films in the optical path. Light is directed via one fiber through the mounted film to a mirror. Then light is redirected back through the film to a receive fiber that returns the light to the spectrometer. The sample is free to flow over the sides of the film.



By using an RTP-2-10 (adjustable 2-10 mm) Transmission Tip, the TP300-UV-VIS can be used for routine transmission measurements.

Item Code: TP300-UV-VIS

Item	Specifications
Fiber type:	TP300-UV-VIS: 300 µm UV/SR optical fiber TP300-VIS-NIR: 300 µm VIS-NIR optical fiber
Outer diameter:	3.175 mm diameter for internal stainless steel assembly, 6.35 mm with PEEK polymer sleeve
Probe length:	107.9 mm
Fiber length:	2 meters
Optics:	Fused silica
Pressure limit (w/RT-PH fixed at 16 mm):	100 psi
Temperature limit:	Up to 200 ºC with PEEK sleeve
Pathlength:	Adjustable from 2-10 mm (the RTP-2-10) or from 10-20 mm (RTP-10-20)
Probe sleeve:	Stainless steel internal assembly, PEEK for outer sleeve
Fiber jacketing:	PVDF jacketing
Connector:	SMA 905
Operating temperature:	Up to 100 ºC without sleeve

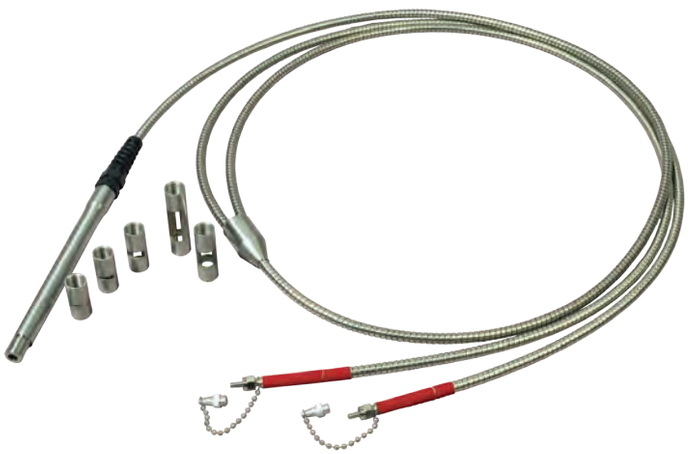
Industrial Transmission Process Probes

High-Pressure, High-Temperature

Item	Specifications
Fiber type:	TI300-UV-VIS - 300 µm diameter UV-SR fiber type (200-1100 nm) TI300-VIS/NIR - 300 µm diameter VIS-NIR fiber type (400-2100 nm)
Pressure limit:	250 psi
Temperature limit:	300 °C for probe body
Sampling tip body:	316 stainless steel
Sampling tip optics:	Quartz back-coated mirror and quartz lens
Sampling tip O-ring:	Parker perfluoroelastomer (Parofluor ULTRA) O-ring seal
Probe ferrule:	12.7 mm outer diameter 316 stainless steel
Probe jacketing:	Fully interlocked stainless-steel jacketing over Teflon tubing; total 7.0 mm outer diameter
Length:	Fiber -- 2 meters Ferrule -- 12.7 cm without tip Tips -- 2.6 cm to 4.99 cm, depending on tip
Breakout distance:	1 meter from the end of the probe
Immersible length:	12.7 cm
Optical pathlengths:	2, 5, 10, 25 and 50 mm pathlengths available
Connectors:	SMA 905

Our TI300-series Transmission Industrial Dip Probes can be used in environments with pressure limits up to 250 psi and at temperatures up to 300 °C. The TI300-UV-VIS uses 300 µm diameter solarization-resistant optical fiber (200-1100 nm), while the TI300-VIS-NIR uses 300 µm diameter VIS-NIR optical fiber (400-2100 nm). The TI300 probes couple to our spectrometers and light sources to measure solution absorbance and transmission in industrial applications.

Item Code: TI300-UV-VIS, TI300-VIS-NIR

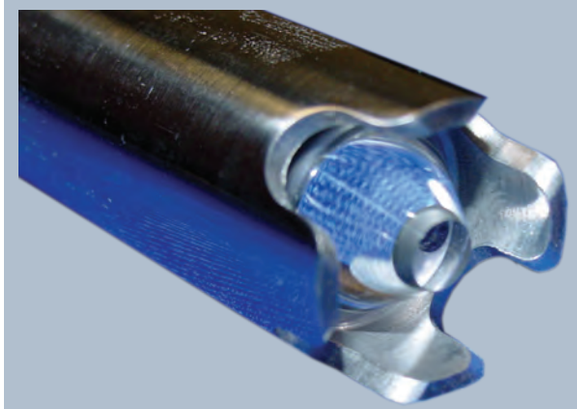


Attenuated Total Reflection Probe

Ideal for Samples with High Optical Density

The PRO-PROBE-ATR Probe is an Attenuated Total Reflection Probe designed for measuring highly absorbent samples. The ATR Probe is ideal for applications where the absorbance of samples is in the 4000-5000 AU/cm range. The ATR Probe can be inserted directly into the sample and spectra can be taken without sample dilution. Typical applications involve measurement of pure inks, dyes and crude oil samples. What's more, the ATR Probe can be used as a general deposition probe if the refractive index (RI) of the material that is depositing on the probe tip is greater than the RI of the ATR's sapphire crystal or is greater than 1.7.

Item Code: PRO-PROBE-ATR



Item	Specifications
Recommended fiber diameter:	600 µm
Outer diameter:	19 mm (0.75")
Probe length:	~305 mm
Body materials:	316 stainless steel (standard); Hastelloy C, Titanium and Monel also available
Crystal material:	Sapphire
Seals:	Viton (standard); Chemraz, Kalrez also available
Pressure limit:	10,000 psig
Fiber connections:	SMA 905
Temperature limit:	300 ºC
Wavelength range:	UV-NIR

Single and Double Pass Transmission Probes

Robust Transmission Probes for Process Applications

Single- and Double-Pass Transmission Probes are process-ready probes useful for online measurements (200-2400 nm) of sample streams. The probes send light energy from a source through the sample by offset-folding the beam 180º and back via a protected reflector. The transmitted/absorbed light is carried back to a spectrophotometer where the intensity of the returning optical energy can be converted to concentration units. Specify Single-pass Probes for pathlengths from 1-6 mm and Double-pass Probes for pathlengths from 5-20 mm.

Item Code: PRO-PROBE-SPP, PRO-PROBE-TR

	Single Pass	Double Pass
Recommended fiber diameter:	600 µm	600 µm
Outer diameter:	25.4 mm (1.0")	19.1 mm (0.75")
Probe length:	~305 mm	~305 mm
Pathlength:	1 mm-10 mm; please specify	2 mm-20 mm; please specify
Body materials:	316 stainless steel (standard); Hastelloy C, Titanium and Monel also available	316 stainless steel (standard); Hastelloy C, Titanium and Monel also available
Window materials:	Quartz (standard); sapphire also available	Quartz (standard); sapphire also available
Seals:	Viton (standard); Chemraz, Kalrez also available	Viton (standard); Chemraz, Kalrez also available
Pressure limit:	7,000 psig	7,000 psig
Fiber connections:	SMA 905	SMA 905
Temperature limit:	300 ºC for probe body	300 ºC for probe body
Wavelength range:	UV-NIR	UV-NIR
Fiber jacketing:	PVDF jacketing	PVDF jacketing
Connector:	SMA 905	SMA 905
Operating temperature:	Up to 100 ºC without sleeve	Up to 100 ºC without sleeve

OptoTemp Probes

Fiber Optic Thermometer - Contact up to 950 °C

Designed for reliable operation in harsh chemical and electrical environments, the OptoTemp 2000 is unaffected by microwave radiation and plasma. It measures temperature using fluorescent decay, a field-proven technique in hundreds of industrial installations for 25 years.

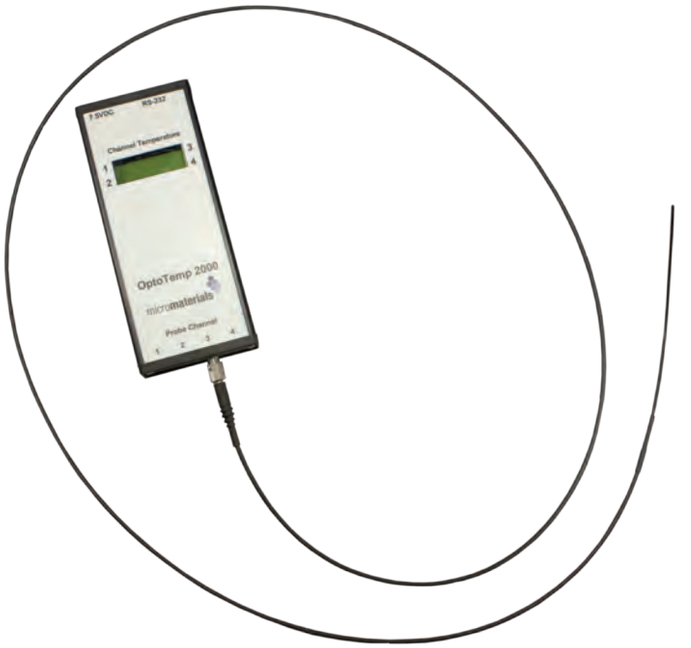
Item Code: OPTOTEMP-FLEX, OPTOTEMP-SUPER, OPTOTEMP-ULTRA

Features include:

- Immune to EMI, RF and microwave
- Operates up to 950 °C
- Precise and reliable
- Inert all-crystalline probe
- Micro sensing tip

Applications include:

- Microwave/RF heating
- Chemical processing
- Molten metal measurements
- Plasma processing
- Semiconductor processing



Product	OptoTemp 2000
Channels:	Up to 4
Measurable temperature range:	Flex: 10 °C to 150 °C Super: 20 °C to 400 °C Ultra: 200 °C to 950 °C
Response time:	250 msec
Sample rate:	4 samples/sec
Precision:	± 1.0 °C RMS over 8 samples
Accuracy:	± 2.0 °C
Power:	5W 7.5 VDC wall adapter at 90-260 VAC, 47 to 63 Hz
Output ports:	RS-232
Display:	LCD
Dimensions:	15 cm x 7 cm x 3.5 cm
Housing material:	Anodized aluminum

Front-Surface Fluorescence Probe

Real-Time Fluorescence Monitoring

The Front-surface Fluorescence Probe is a process-ready probe for measuring fluorescence from the surface of a liquid, solid, paste or slurry. The probe can be used as part of a process system or combined with Ocean Optics spectrometers and accessories to create a real-time monitoring system for a variety of fluorescence applications.

The Fluorescence Probe has a special optical configuration that has a very sharp focus at the wetted end of the window and does not need to penetrate deeply into the sample for a reading. This concentrated focus and shallow penetration depth significantly reduce the inner filter effect from competitive optical devices. The probe is 12 mm in diameter and can be inserted into a standard benchtop fermenter via a PG-13.5 fitting (contact an Applications Scientist for details).

Item Code: PRO-PROBE-BS

Item	Specifications
Recommended fiber diameter:	800 µm
Outer diameter:	12 mm; 12.7 mm (0.5") also available
Probe length:	~305 mm
Body materials:	316 stainless steel (standard); Hastelloy C, Titanium and Monel also available
Crystal materials:	Sapphire
Seals:	Viton (standard); Chemraz, Kalrez also available
Pressure limit:	7,000 psig
Fiber connections:	SMA 905
Temperature limit:	300 °C
Wavelength range:	UV-VIS
Housing material	Anodized aluminum

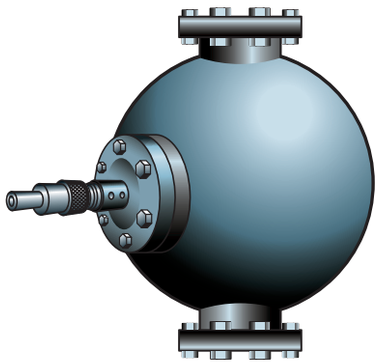
Feedthroughs for Vacuum Applications

Full Range of Fiber Accessories

We offer a full range of vacuum feedthrough (VFTs) accessories for your chamber applications. General-purpose bolt-style VFTs come with an O-ring and a pair of splice bushings and are designed to penetrate NEMA enclosures. For more robust environments, we offer VFTs with a conflat flange or ISO KF industrial-grade flange.

VFTs have in-vacuum and in-air sides with SMA 905 connectors for coupling to optical fibers (available separately). VFTs are an excellent option for optical measurement applications in semiconductor and thin film processing or anywhere ultra-high vacuum applications occur.

Gaskets, mounting hardware and other accessories are available through our reseller partner Accu-Glass Products, Inc. (accuglassproducts.com).



Wavelength	Item Code	Fiber Type	Flange Type or O-ring				
			1.33" OD Conflat	2.75" OD Conflat	1.18" OD KF16 ISO	2.16" OD KF40 ISO	O-ring
VIS-NIR Low OH Content 400-2200 nm	VFT-100-VIS	100 µm diameter VIS-NIR					X
	VFT-200-VIS Series	200 µm diameter VIS-NIR	X	X	X	X	X
	VFT-400-VIS Series	400 µm diameter VIS-NIR	X	X	X	X	X
	VFT-600-VIS Series	600 µm diameter VIS-NIR	X	X	X	X	X
	VFT-1000-VIS Series	1000 µm diameter VIS-NIR	X	X	X	X	X
UV-VIS High OH Content 300-1100 nm	VFT-100-UV	100 µm diameter UV-VIS					X
	VFT-200-UV Series	200 µm diameter UV-VIS	X	X	X	X	
	VFT-400-UV Series	400 µm diameter UV-VIS	X	X	X	X	
	VFT-600-UV Series	600 µm diameter UV-VIS	X	X	X	X	
	VFT-1000-UV Series	1000 µm diameter UV-VIS	X	X	X	X	X
UV/SR-VIS High OH Content 200-1100 nm	VFT-200-SR	200 µm diameter SR					X
	VFT-400-SR	400 µm diameter SR					X
	VFT-600-SR	600 µm diameter SR					X
UV-VIS XSR Solarization-resistant 180-900 nm	VFT-115-XSR-133	115 µm diameter XSR	X				
	VFT-230-XSR-133	230 µm diameter XSR	X				
	VFT-450-XSR-133	450 µm diameter XSR	X				
	VFT-600-XSR-133	600 µm diameter XSR	X				

Fibers and Probes

Fiber and Probe Fixtures and Holders

C-Mounts

Our C-MOUNT-MIC Adapter Assembly with adjustable focusing barrel has an SMA 905 Connector in its center for attaching to optical fibers. The internal C-mount threads of this assembly allow you to adapt fiber optic spectrometers to other optical devices such as microscopes and telescopes.

The MFA-C-MOUNT also connects to optical devices such as microscopes and telescopes, but its center connector is designed to accept probes with 6.35-mm (1/4") outer diameter ferrules.

Item Code: C-MOUNT-MIC, MFA-C-MOUNT

The MFA-C-MOUNT

The C-MOUNT-MIC Adapter Assembly

Phototubus Microscope Adapter

The MFA-PT Phototubus Microscope Adapter adapts to a Phototubus outlet on microscopes and accepts SMA 905-terminated optical fibers.

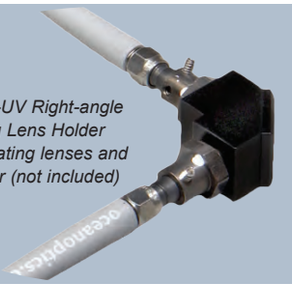
Item Code: MFA-PT

The MFA-PT Phototubus Microscope Adapter

Right-angle Collimating Lens Holder

The 74-90-UV is an assembly for mounting lenses at right angles, and is especially useful for applications involving awkward optical fiber routing. It has a mirror located under its cap bonded with high-temperature epoxy, and reflects light from the collimating lens to 90°. Two ports accommodate 74-series Collimating Lenses (not included).

Item Code: 74-90-UV



The 74-90-UV Right-angle Collimating Lens Holder with collimating lenses and optical fiber (not included)

Reflection Probe Holders

The RPH-1 (far right) and RPH-2 (near right) are anodized aluminum platforms with holes drilled at 45° and 90° angles to the surface. The RPH-1 holds 6.35-mm (1/4") diameter probes but with the RPH-ADP -- an adapter that fits on the RPH-1 -- you can secure 3.17 mm (1/8") diameter probes as well. The RPH-2 is for use only with probes with QSMA 905 Connectors. The Curved Surface Probe Holders accommodate 6.35-mm (1/4") outer diameter probes for measuring reflection of curved surfaces. The CSH (right) has a hole drilled at a 90° angle to the surface. The CSH-45 has a hole drilled at a 45° angle to the surface.

Item Code: RPH-1, RPH-2, CSH, CSH-45

RPH-2

RPH-1

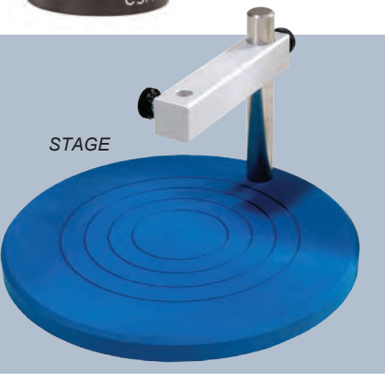
CSH

Optical Stages

The Single-Point Reflection Stage (at right) is a probe holder for reflection measurements of optical layers and other substrates up to 150 mm in diameter. The probe holder accommodates fiber optic probes and other sampling devices up to 6.35 mm in diameter.

The Stage-RTL-T is also a sampling system for analysis of substrate materials. The STAGE-RTL-T can be configured for reflection and transmission measurements.

Item Codes: STAGE, STAGE-RTL-T



STAGE

Fibers and Probes
Fiber and Probe Accessories

Bulkhead Bushing
The 21-01 SMA Bulkhead Bushing assembly is a device mount for optical fibers. The 21-01 SMA Bulkhead Bushing allows easy coupling of an LED or photodiode in a TO-18 can to an SMA-terminated optical fiber .
Item Code: 21-01

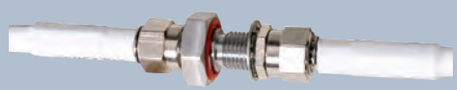

21-01 SMA Front


21-01 SMA Rear

Splice Bushings
The 21-02 SMA Splice Bushings are in-line adapters that connect SMA 905-terminated optical fibers (or any two objects with SMA 905 terminations). A splice bushing consists of a 0.75" screw with female ends. The standard 21-02 is made of nickel-plated brass while the 21-02-SS is made of stainless steel. They are useful for coupling patch cords to fiber optic probes and other devices, or for any multiple-fiber application where coupling our standard optical fibers and accessories is preferable to creating costly and complex fiber optic assemblies.
Item Code: 21-02, 21-02-SS


21-02 SMA

Bulkhead and Splice Bushing Combo
The 21-02-BH SMA Bulkhead Splice Bushing is an in-line adapter that connects SMA 905-terminated optical fibers through a chamber wall or panel. The 21-02-BH features an O-ring for sealing against the inside of the panel wall and a nut and lockwasher for mounting to the outside of the panel wall.
Item Code: 21-02-BH


21-02-BH SMA SMA 905

FC Barrel
Our collimating lenses come standard with SMA 905 Connectors and interface to our SMA-terminated fibers. If you have FC-terminated fiber, you could remove the inner 6.35-mm OD SMA barrel and replace it with this FC Barrel to connect to our products. Spare SMA 905 barrels are also available.
Item Code: FCBARREL


FC Barrel

Custom Option: Connector Adapters
Connector adapters allow you to mate an item with an SMA 905 Connector to an item with either an ST or FC Connector. Additional options are available for single-fiber laser coupling and other applications.
Item Code: SMA-ST-ADP, SMA-FC-ADP


SMA-ST-ADP


SMA-FC-ADP

Finger Fiber Wrench
The FOT-SMAWRENCH is a wrench that slips over the hex nut of the SMA 905 Connector used in Laboratory-grade Optical Fibers and helps to easily attach the fiber to connectors on spectrometers, light sources, collimating lenses and many other accessories.
Item Code: FOT-SMAWRENCH


FOT-SMAWRENCH

Modemixer/Modestripper
The Modemixer/Modestripper is an in-line, 3-mm Suprasil rod that connects two SMA 905-terminated optical fibers to mix core modes and eliminate clad modes throughout 180-2100 nm.
Item Code: ADP-SMA-SMA

ADP-SMA-SMA

Unjacketed Bulk Optical Fiber

DIY Fiber and Tools for the Modern Spectroscopist

We offer spooled, unjacketed optical fiber for customers who build their own assemblies. Choose from core diameters from 50 µm to 100 µm and High OH, Low OH and Solarization-resistant fiber. To improve the strength and flexibility of our fiber, we triple-coat it with a polyimide buffer prior to the spooling process.

Unjacketed Bulk Optical Fiber				Fiber Type				
Wavelength Range	Item Code	Core Diameter	Buffer/ Coating	UV-VIS	VIS-NIR	UV/SR-VIS	LTBR	STBR
VIS-NIR Low OH content 400-2100 nm	FIBER-50-VIS-NIR	50 µm	Polyimide		X		4 cm	2 cm
	FIBER-100-VIS-NIR	100 µm	Polyimide		X		4 cm	2 cm
	FIBER-200-VIS-NIR	200 µm	Polyimide		X		8 cm	4 cm
	FIBER-300-VIS-NIR	300 µm	Polyimide		X		12 cm	6 cm
	FIBER-400-VIS-NIR	400 µm	Polyimide		X		16 cm	8 cm
	FIBER-500-VIS-NIR	500 µm	Polyimide		X		20 cm	10 cm
	FIBER-600-VIS-NIR	600 µm	Polyimide		X		24 cm	12 cm
	FIBER-1000-VIS-NIR	1000 µm	Acrylate		X		30 cm	15 cm
UV-VIS High OH Content 300-1100 nm	FIBER-50-UV-VIS	50 µm	Polyimide	X			4 cm	2 cm
	FIBER-100-UV-VIS	100 µm	Polyimide	X			4 cm	2 cm
	FIBER-200-UV-VIS	200 µm	Polyimide	X			8 cm	4 cm
	FIBER-300-UV-VIS	300 µm	Polyimide	X			12 cm	6 cm
	FIBER-400-UV-VIS	400 µm	Polyimide	X			16 cm	8 cm
	FIBER-500-UV-VIS	500 µm	Polyimide	X			20cm	10 cm
	FIBER-600-UV-VIS	600 µm	Polyimide	X			24 cm	12 cm
	FIBER-1000-UV-VIS	1000 µm	Acrylate	X			30 cm	15 cm
UV/SR-VIS High OH content 200-1100 nm	FIBER-200-UV/SR-VIS	200 µm	Polyimide			X	4 cm	2 cm
	FIBER-300-UV/SR-VIS	300 µm	Polyimide			X	12 cm	6 cm
	FIBER-400-UV/SR-VIS	400 µm	Polyimide			X	16 cm	8 cm
	FIBER-600-UV/SR-VIS	600 µm	Polyimide			X	24 cm	12 cm

Bare Fiber Adapter Kit

DIY - Fiber Termination and Polishing

The BFA-KIT Bare Fiber Adapter Kit is for the fiber tinkerer who wants to polish bare (unjacketed) optical fiber. The kit comes with fiber polishing holders for various sizes of optical fibers.

The Bare Fiber Adapter Kit includes the following:

- 6 fiber polishing holders for various sizes of optical fiber (1 each for 100 µm, 200 µm, 300 µm, 400 µm, 600 µm and 1000 µm optical fibers)
- A BFA-KIT-CHUCK connect-and-release adapter (which can be purchased separately as well) to fasten the SMAs onto bare optical fiber
- Several pieces of wire for cleaning out the polishing holders and connect-and-release adapter

An SMA-PUCK polishing puck is not included with the BFA-KIT, but is available separately. The puck is used to polish the surface of an optical fiber.

The FT-KIT Fiber Tinkerer Kit (not shown) includes an assortment of randomly selected, unterminated UV-VIS and VIS-NIR optical fibers. Each fiber included in the kit will be at least one meter in length. The Fiber Termination Kit (TERM-KIT) includes all the tools needed to terminate and polish fiber.

Fiber Termination Kits

Repair and Retool Like a Pro

The TERM-KIT Termination Kit provides you with all the tools you need to properly polish and terminate an optical fiber. The TERM-KIT is great for inspecting, repairing and polishing optical fiber assemblies.

Included in the kit are polishing papers in thicknesses ranging from 1 mm to 30 mm.

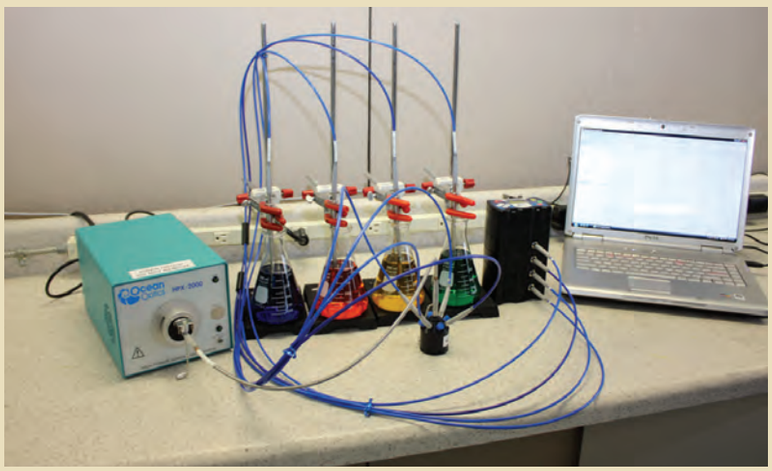
Included in Each TERM-KIT

- 4 SMA 905 Connectors for 50 µm or 100 µm fibers
- 4 SMA 905 Connectors for 200 µm optical fibers
- 4 SMA 905 Connectors for 400 µm optical fibers
- 4 SMA 905 Connectors for 600 µm optical fibers
- 4 SMA 905 Connectors for 1000 µm optical fibers
- Polishing puck
- Glass polishing plate (15 cm x 15 cm)
- Dozens of polishing papers
- 5-cavity crimp tool (for 2.6, 3.4, 3.8, 4.5 and 6.4 mm cavities)
- Scoring tool
- Inspection scope
- 2-hour cure epoxy
- Optical wipes

Technical Tip

Optical Probes in Air and Water

Fiber probes, such as the Ocean Optics transmission dip cells and "R" series reflection probes, are optical systems that are designed to work in either air or liquids. Their behavior changes when the refractive index of the media changes because the fibers and lenses in these systems are operating under Snell's Law. The refractive index of air is approximately 1, while the refractive index of water (1.33) and organic solvents like ethanol (1.36) are considerably higher. Ocean Optics silica fibers, for example, have a numerical aperture of 0.22 and an acceptance angle of about 25° in air. When placed in water, however, the acceptance angle is reduced to ~19°.



Our standard transmission dip probe is specifically designed for use in liquids. The probe has two fibers projecting light through a shared lens. Light from the source is focused by the lens onto a mirror across the sample gap. The light is reflected back through the lens to the read fiber, which brings the light to the spectrometer. The lenses are focused for use in water, and if used in air, will be severely out of focus and inefficient.

The CC-3 cosine corrector is a diffuser that screws on to the end of a fiber. It expands the fiber field of view to 180°, and transmits light energy to the fiber scaled to the cosine of the angle of the light. The cosine corrector works in air but fails in water because it is not waterproof. If water contacts the fiber, the acceptance angle will change and the calibration of the system will be in error.

The reflection probe, a bundle consisting of one fiber surrounded by six fibers, can work in air or water, but with quite different performance. In air, light exits the 6 illumination fibers in a 25° cone. The center read fiber accepts energy from a 25° cone. These cones overlap at a distance determined by the space between the fibers (usually twice the cladding thickness), so that samples that fluoresce or reflect light will be detected in this overlap region. When used in water, the cones are only 19° and the overlap region is smaller and farther from the tip of the probe.

A positive aspect of using fibers and probes in water is that the efficiency improves. This is because the Fresnel reflection (r) at the interface between a fiber or lens (n_1) and the media (n_2) scales with refractive indices:

$$r = ((n_1 - n_2)/(n_1 + n_2))^2$$

In a silica fiber, the fiber-to-air loss is about 3.5%. In water the loss is only 0.2%. An example of this benefit is the increase in signal obtained by using a reflection probe inserted in a liquid sample to measure fluorescence. The losses of excitation energy and fluorescence at the sample/probe interface are minimal. In comparison, there are eight air-to-silica interfaces in a standard cuvette-based system leading to a 25% reduction in signal.

Software

Our comprehensive library of data acquisition and display software helps you make the most of your spectroscopic measurements and analysis. No matter what operating system you prefer, Ocean Optics has the software tool you need.

From analysis to drivers and from spectrometer operation to scripting and development, Ocean Optics software is the ideal partner.

Tip

You can get the latest updates to your Ocean Optics software online at www.oceanoptics.com.

Software
Software Overview

Ocean Optics offers a comprehensive library of data acquisition and spectral processing software for a variety of spectroscopic applications.

Depending on the type of work you do, you can choose from a full line of spectral processing software, development tools or application-support software.

Operating Software

Overture
Free Windows-based spectroscopy software. Perfect for new users and basic measurements

SpectraSuite
Spectrometer Operating Platform. Advanced spectral analysis and functions

Development Tools

OmniDriver
Java-based development tool. Multi-platform environment for acquisition, processing and analysis

SPAM
Spectral processing and manipulation

SeaBreeze
OEM package for software development

Jaz API
Development software for Jaz Spectrometers

Application Specific

SpecLine
Element and Compound Identifier (See Metrology section for details)

Analyze IQ Spectra Manager
Analytical software suite for Raman analysis of molecular spectroscopy data

Analyze IQ Spectral Library
Optional library of Raman Spectra. Library of over 1,800 spectra for use with Analyze IQ Spectra Manager (See LIBS and Raman section for details on Analyze IQ and other software products)

Software
SpectraSuite and Overture

SpectraSuite

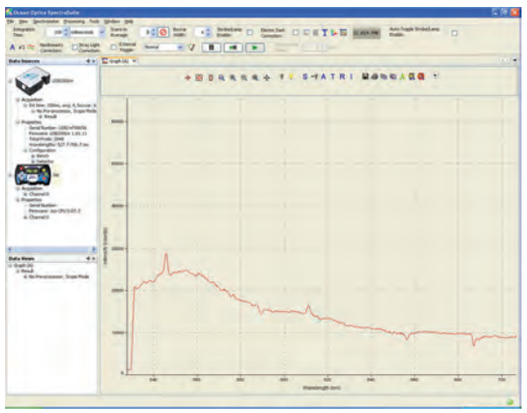
Spectroscopy on any Operating System

SpectraSuite is a completely modular, Java-based spectroscopy software platform that operates on Windows (both 32- and 64-bit), OS X and Linux operating systems. The software can control any Ocean Optics USB spectrometer and device. The SpectraSuite interface looks and feels the same on all operating systems, yet retains the familiar appearance of an application native to each OS.

SpectraSuite easily manages multiple USB spectrometers – each with different acquisition parameters – in multiple windows and provides graphical and numeric representations of spectra from each spectrometer.

All-in-One SpectraSuite

- Allows you to annotate graphs and to specify format and precision of displayed values
- Displays a color spectrum behind graphs
- Corrects for non-unity for reflection measurements
- Performs reference monitoring
- Displays x-axis in GHz, microns, pixel number, Raman shifts, wavenumbers or nanometers
- Stores data in a number of formats such as tab-delimited ASCII (for Excel or other analysis packages) and GRAMS SPC
- Provides Strip Charts using any processing mode (transmission, absorbance, etc.) to track processes, perform kinetic analyses and monitor spectral events -- all as a function of time



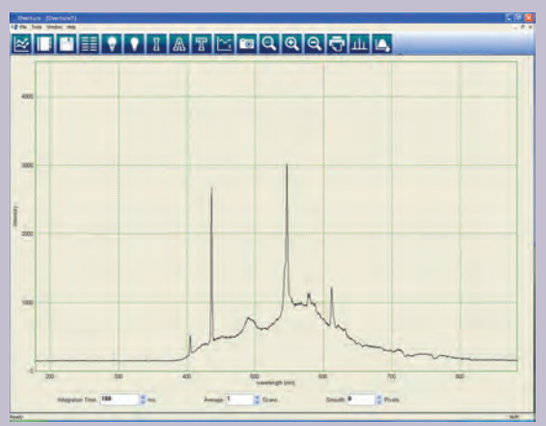
Features for Reflective and Emissive Color and Absolute Irradiance

- Provides dominant wavelength and wavelength purity
- Calculates reflective or emissive color
- Provides chromaticity diagram of color-space values
- Offers CIE standard illuminants for reflective color (A, B, C, D50, D55, D65, D75, E, F1-F12)
- Calculates CIELAB, XYZ, xyz, u'v'w', hue, chroma, CCT (correlated color temperature), saturation, CRI and more

Overture

Overture Spectrometer Operating Software

Overture is our free, Windows-based software that is an excellent introduction software package for conducting basic spectroscopic measurements. This simplified operating software is the perfect choice for users who are new to spectroscopy or who do not require the more sophisticated functionality of our other offerings. Overture is for 32-bit and 64-bit Windows with support through XP, Vista and Windows 7.



Overture Features

- Works with all Ocean Optics USB Spectrometers
- Is compatible with Windows XP, Vista and 7; 32-bit and 64-bit
- Simplified interface has easy-to-follow icons and wizards
- Allows control of integration time and other spectrometer operating parameters
- Manipulates how data is displayed using tools such as smoothing, snapshot and zoom
- Allows user to open two graphs at the same time
- Has Absorbance, Transmission and Intensity Modes

Software
OmniDriver

OmniDriver is a powerful Software Developer's Kit for Windows, OS X and Linux operating systems that allows you to easily write custom software solutions for your Ocean Optics USB spectrometers and direct-attach devices. OmniDriver is the culmination of our best software driver packages; it's developed in Java and includes cross-platform native libraries to offer the following:

High-Res Timing
Time stamping that is accurate to sub-millisecond performance; great for chemical kinetics and other applications that require complex time accountability.

LabVIEW Support
OmniDriver provides drivers for LabVIEW (Version 7.1 or greater) to enable you to configure Ocean Optics spectrometers as real-time virtual instruments in National Instruments' LabVIEW graphical programming environment.

Support for Ocean Optics USB Spectrometers

- S2000 Spectrometer (with USB A/D Converter)*
- USB650 Spectrometer
- USB2000 Spectrometer*
- USB2000+ Spectrometer
- USB2000-FLG Spectrometer*
- USB4000 Spectrometer
- HR2000 High-resolution Spectrometer*
- HR2000+ High-resolution Spectrometer
- HR4000 High-resolution Spectrometer
- Jaz System
- QE65000 Scientific-grade Spectrometer
- NIR-512 Near-IR Spectrometer*
- NIR256-2.1 and NIR256-2.5 Near-IR Spectrometers*
- NIRQuest Model Spectrometers
- Torus Spectrometer
- Maya2000 Spectrometer*
- Maya2000 Pro Spectrometer
- MMS Raman Spectrometer*
- ARCoptix ANIR Series FTS Spectrometers*
- STS Spectrometer

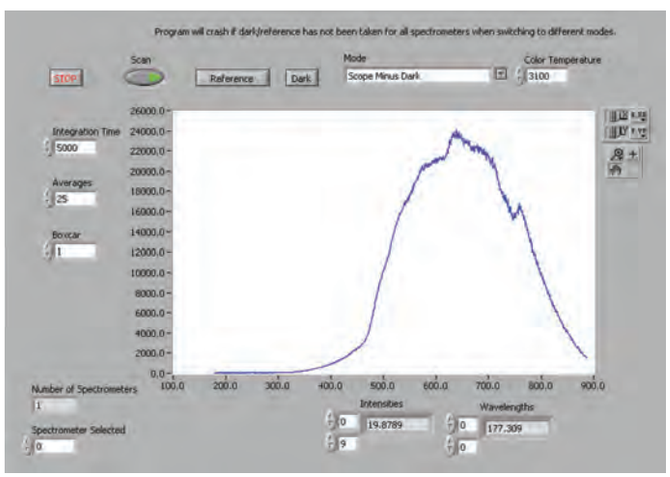
*Legacy spectrometer models

Note: OmniDriver does NOT support PCI or ISA products.

Operating System Support
- Windows: Windows XP, Vista, Windows 7 ; 32- and 64-bit
- Mac: OS X 10.5 or later
- Linux: Many x86 distributions are supported, Kernel 2.4.20 and libusb 0.1.10 or later are required

Measurement Corrections
- Detector nonlinearity
- Electrical dark (automatic baseline removal)
- Stray light
- Boxcar smoothing (averaging across pixels)
- Averaging multiple scans

Control of the following extended functions (depending on spectrometer model):
- Strobe enable
- Thermo-electric cooling (TEC) and reading detector and PCB temperatures
- Gated fluorescence mode
- Analog output (4-20 mA current output for LS-450 and AOUT); voltage out for HR4000
- Analog input for the supported spectrometers (voltage only)
- Digital (TTL) input/output (control of GPIO pins)
- Setting external trigger modes
- Reading out wavelength calibration
- Setting continuous strobe delays



Integrate OmniDriver into your own software application for complete control over USB spectrometers and devices in virtually any OS environment.

Software
SPAM Spectral Processing Math

SPAM is the perfect complement to OmniDriver since it features the additional functions needed to perform spectral processing such as peak-finding, radiometric and color analysis, etc. The SPAM library can be used to process spectral data.

SPAM Features

SPAM provides the following powerful tools for processing your spectral data:

- Scope mode
- Scope minus dark
- Absorbance
- Transmission
- Reflection
- Relative irradiance (with user-specified color temperature)
- Raman (with user-specified wavelength)
- Blackbody and CIE Relative daylight spectrum generators with user-defined color temperature
- Peak finding and metrics (centroid, full width at half max in units of pixels and wavelengths, center wavelength, integral, pixel number, 90% enclosing width)

Robust Set of Functions

- Absolute irradiance
  - New calibration from lamp files
  - Photometry
  - Lumens
  - Lux
  - Candela
  - Luminance
  - µJoule
  - µWatt
  - µJoule/cm2
  - µWatt/cm2
  - dBm
  - Photons/cm2
  - Total photons
  - Moles of photons
  - Electron volts
- Color
  - Reflective and emissive color
  - Emissive color can use relative or absolute irradiance
  - CIE 1931 and CIE 1964 observers
  - CIE Illuminants A, B, C, D50, D55, D65, D75, E (unity), F1-F12
  - Color spaces
    + CIE XYZ
    + x, y, z
    + Color Rendering Index (CRI)
    + General CRI Ra
    + Special CRI R1- R14
    + Correlated Color Temperature (CCT)
    + Dominant wavelength and purity
    + u'v'w', u,v hue angle, u,v saturation
    + CIE Whiteness and Tint
    + CIELAB (L*a*b*, hue angle, chroma)
    + CIE 1960 u,v
    + Hunter Lab

Measurement Units

- Nanometers
- Microns
- Pixel number
- Gigahertz
- Wave numbers
- Raman shifts

SPAM Corrections

- Nonunity reference
- Reference Monitoring

SeaBreeze

SeaBreeze is the newest multi-platform device driver from Ocean Optics that was designed specifically for OEM use for embedded system applications. SeaBreeze is the scaled-down software device driver that is ideal for developers who want a leaner platform for their applications.

SeaBreeze provides some spectral correction and manipulation but is scaled down so that developers can add their own enhancements and features.

Application Notes

Blood Analysis Without Pain for Neonates

Background

Jaundice is a common and often harmless condition in neonates. However, especially preterm neonates have an increased risk for developing jaundice related brain damage, which is the reason for close monitoring of the blood bilirubin concentration (the indicator of jaundice) in these patients. The bilirubin concentration is determined from a blood sample obtained by a heel stick, often up to three times a day. Naturally, this is a very painful and harmful procedure for the child. In addition, this diagnosis creates an unwanted delay in the treatment of the patient, since it may last more than one hour.

Researchers investigated the possibility to measure the bilirubin concentration faster and non-invasively, by using optical spectroscopy. The absorption peak of bilirubin around 455 nm allows for spectroscopic assessment of its presence in the blood vessels of the skin. Although bilirubinometers based on this principle have been developed since 1980, no device has been found accurate enough to completely replace the heel stick. The focus of this study is therefore 1) to investigate the reasons for the inaccuracy of current bilirubinometers and 2) to develop a bilirubinometer that can replace the painful heel stick.

Ocean Optics Probe

To investigate the reasons for the inaccuracy of current bilirubinometers, a special bilirubinometer was developed by our customer, based on a multidistant fiber optic probe that was fabricated by Ocean Optics. Using diffusion theory, the customer obtained not only the bilirubin concentration from the skin reflection spectrum (430-600 nm), but also determined the blood volume fraction in the investigated tissue volume. In an explorative patient study at a neonatal intensive care unit, the customer found that the measured bilirubin concentration consists primarily of bilirubin in the tissue surrounding the blood vessels in the skin, instead of bilirubin inside the blood vessels themselves. Since the bilirubin concentration in the surrounding tissue is difficult to relate to the concentration in blood, this introduces an inevitable inaccuracy in the comparison of existing bilirubinometers to the heel stick determination.

Low Coherence Spectroscopy (LCS)

The only possibility to improve the accuracy of the existing bilirubinometers is by confining the measurement volume to the inner lumen of a blood vessel. Current spectroscopic techniques are unable to do such a determination, since light scattering from the surrounding tissue always contributes to the measured value. Therefore, the customer developed a new spectroscopic technique – low coherence spectroscopy (LCS) – which, based on low coherence interferometry, allows for very careful control over the size and location of the investigated tissue volume. To validate our LCS measurements, the USB4000 was used repeatedly for measuring reference spectra. Currently, LCS is the only spectroscopic technique that can be used for the measurement of blood values inside a single blood vessel, without any influence from the surrounding tissue. The first in vivo measurements with this technique are very promising.

The relatively slow acquisition time of the LCS system limits the current clinical utility of the technique. Therefore, the customer investigated the possibility to replace the detecting photodiode in the LCS system by a spectrograph. The USB4000 proved to be very suitable for this purpose, resulting in an almost 4x faster acquisition time.

Outlook

Besides the applications described above, the customer also used the Ocean Optics probe for the determination of the optical properties of neonatal skin in the investigated patient population. This information is of great value for this research and other studies involving optics and neonatal skin.

For further improvement of the clinical utility of LCS, it is necessary to implement a spectrograph that has a higher acquisition rate than the USB4000. Since a spectrograph with the required specifications is not commercially available, such a spectrograph needs to be designed and developed. Furthermore, a fiber optic probe for clinical LCS measurements needs to be developed as well.

The future development of LCS offers additional opportunities for clinical applications. The technique may not only be used for bilirubin concentration measurements, but also for the determination of other blood values, such as hemoglobin concentrations and oxygen saturation. Also for the determination of these blood values, a localized measurement in a single blood vessel implies a very valuable improvement compared to existing spectroscopic determinations. The expected clinical utility of the technique is extensive, since it may be applied not only on neonates, but also on older children and adults. Furthermore, the customer found that LCS is also sensitive to the changes in tissue scattering that are related to the morphology and organization of cells. The latter offers new opportunities for the diagnosis of cancer.

Sensors

Ocean Optics pH and oxygen optical sensors provide an outstanding alternative to traditional chemical sensing devices and are used in life sciences, pharmaceutical manufacturing, quality control, food and beverage, and a host of other applications.

Our exclusive indicator materials are embedded in sol gel coatings that are applied to probes and other form factors. The indicators respond to specific analytes in their immediate environment – with formulations available for a variety of oxygen and pH sensing needs.

Tip

Our oxygen and pH sensing materials can be applied to probes, patches, cuvettes and a variety of custom substrates.

Fiber Optic Chemical Sensors

Real-Time, In Situ Analyte Monitoring

We've taken our expertise in miniature fiber optic spectroscopy and combined it with advances in materials sciences to develop an innovative line of modular fiber optic chemical sensing solutions.

Ocean Optics designs its sensors by placing a transducer material at the end, or tip, of an optical fiber. These materials change optical properties in response to specific analytes in their immediate environment.

Our transducer materials include both fluorescence-based and absorbance-based indicators. These indicators are immobilized, or trapped, in a variety of proprietary hydrophobic and hydrophilic polymers and sol-gel materials. Materials can be coated on flat substrates such as optical fibers, optical flats, cuvettes and other containers.

Ocean Optics produces components that can be used to monitor oxygen or pH in biological samples, headspace gases, slurries, cosmetics, foods and liquids in natural environments.

Optical Sensors vs. Commercial Electrodes

Fiber Optic Chemical Sensor Systems	Commercial Electrodes
O2 and pH sensors are immune to environmental changes in pH, salinity and ionic strength	Polarographic electrodes can be affected by changes in pH, salinity and ionic strength
O2 and pH sensors are immune to interference from moisture, CO2, methane and other substances	Electrodes are subject to interference from a number of substances and sampling conditions
Sensing materials are easily applied to probes, patches, cuvettes and other media	Electrodes typically are available in probe or cell membrane format only
Sensor coating formulations (especially for O2) are available for a variety of environments	Electrodes often have limited range of chemical compatibility
Optical sensors require less maintenance and are more robust than most electrodes	Electrodes often require tedious maintenance and have a delicate glass body that is prone to breakage
O2 sensors do not consume oxygen, allowing for continuous contact with the sample	O2 electrodes can consume oxygen at rates of ~0.1 micrograms/hour
Calibration is easily handled and can last many months before recalibration is necessary	Electrodes can require recalibration as frequently as hourly
O2 and pH sensors have a long life – up to a year for O2 coatings and 50 uses for pH materials	Electrodes have a typical lifetime of just three months

Sol-Gel Formulation

The Secret to Our Sensor Success

Our propriety sol-gel process produces a silica glass structure at room temperature into which we embed chemically sensitive indicator dyes. We can control matrix pore size to ensure that embedded indicator dyes do not leach out.

We now offer several indicators: ruthenium and Pt-porphyrin for photoluminescent quenching in oxygen applications and an organically modified sol gel (Ormosil) engineered to maximize immunity to ionic strength sensitivity for pH applications. Sol-gel matrices also will accommodate other indicators; contact an Applications Scientist for details.

Fiber Optic Chemical Sensors

Ideal for Full Range of O2 and pH Applications

Our optical oxygen and pH sensors are available in various form factors (patch, probe, cuvette and more) and with a range of sensing formulations appropriate for all sorts of applications. We're able to work equally effectively with both researchers who select one of our standard sensor options and OEMs who have high-volume needs or request a non-standard substrate for us to coat. That flexibility is what sets our fiber optic chemical sensors apart from galvanic electrodes and similar technologies.

Biological Environments
- Biofermentation processes
- Cell culture monitoring
- Sterile environments

Biomedical and Life Sciences
- Blood oximetry
- Cellular analysis
- Lab samples (pH titrations, low ionic strength samples)
- Tissue analysis

Food Process and Storage Monitoring
- Beverage packaging
- Vacuum-packaged foods
- Vegetable oils
- Wine fermentation

Vacuum and Semiconductor Processes
- Controlled-environment glove boxes
- Ion deposition processes

Aerospace
- Cell growth in space
- O2 monitoring in confined spaces

Pharmaceutical and Chemical Processing
- Harsh chemicals (hexane, toluene and mineral oil)
- Hydrocarbons (fuels, alcohols, hydraulic fluids)
- Packaging and headspace
- Pharmaceutical fermentation

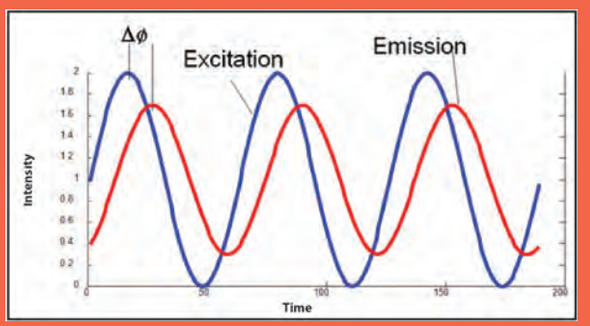
Environmental and Ecological
- Aquaculture applications
- Marine organisms
- Natural waters (marine, surface)
- Soils and sediments
- Wastewater treatment

Fuel Monitoring
- Fuel storage monitoring
- Fuel transportation

Fiber Optic Chemical Sensors

Get to Know Your Sensors

How Oxygen Sensors Work



Our oxygen sensors combine sol-gel materials and phase fluorometry techniques to measure the partial pressure of dissolved or gaseous oxygen. Oxygen-sensitive, fluorescence-based transducer materials (ruthenium) are trapped in a sol-gel coating that is applied to a probe, patch or other media. When the indicator changes optical properties in response to specific analytes in its immediate environment, our NeoFox Phase Fluorometer measures the response.

Sensor operation is simple and elegant. A pulsed blue LED transmits light at ~475 nm through an optical fiber to a probe, patch or other media coated with a thin layer of a hydrophobic sol-gel material. The light from the LED excites the indicator, emitting energy at ~600 nm. If the excited complex encounters an oxygen molecule, the excess energy is transferred to the oxygen molecule in a non-radiative transfer, decreasing or quenching the fluorescence signal. The degree of quenching correlates to the level of oxygen concentration or to oxygen partial pressure in the coating, which is in dynamic equilibrium with oxygen in the sample.

The emitted energy is collected by the probe or fiber and carried to the NeoFox Phase Fluorometer. Phase fluorometry measures the phase shift between the excitation (blue LED) and emission (ruthenium fluorescence), which is used to calculate the excited state lifetime (tau). The fluorescence phase is measured and related to the partial pressure of oxygen through the Stern-Volmer equation. This data is then displayed in software.

How pH Sensors Work

Our pH Sensors use a proprietary sol-gel formulation that is optimized to perform in the biological range. No matter what the form factor, all of our optical pH sensors work on the same principle – colorimetric change detected by a spectrometer.

A pH-sensitive dye is immobilized in a modified sol-gel glass matrix and free diffusion of hydrogen ions in and out of these pores allows for interaction with the dye. When this occurs, the dye exhibits a visible color change.

By passing light through this film and analyzing the resulting optical signal using an Ocean Optics spectrometer, we observe absorbance curves form near 620 nm as pH changes. The isosbestic point is very well defined at 514 nm. Using pH 1 as a reference, the absorbance values at 620 nm may be related to pH through a logarithmic ratiometric algorithm.

$$\mathbf{pH = pK + Slope*log}\left(\frac{\mathbf{Abs}_{Sample}}{\mathbf{Abs}_{pH11} - \mathbf{Abs}_{Sample}}\right)$$

For our pH sensing options, the Smart pH Cuvettes and Transmissive pH Patches are ideal for transmissive samples and supporting hardware can be either desktop or completely portable.

Choosing the Right O2 Sensor

Getting the Most Out of Your Sensor System

Our Fiber Optic Oxygen Sensors can be configured for dissolved and gaseous oxygen measurements. We offer sensor kits and modular options. For the latter, start by selecting a sensor coating formulation, then select a form factor (probe or patch) and electronics (benchtop or handheld). All components are priced separately.

Sensor Formulations

HIOXY Sensor Formulation Hydrocarbon Environments

The HIOXY sensor is designed for monitoring oxygen partial pressure in non-aqueous vapors and solutions. This sensor coating is ideal for use with oils, alcohols and hydrocarbon-based vapors and liquids. HIOXY has been tested successfully in commercial and military aviation fuels, gasoline, diesel, some alcohols, glycol, military hydraulic fluids and wine.

FOSPOR Sensor Formulation High-Sensitivity Coating

Our FOSPOR coating is applied to the distal end of your fiber and has a fluorescence-based Pt-porphyrin indicator. The sensor uses fluorescence quenching of the porphyrin to measure the partial pressure of dissolved or gaseous oxygen. FOSPOR coating can be applied to substrates other than fibers and probes and used for applications such as through-packaging measurements in the food and pharmaceutical industries.

FOXY Sensor Formulation General Purpose Sensor Coating

Our standard FOXY probe tips are covered with a layer of hydrophobic sol-gel material with a ruthenium compound that is trapped in the sol-gel. When excited by an LED, the ruthenium complex fluoresces. If the excited energy encounters an oxygen molecule, the excess energy quenches the fluorescent signal. The intensity or phase shift is then measured using an Ocean Optics fluorometer.

Form Factors: Probes and Patches

Unlike traditional electrochemical sensors, Ocean Optics optical oxygen sensors can be made in small and customizable form factors. The sensing material -- an oxygen-sensitive fluorophore in a sol-gel host matrix -- can be applied to the tip of a fiber or probe, an adhesive membrane such as a patch, or a flat substrate such as a cuvette or microtiter plate. Probes and patches are the standard options.

Probes are especially versatile because they can be offered in many sizes and designs and can be strengthened for use in harsh environments. Patches are ideal for through-package measurements in the pharmaceuticals and food and beverage industries and for non-intrusive measurements in biosystems.

Probes

We offer more than a dozen oxygen sensing probe options -- everything from slender probes for fine spatial resolution to rugged stainless steel probes for process environments. Our offerings cover a wide range of sampling needs, whether your application involves penetrating a package or the sample media itself or the sample environment requires a non-metallic probe material.

Patches

Our RedEye® oxygen patches can be attached to containers, packaging or other media for non-intrusive oxygen measurements in headspace and solutions. The self-adhesive patches are superior to polymer membranes, with better thermal and mechanical stability, superior chemical compatibility and faster response time.

Electronics

"Electronics" is the term we use to describe the detection part of our oxygen sensing system. The NeoFox Phase Measurement system comes in two versions: the standard benchtop option (item code: NEOFOX) and a portable, handheld version (item code: NEOFOX-SPORT). Both systems measure fluorescence lifetime, phase and intensity and are particularly suited for applications where sensitivity to drift and system stability are critical.

NeoFox comprises a single-channel phase fluorometer with integrated LED; it connects to a PC for data processing and display. NeoFox Sport includes the phase fluorometer-LED combination, plus an onboard microprocessor with OLED display, a user interface and a battery pack for field use. Both options work with all our oxygen sensor probes, patches and other components.

NeoFox Phase Measurement System

Benchtop and Handheld Electronics for Your Optical O2 Sensor

For oxygen sensing, the NeoFox® Phase Measurement System is our most popular fluorescence-based optical sensing system. Because of NeoFox's unique ability to improve overall system stability and make calibration easier for a wide variety of oxygen sensing setups, it is the choice for measuring fluorescence lifetime, phase and intensity. Plus, NeoFox is brilliantly suited for applications where sensitivity to drift and system stability are critical.

The NeoFox uses LED excitation and photodiode detection with filter-based wavelength selection for easy experimental setup and control. Because the unit is self-contained, it is invariant to fiber bending and stray light, and has a wide dynamic range of optical intensity as well as low optical and electronic crosstalk, and low drift and phase noise.

NeoFox is available in two popular formats: NeoFox Benchtop and NeoFox Sport for handheld measurements. NEOFOX-GT is a more robust benchtop option with RS-232 communications capability.

NeoFox Specifications		
	Benchtop Item Code: NEOFOX	**Portable/Handheld Item Code: NEOFOX-SPORT**
Dimensions:	107.95 mm x 63.5 m x 38.1 mm	327.6 mm x 190.5 mm x 66.5 mm
Weight:	642 g	928 g
Principle:	Photoluminescence quenching using a ruthenium compound; sensor measures O2 partial pressure	Photoluminescence quenching using a ruthenium compound; sensor measures O2 partial pressure
Parameters measured:	Luminescence phase shift, AC luminescence intensity, temperature (via optional external thermistors) and pressure (via onboard pressure transducer)	Luminescence phase shift, AC luminescence intensity, temperature (via optional external thermistors) and pressure (via onboard pressure transducer)
Sensor coating formulations (sol gel-embedded dyes):	General purpose (FOXY), high-sensitivity (FOSPOR) and hydrocarbon-ready (HIOXY)	General purpose (FOXY), high-sensitivity (FOSPOR) and hydrocarbon-ready (HIOXY)
Media:	Gases and liquids	Gases and liquids
Computer interface:	PC	For full range of functions – PC
		For basic functions – operate from DPU interface of unit
Operating systems:	Windows XP (32-bit); also, Windows 7 (32-bit)	Windows XP (32-bit); also, Windows 7 (32-bit)
Power input:	5VDC, 500 mA steady state	5VDC, 500 mA steady state
Communications:	USB, analog out, RS-232	USB, analog out, RS-232

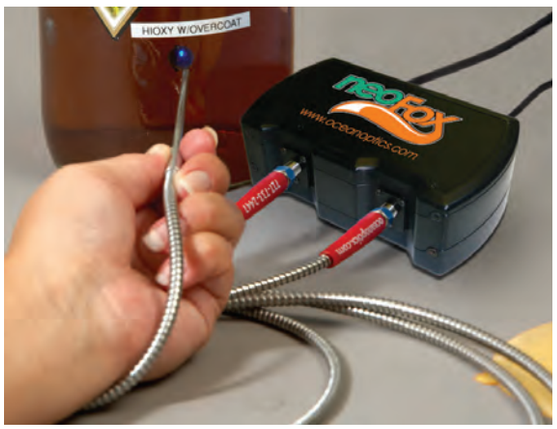
NeoFox Viewer Software

NeoFox Viewer is the Windows-based software that allows you to collect, manage and analyze data with your NeoFox or NeoFox Sport phase measurement system. This nimble software also makes it simple to configure your NeoFox and update firmware when necessary. Use NeoFox Viewer to get the most out of your NeoFox and to ensure reliability through each measurement.

You can download a free copy of NeoFox Viewer at www.oceanoptics.com.

NeoFox Probe and Patch-Based Systems

Full System Performance Specifications



One of the biggest advantages our fiber optic oxygen sensors offer compared with electrodes and other optical sensors is the range of available sampling options. In the table below we've compiled performance data for NeoFox-based systems used with our two primary sampling choices: oxygen probes and patches. Please note that some performance parameters vary according to the sensor format and coating formulation used.

One other item of interest: The specifications for O2% and dissolved oxygen range are given for conditions at 1ATM (atmosphere). At 1 ATM (typical conditions on Earth), we breathe many molecules such as nitrogen, helium, hydrogen and oxygen. All these molecules make up the total pressure in the environment. The ruthenium in our sensors is sensitive only to oxygen, which is just one part of the total pressure in the environment. So, when we determine the percentage of oxygen present in the environment at 1 ATM, we're measuring part of the total pressure, hence the term "partial pressure."

Probe-based System Specifications	FOXY Formulation	FOSPOR Formulation	HIOXY Formulation
Recommended use:	General purpose coating	High-sensitivity coating for low-oxygen environments	Robust coating for hydrocarbon-rich environments
O2% range (at 1 ATM):	0-100%	0-10%	0-20.9%
DO range (ppm at 1 ATM):	0-40 ppm	0-4 ppm	0-8 ppm
Temperature range:	-50-+80 ºC for probes	0-+60 ºC for probes	-50-+60 ºC for probes
O2% resolution:	100 ppm in gas	10 ppm in gas	100 ppm in gas
DO resolution (at room temp):	4 ppb	0.4 ppb	4 ppb
O2% accuracy:	<5% of reading	<5% of reading	<5% of reading
DO accuracy:	<5% of reading	<5% of reading	<5% of reading
Min. detectable level in gas:	0.01% - 0.05%	0.001% - 0.01%	0.01% - 0.05%
Response time:	<1 s in gas	<30-60 s in gas	<1 s in gas
	45-60 s with overcoating in gas	60-90 s with overcoating in gas	NA
	30-45 s in pure water	60-90 s in pure water	~45 s in pure water
Patch-based System Specifications	**FOXY Formulation**	**FOSPOR Formulation**	**HIOXY Formulation**
Recommended use:	General purpose coating	High-sensitivity coating for low-oxygen environments	Robust coating for hydrocarbon-rich environments
O2% range (at 1 ATM):	0-100%	0-10%	0-20%
DO range (ppm at 1 ATM):	0-40 ppm	0-4 ppm	0-8 ppm
Temperature range:	-20 to +60 ºC for patches	0 to +60 ºC for patches	-20 to +60 ºC for patches
O2% resolution:	0.05% (at 20 s averaging)	0.01% (at 30 s averaging)	0.05% (at 20 s averaging)
DO resolution (at room temp):	20 ppb	4 ppb	20 ppb
O2% accuracy:	5% of reading	5% of reading	5% of reading
DO accuracy:	5% of reading	5% of reading	5% of reading
Min. detectable level:	0.1% O2	0.01% O2 (at 30 s averaging)	0.1% O2
Min. detectable level in water (at room temp):	40 ppb	4 ppb	40 ppb
Response time:	<1 s in gas	30-60 s	<1 s in gas
	~30-45 s with overcoating in gas	~60-90 s with overcoating in gas	NA
	~45 s in pure water	~60-90 s in pure water	~30-45 s in pure water
Stability (Continuous LED)	**FOXY Formulation**	**FOSPOR Formulation**	**HIOXY Formulation**
Lifetime stability (Tau):	0.0006 µsec/hour	0.003 µsec/hour	0.0002 µsec/hour
Oxygen stability %:	0.01% hour	0.005% hour	0.007% hour
Modulation range:	0.73 kHz-93.75 kHz	0.73 kHz-93.75 kHz	0.73 kHz-93.75 kHz

FoxyKits for Oxygen Sensing

Fully Integrated Systems for Your Probe or Patch Applications

We've packaged everything you'll need for probe- or patch-based oxygen sensing applications into two convenient kits.

NEOFOX-KIT-PROBE and NEOFOX-KIT-PATCH are complete, out-of-the-box solutions for a variety of benchtop applications in research environments, teaching labs and commercial labs. Each kit allows you to set single- or multi-point calibration and to display oxygen readings in percent oxygen, partial pressure, moles per liter and more.

You'll note that we selected FOXY sensor formulation for both the NeoFox probe and patch kits. FOXY is our most versatile sensor coating chemistry and is useful for a wide range of applications. If FOXY is not appropriate for your applications, you can always opt for one of our modular oxygen sensing systems with a different coating formula.

Here's what you get with each kit:

NEOFOX-KIT-PROBE

- NeoFox Phase Fluorometer
- NeoFox Viewer software
- NeoFox-TP temperature probe (thermistor)
- 1000 µm bifurcated optical fiber and SMA 905 splice bushing for coupling NeoFox to the probe
- FOXY-R multipurpose probe

Probe kits are great for applications involving biological samples such as tissue and organic matter, foods and beverages and liquids in natural environments.

NEOFOX-KIT-PATCH

- NeoFox Phase Fluorometer
- NeoFox Viewer software
- NeoFox-TP temperature probe (thermistor)
- 1000 µm bifurcated borosilicate optical fiber
- 5-unit package of 8 mm diameter, self-adhesive FOXY sensor patches

Patch kits are useful anywhere non-intrusive and through-package oxygen measurements are necessary: headspace in food packaging, process monitoring in bioreactor environments and partial pressure of oxygen in biomedical vessels.

Technical Tip
Calculating Drift in Ocean Optics Oxygen Sensors

Because our optical oxygen sensors use an LED to excite the fluorescence in the oxygen-sensitive coating, the systems do experience some drift. The drift will vary by sensor formulation – FOXY, FOSPOR or HIOXY – and is reported in the NeoFox specifications table on p.165 of this section.

You can calculate drift for your experiment by adding just a few experiment parameters to a simple formula. For example, imagine you have a FOXY Probe and need to measure your sample every 2.5 hours for 100 hours. To excite the fluorescence in your sensor coating, you turn on the LED and ideally, keep it on as long as you can; this helps to ensure a good average reading.

For purposes of our example, let's say you can leave the LED on for 1 minute. You now have all the data you need to calculate drift:

New drift = reported drift * duty cycle on/duty cycle off
New drift = 0.01%/hr. (use oxygen stability value from table on p. 165) * (1 minute/(2.5 hrs.* 60 minutes/hr.)

We normalize the time units to minutes; 2.5 * 60 minutes/hr. converts into 150 minutes.

New drift = 0.01%/hr. * (1 minute/150 minutes)
New drift = 0.01%/hr. * (0.0066)
New drift = 0.000066%/hr.

We want to run the experiment for 100 hours, so to calculate the drift:

New drift = 0.000066%/hr. * 100 hrs.
New drift = 0.006%

Oxygen Sensor Probes

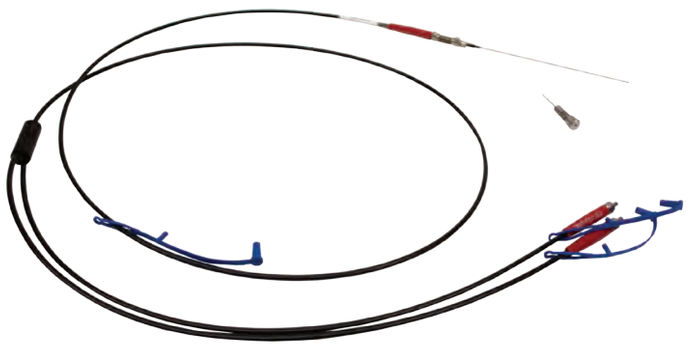
Options for a Wide Range of Sensing Environments

Oxygen sensor probes typically are available in a variety of designs and with each of our standard coating formulations (FOXY, FOSPOR and HIOXY). Custom probes and accessories are also available. In most cases, you'll need a 21-02 Splice Bushing and a BIF-BORO bifurcated optical fiber to couple your probe to the NeoFox electronics. Information on the proper care of probes is available elsewhere in this section.

HypoTube Probes

HypoTube probes are ideal for penetrating septa in packaging, vials and other vessels. The probes are suitable for use in solutions and headspace.

Item:	HypoTube Oxygen Probe
Use:	Puncturing septa, packaging and other rigid materials; especially good for solutions
Core diameter:	300 µm
Outer diameter:	1000 µm
Length:	2 m (assembly), 127 mm (tube)
Ferrule/jacketing:	PVC Monocoil
Reconditioning available:	Yes
Options:	FOXY-HPT-1-PNA general-purpose FOSPOR-HPT-1-PNA high-sensitivity HIOXY-HPT-1-PNA hydrocarbon-ready HPT-PNA (puncture accessory only)



Oxygen Sensor Probes

Options for a Wide Range of Sensing Environments

Electrode-replacement Probes

Our OR125-series probes are designed to replace standard 1/8″ (0.125 mm) electrode probes. We offer smooth and O-ring grooved versions.

Item:	Direct-replacement Probes for O-ring grooved electrodes
Use:	Replacement for 1/8” OD (3.175 mm) oxygen electrodes (O-ring grooved)
Core diameter:	1000 µm
Outer diameter:	3.175 mm
Length:	63.5 mm
Ferrule/jacketing:	Stainless steel, titanium and PEEK versions; smooth or O-ring grooved
Reconditioning available:	Yes
Options:	FOXY-OR125-G general-purpose FOSPOR-OR125-G high-sensitivity HIOXY-OR125-G hydrocarbon-ready FOXY-OR125-GT general-purpose FOSPOR-OR125-GT high-sensitivity HIOXY-OR125-GT hydrocarbon-ready

Item:	Direct-replacement Probes for 1/8” OD (3.175 mm) electrodes
Use:	Replacement for 1/8” OD (3.175 mm) oxygen electrodes (smooth)
Core diameter:	1000 µm
Outer diameter:	3.175 mm
Length:	63.5 mm
Ferrule/jacketing:	Stainless steel, titanium and PEEK versions; smooth or O-ring grooved
Reconditioning available:	Yes
Options:	FOXY-OR125 general-purpose FOSPOR-OR125 high-sensitivity HIOXY-OR125 hydrocarbon-ready

Polyimide Probes

Choose a polyimide probe for applications where the sample environment is hostile to metallic probes. Polyimide also offers good resistance to harsh chemicals. Note: The 200 µm version of these probes is less robust and should be handled carefully. Contact us about custom probe lengths and availability of HIOXY formula probe coatings.

Item:	Polyimide Probes
Use:	Environments hostile to metallic probes
Core diameter:	200 µm and 600 µm versions available
Outer diameter:	710 µm
Length:	2 m (other lengths available)
Ferrule/jacketing:	Silicone
Reconditioning available:	Yes
Options:	FOXY-PI600 and FOXY-PI200 general-purpose FOSPOR-PI600 and FOSPOR-PI200 high-sensitivity

Oxygen Sensor Probes

Options for a Wide Range of Sensing Environments

General-purpose Probes

Stainless steel 1/16″ (1.587 mm) OD probes are versatile options for a range of lab and other applications.

Item:	General-purpose 1.587 mm (1/16”) Probes
Use:	General purpose
Core diameter:	1000 µm
Outer diameter:	1.587 mm (1/16”)
Length:	152.4 mm
Ferrule/jacketing:	Stainless steel
Reconditioning available:	Yes
Options:	FOXY-R general-purpose FOSPOR-R high-sensitivity HIOXY-R hydrocarbon-ready

Item:	General-purpose 1.587 mm (1/16”) Probes; short-length versions
Use:	General purpose
Core diameter:	600 µm
Outer diameter:	1.587 mm (1/16”)
Length:	32 mm (other lengths available)
Ferrule/jacketing:	Titanium
Reconditioning available:	Yes
Options:	FOXY-600-32MM general-purpose FOSPOR-600-32MM high-sensitivity HIOXY-600-32MM hydrocarbon-ready

Process-ready Probes

Robust 1/4″ (6.35 mm) stainless steel probes have a high pressure rating for process environments.

Item:	Process-ready 6.35 mm probes
Use:	Process environments
Core diameter:	1000 µm
Outer diameter:	6.35 mm
Length:	177.8 mm
Ferrule/jacketing:	Stainless steel
Reconditioning available:	Yes
Options:	FOXY-T1000 general-purpose FOSPOR-T1000 high-sensitivity HIOXY-T1000 hydrocarbon-ready

Technical Tip

Although our line of oxygen sensor probes is extensive, there may be applications where a different probe design is required. We can coat your custom probe with our sensor material, as long as the probe is polished at a 45° angle to ensure maximum performance. Consult an Applications Scientist for details.

Oxygen Sensor Probes

Options for a Wide Range of Sensing Environments

Small-diameter Probes

Slender, aluminum-jacketed probes work well where sampling space is limited. Standard and tissue-monitoring versions are available.

Item:	Small-diameter, Al-jacketed Probes
Use:	Fine spatial resolution applications
Core diameter:	300 µm
Outer diameter:	500 µm
Length:	1 m (other lengths available)
Ferrule/jacketing:	Aluminum
Reconditioning available:	Yes
Options:	FOXY-AL300 general-purpose FOSPOR-AL300 high-sensitivity HIOXY-AL300 hydrocarbon-ready

Item:	Small-diameter Probe for Tissue Monitoring
Use:	Tissue monitoring
Core diameter:	300 µm (fiber)
Outer diameter:	500 µm (fiber) 25.4 mm (1”) at tip, body 1.6 mm (1/16”) stainless steel
Length:	1 m (other lengths available)
Ferrule/jacketing:	Aluminum
Reconditioning available:	No
Options:	FOXY-AL300-TM general-purpose

Respiration Probe

This plastic probe is designed for monitoring oxygen respiration.

Item:	Respiration Probes (Standard)
Use:	Monitoring of oxygen tension in respiratory gases
Core diameter:	200 µm
Outer diameter:	6.35 mm
Length:	107.9 mm
Ferrule/jacketing:	Plastic
Reconditioning available:	No (uses replaceable glass fiber membranes)
Options:	FOXY-RESP general-purpose FOSPOR-RESP high-sensitivity

Technical Tip – Probe Care

Your Oxygen Sensor probe is very easy to maintain. It can be left in air indefinitely, but don’t leave it exposed to your excitation light source when it is not in use. Dropping the probe could cause the optical fiber to break. Be sure not to over tighten the SMA connections.

Cleaning and sterilization guidelines vary by sensor formulation and other variables. Ethylene oxide will sterilize all formulations safely. Be sure to visit our website for details.

Oxygen Sensor Probes

Options for a Wide Range of Sensing Environments

Oxygen Probe Accessories

Accessory options include a needle probe accessory for use with R-series probes and an in-line flow cell option for low-pressure liquid streams.

The flow cell is made of PEEK polymer and includes tubing barbs for 1/16″ (1.587 mm) and 1/8″ (3.175 mm) ID tubing. It's designed for use in a low-pressure flowing stream of liquid with a peristaltic or positive displacement pump.

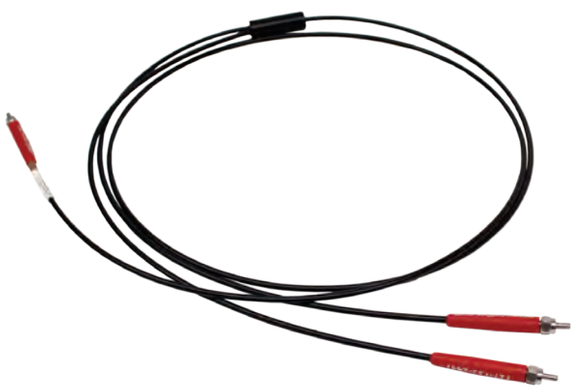
Item:	Puncturing Needle Probe Accessories (two needle lengths available)
Use:	Puncturing septa or seals without damaging sensor coating; adapts to standard 1.587 mm (1/16”) probes and includes Swagelok adapter
Core diameter:	1000 µm (probe)
Outer diameter:	1.587 mm (1/16”)
Length:	152.4 mm (probe) and 63.5 mm (accessory)
Ferrule/jacketing:	Stainless steel
Reconditioning available:	Yes (probe)
Options:	FOXY-R-PNA FOXY-R-PNA-2.5

Item:	In-line Flow Cell Accessories for General-purpose Probes
Use:	Low-pressure liquid flow streams
Core diameter:	1000 µm (probe)
Outer diameter:	1.587 mm (1/16”)
Length:	32 mm (probe)
Ferrule/jacketing:	PEEK (flow cell)
Reconditioning available:	Yes
Options:	FOXY-FLOW-CELL

Bifurcated Assemblies for Your Probe Setups

Our BIF-BORO bifurcated optical fibers are designed for optimizing the connection between your oxygen probe and the NeoFox electronics. You'll also need a 21-02 SMA Splice Bushing, which mates SMA-terminated optical fibers and connects the oxygen probe to the bifurcated optical fiber assembly. Both fibers and splice bushings are required for most probe setups and are priced separately. The RE-BIFBORO-2 is designed for seamless integration with RedEye patch applications.

Item:	Bifurcated borosilicate optical fiber assembly couples to sensor probe
Use:	For sensor probes of applicable size and sensitivity
Core diameter:	1000 µm, 600 µm, 300 µm
Length:	2 m or 3 m
Ferrule/jacketing:	Black PVC Monocoil
Reconditioning available:	NA
Options:	BIFBORO-1000-2 BIFBORO-600-2 BIFBORO-300-2 RE-BIFBORO-2 (3.175 mm OD, 2 m length)



Sensor Probe Care and Chemical Compatibility

How to Get the Most Out of Your Oxygen Probe

Our oxygen sensor probes are both robust and simple to maintain. Probe lifetime is typically one year before reconditioning may be necessary, providing that users are careful in handling the probe and ensure that it's not exposed to the excitation source energy for lengthy periods. Some sensor coatings are more appropriate for specific sample environments, so be sure to check the coating compatibility chart on the next page or consult with an Applications Scientist.

Oxygen Sensor Probe Cleaning and Sterilization Guide

Proper maintenance of your oxygen sensor probes may include occasional cleaning and sterilization, which is often required in biological applications. These guidelines apply to probes only and may vary as sensor formulations and other variables change. Please check our website for the most up-to-date information available. Sterilization is a more thorough probe maintenance method than cleaning. Cleaning is useful for removing inclusions, oil and the like, while sterilization refers to any process that eliminates (removes) or kills all forms of life, including transmissible agents that may contaminate the probe.

Cleaning Methods

	FOXY Formulation	FOSPOR Formulation	HIOXY Formulation	Comments
H2O2 (hydrogen peroxide at 30%)	Safe	Safe	Safe	FOXY requires single-point recalibration after each cleaning; also, frequent cleaning will shorten FOXY probe lifespan
Isopropanol	Safe	Safe	Safe	FOXY requires single-point recalibration after each cleaning; also, frequent cleaning will shorten FOXY and HIOXY probe lifespan
Ethanol	Safe	Safe	Safe	FOXY requires single-point recalibration after each cleaning; also, frequent cleaning will shorten FOXY probe lifespan
Methanol	Not recommended	Safe	Not recommended	

Note: Brief exposure of probes to these cleaning agents is recommended. Long-term exposure will affect the sensor coating.

Sterilization for Probes

	FOXY	FOSPOR	HIOXY	Comments
Autoclaving	No	No	Yes	HIOXY Probes require single-point reset after autoclaving
Ethylene Oxide	Yes	Yes	Yes	Signal intensity decreases after EtO exposure; recalibration or single-point reset is required
Gamma Radiation	Yes	Not Tested	Not Tested	FOXY Probes require single-point reset after gamma radiation

Sterilization for Patches

RedEye Patches	FOXY	HIOXY	Comments
Ethylene Oxide	Yes	Yes	The signal intensity decreases, reducing the lifespan of the sensor; single-point reset is required
Gamma Radiation	Yes	Not Tested	The signal intensity decreases, reducing the lifespan of the sensor; single-point reset is required

Also available is an autoclavable HIOXY patch (RE-HIOXY-HTC) that uses a BK-7 glass disc as the substrate.

Oxygen Sensor Probe Reconditioning

Good maintenance practices and protection from harsh environments, biofouling, physical abrasion and photobleaching will ensure optimum probe life. If the sensor coating on your oxygen probe is damaged or wears out, recoating services for most of our probe options are available. This reconditioning also includes a recalibration of the probe.

Item codes: FOXY-RECOV, FOSPOR-RECOV and HIOXY-RECOV

Technical Tip

Our oxygen-sensitive RedEye patches are designed primarily for benign gas and liquid environments. The patches are not compatible with chemicals that may attack acrylates and polyester adhesive polymers.

Patches are semi-disposable and do not lend themselves well to cleaning, although some sterilization methods (gamma radiation) may extend their use in biological and other environments. Please consult an Applications Scientist for details.

Sensor Probe Care and Chemical Compatibility

How to Get the Most Out of Your Oxygen Probe

Some chemicals and gases may interfere with oxygen sensor performance by attacking the coating or deteriorating the fluorescence signal. The tables below list observed effects of chemicals and gases on coated test slides and on probes immersed in liquids. Up-to-date compatibility charts are available at our website.

Visual Observation of Sol-Gel Coating on Slides

Probes Without Overcoat in Headspace or Immersed in Chemicals

Chemical	FOXY	HIOXY	FOXY	HIOXY	Comments	Final Determination	
						FOXY	HIOXY
Acetone (Reagent Plus, ≥ 99%)	No	No	No	No	Lifetime not reproducible	No	No
Acetonitrile	No	Yes	No	No	The lifetime of the probe fluctuates and is not stable in the solution.	No	No
Benzene (99%, A.C.S. reagent)	No	Yes	No	Yes	The probe has a one-time permanent decrease in lifetime when immersed in chemical, therefore it needs to be calibrated in the chemical.	No	Conditionally
Cyclohexane	No	Yes	No	Yes	The HIOXY probe has a one-time permanent decrease in lifetime when immersed in chemical, therefore it needs to be calibrated in the chemical. The FOXY probe decreases both in Signal Level and lifetime.	No	Conditionally
DichloroMethane	No	Yes	No	Yes	The HIOXY probe has a one-time permanent decrease in lifetime when immersed in chemical, therefore it needs to be calibrated in the chemical. The FOXY probe decreases both in Signal Level and lifetime.	No	Conditionally
Heptane	Yes	Yes	Yes	No	FOXY Probe has a one-time permanent decrease in lifetime when immersed in chemical, therefore it needs to be calibrated in the chemical.	Conditionally	No
Hexane (95+%, HPLC grade)	Yes	Yes	No	No	Lifetime not reproducible	No	No
Methanol (98% Histological Grade)	No	Yes	No	Yes	The probe has a one time permanent decrease in lifetime when immersed in chemical, therefore it needs to be calibrated in the chemical.	No	Conditionally
Methyl Methacrylate (99%)	Yes	No	No	No	Lifetime not reproducible	No	No
Styrene (Reagent plus, ≥ 99%)	No	Yes	No	Yes	HIOXY Probe – The probe has a one-time permanent decrease in lifetime when immersed in chemical, therefore it needs to be calibrated in the chemical.	No	Conditionally
Tetrahydrofuran (99+ %)	No	No	No	No	Lifetime not reproducible	No	No
Toluene (99%)	No	No	No	Yes	HIOXY Probe - The probe has a one-time permanent decrease in lifetime when immersed in chemical, therefore it needs to be calibrated and conditioned in the chemical.	No	Conditionally
Xylene (Isomers plus ethyl benzene, reagent plus)	No	Yes	No	No	Lifetime not reproducible	No	No
Ethlyne Glycol	Yes	Yes	No	Yes	HIOXY Probe- The probe has a one time permanent decrease in lifetime when immersed in chemical, therefore it needs to be calibrated in the chemical.	No	Conditionally
JP8 (Jet fuel)	No	Yes	No	Yes		No	Yes
Propylene Carbonate	Not tested	Not tested	Not tested	No	Lifetime not reproducible	Not tested	No

Oxygen Sensor Temperature Compensation

Options for Dealing with Temperature Effects in O2 Measurements

Our optical O2 sensors are affected by temperature. Temperature affects both fluorescence intensity and excited state lifetime due to the decrease of fluorescence energy quantum efficiency with temperature increase. The effect of change in temperature is seen as a change in the calibration slope.

As temperature increases and partial pressure of oxygen remains the same, compensating for temperature mitigates the risk of a false partial pressure reading. For best results, the sample must be held at a constant temperature (+/-1 °C). The temperature response of our sensors can be determined by the user, or can be supplied by a factory calibration. In a multichannel sensor setup, the user must account for temperature effects in each channel.

In-house Temperature Calibration Services

If your sample cannot be maintained at a constant temperature (+/-1 °C), you can perform a temperature calibration in NeoFox Viewer software or include our temperature calibration service as part of your order. The standard service covers environments from 0-80 ºC; extended-range service is available for environments outside those parameters. You'll need to tell us which oxygen sensor formulation you're using (FOXY, FOSPOR or HIOXY) and provide the temperature and oxygen concentration ranges of your sample environment.

Item codes: xxxx (sensor formulation)-CAL (standard option) and xxxx (sensor formulation)-CAL-EXT (extended temperature range)

Temperature Probe Options for Optical Oxygen Sensor Systems

We offer temperature probe options for use with our oxygen sensor systems: a rugged, discrete thermistor or a T1000-style ¼" (6.35 mm) stainless steel probe with an embedded thermistor. The latter is available in each of three coating formulations (FOXY, FOSPOR, HIOXY).

T1000-TS-6CM-NEO

T1000-TS-NEO

NEOFOX-TP

Temperature Probes for Oxgen Sensor Systems

Item	Description	Core Diameter	Outer Diameter	Length	Ferrule/ Jacketing	Pressure Rating	Reconditioning Available
FOXY-T1000-TS-NEO	1/4" process probe w/general-purpose coating and thermistor	1000 µm	6.35 mm	177.8 mm	Stainless steel	3000 psi	Yes
FOXY-T1000-TS-6CM-NEO	1/4" process probe w/general-purpose coating and thermistor	1000 µm	6.35 mm	60 mm	Stainless steel	3000 psi	Yes
FOSPOR-T1000-TS-NEO	1/4" process probe w/high-sensitivity coating and thermistor	1000 µm	6.35 mm	177.8 mm	Stainless steel	3000 psi	Yes
FOSPOR-T1000-TS-6CM-NEO	1/4" process probe w/high-sensitivity coating and thermistor	1000 µm	6.35 mm	60 mm	Stainless steel	3000 psi	Yes
HIOXY-T1000-TS-NEO	1/4" process probe w/hydrocarbon-ready coating and thermistor	1000 µm	6.35 mm	177.8 mm	Stainless steel	3000 psi	Yes
HIOXY-T1000-TS-6CM-NEO	1/4" process probe w/hydrocarbon-ready coating and thermistor	1000 µm	6.35 mm	60 mm	Stainless steel	3000 psi	Yes
NEOFOX-TP	3" x #32 AWG thermistor w/10,000 Ohm resistance @ 25 ºC	115 mm	3.5 mm	76.2 mm	Radial leaded wires	Not tested	No

RedEye Optical Sensing Patches

Self-adhesive Patches for Non-intrusive Oxygen Measurements

The RedEye® indicator patch measures oxygen non-invasively in sealed packaging and containers used in medical, pharmaceutical and food applications. Using a combination of proprietary sensing material and measuring technologies, this non-invasive patch enables quick determination of the presence of oxygen, as well as quantitative measurements. Oxygen monitoring can also ensure patient safety in point-of-care analysis or indicate a sterile seal on surgical instruments and drug packaging. RedEye patches meet USP Class VI certification for biocompatibility.

RedEye Features a Propriety Sol Gel Coating

RedEye patches are unique in that high-performance sol gel coatings are used – rather than polymer membranes. RedEye coatings are capable of monitoring low levels of oxygen in gas (to 0.01%) and dissolved oxygen in liquids (to 4 ppb), as well as the higher oxygen levels present in cell culture and respiratory monitoring. Also available is a new design that uses the HIOXY formulation on a BK7 glass substrate autoclavable at 100 °C. Contact an Applications Scientist for details on item RE-HIOXY-HTC.

The RedEye can be integrated into packaging for continuous monitoring or used externally for post-production and R&D monitoring purposes. Depending on the application, the simple presence of oxygen can be visually determined by color change with a handheld LED. A fluorometer can also be used to directly measure oxygen partial pressure.

Typical Applications

- Point-of-care analysis (e.g., disposable oxygen attachments for ventilators used during anesthesia operation)
- Blood bag analysis
- Beverage and food packaging
- Bioprocess control
- Cell culture monitoring

Specifications	FOXY Formulation	FOSPOR Formulation	HIOXY Formulation	HIOXY High-Temp Option
Recommended use:	General purpose coating	High-sensitivity coating for low-oxygen environments	Robust coating for hydrocarbon-rich environments	Applications where autoclaving is necessary
O2% range (at 1 ATM):	0-100%	0-10%	0-20%	0-20.9%
DO range (ppm at 1 ATM):	0-40 ppm	0-4 ppm	0-8 ppm	0-8 ppm
Temperature range:	0 to +60 ºC for patches	0 to +60 ºC for patches	0 to +60 ºC for patches	0 to +100 ºC for glass window (patch)
O2% resolution:	0.05% (at 20 s averaging)	0.01% (at 30 s averaging)	0.05% (at 20 s averaging)	0.05% (at 20 s averaging)
DO resolution (at room temp):	20 ppb	4 ppb	20 ppb	4 ppb
O2% accuracy:	5% of reading	5% of reading	5% of reading	<5% of reading
DO accuracy:	5% of reading	5% of reading	5% of reading	<5% of reading
Min. detectable level in gas:	0.1% O2	0.01% O2 (at 30 s averaging)	0.1% O2	0.01%-0.05%
Min. detectable level in water (at room temp):	40 ppb	4 ppb	40 ppb	40 ppb
Response time:	<1 s in gas	30-60 s in gas	<1 s in gas	5-10 s in gas
	~30-45 s with overcoating in gas	~60-90 s with overcoating in gas	~30 s with overcoating in gas	~30 s with overcoating in gas
	~45 s in pure water	~60-90 s in pure water	~30-45 s in pure water	~40-60 s in pure water
Patch material:	Acrylate	Acrylate	Acrylate	BK7 glass
Patch dimensions:	4 mm, 8 mm and 127 mm disk (standard); custom sizes also available	4 mm, 8 mm and 127 mm disk (standard); custom sizes also available	4 mm, 8 mm and 127 mm disk (standard); custom sizes also available	4 mm (standard); custom sizes also available
Standard patch options:	Single patch or pack of 5	Single patch or pack of 5	Single patch or pack of 5	Single glass window
Patch-cuvette options:	Patch applied to quartz or polystyrene cuvettes	Yes	Yes	No
Overcoat option:	Medical-grade overcoat	Medical-grade overcoat	Medical-grade overcoat	Medical-grade overcoat
Adhesive pH compatibility:	Yes (pH 4.0-10.0)	Yes (pH 4.0-10.0)	Yes (pH 4.0-10.0)	Yes (pH 4.0-10.0)

Oxygen Sensor Testing Options and Accessories

Determine the Feasibility of Our Sensors for Your Applications

Sensor Chemical Compatibility Testing

Our optical oxygen sensor probes work well in most environments. But where there is uncertainty about chemical compatibility, users can select from a variety of coated substrates for testing – including free cover slips coated with the formulation of your choice. For more complex testing, consult an Applications Scientist.

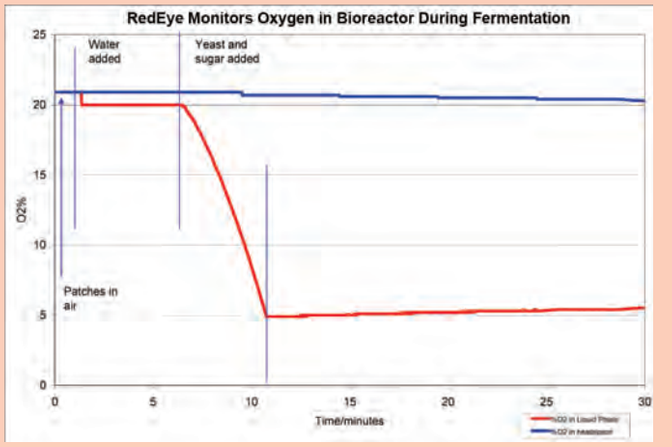
Item	Description	Typical Use	Coatings
xxxx (coating formulation)-GF	Coated glass filters; pack of 5	Qualitative and quantitative testing	FOXY, FOSPOR, HIOXY
xxxx (coating formulation)-SGS-M	Spin-coated microscope slide, 1" x 3"	Qualitative and quantitative testing	FOXY, FOSPOR, HIOXY
xxxx (coating formulation)-SGS-Test	Coated cover slips; no charge	Qualitative and quantitative testing	FOXY, FOSPOR, HIOXY

Optical Oxygen Sensing

In a recent study we demonstrated the feasibility of our RedEye® oxygen sensing patch in a bioreactor. Oxygen levels in the headspace as well as in liquid phase were monitored non-intrusively during the aerobic and anaerobic process.

Yeasts are a growth form of eukaryotic micro-organisms that are capable of both aerobic and anaerobic respiration. In the presence of oxygen, yeast will consume both oxygen and glucose to produce carbon dioxide and water. In the absence of oxygen, yeast will consume glucose to produce carbon dioxide and ethanol. We investigated the aerobic metabolism of sugar by yeast in order to determine the consumption of oxygen in a closed system.

We used our NeoFox Phase Fluorometer and a bifurcated optical fiber for the excitation and detection of RedEye patches in a lab-scale bioflask. Two RedEye patches were placed inside the flask -- one patch in the upper portion to measure oxygen in the vapor phase and one in the lower portion to measure oxygen in the liquid phase. The RedEye patches were calibrated at 0% and 20.9% oxygen in gas. We added 300 mL of water to the flask to a level between the two patches. Oxygen was monitored for a couple of minutes to observe the difference in oxygen between the vapor and liquid phases. We then added 2 g of yeast and 10 g of sugar, sealed the system and monitored the process.



Results

The RedEye patches gave a reading of 20.9% during the first minute of the experiment as they were exposed to air. After we added water, the RedEye patch monitoring the vapor held at 20.9% while the patch in the liquid phase dropped to 20.0% -- showing that the water had not yet reached steady-state equilibrium with the ambient conditions. After several minutes the yeast and sugar were added to the flask and the flask was sealed. During the next minutes we observed that the yeast metabolized the sugar and consumed oxygen in the process. By the time the yeast had consumed all of the sugar the oxygen level in the liquid phase dropped from 20.0% to 5.0%. As the oxygen in the vapor phase diffused into the liquid phase, the system began to approach steady-state equilibrium.

USP Class VI Certification

Sensors Division Granted USP Class VI Certification

Ocean Optics has achieved USP Class VI certification for its optical oxygen and pH sensor patches. United States Pharmocopeia (USP) is a standards-setting organization for medicines, healthcare products, food ingredients and related items. Class VI certification relates to the reactivity of plastics in various biological samples and helps to ensure the safety of the sensors for use in biological and pharmaceutical processes, implantable devices, cell cultures, biodegradable bags and more.

Ocean Optics optical O2 and pH sensors are a convenient alternative to galvanic sensors for real-time, in situ measurements in pharmaceutical and biological processes, biotechnology applications and more. Our proprietary sensor coating materials do not consume the sample and can be applied to substrates such as probes, self-adhesive acrylic patches (the format tested for USP Class VI) and microtiter wells. Coating options are available for general lab use, high-sensitivity applications and hydrocarbon-rich environments.

pH Sensor Systems

Optical pH Sensors Available in a Variety of Form Factors

Our optical pH sensors use a proprietary sol-gel formulation optimized for the biological range and are available in probe, cuvette and patch formats. Each pH sensor works on the same principle: a colorimetric change that's detected with a spectrometer. We immobilize a pH-sensitive dye in a modified sol-gel matrix, where the free diffusion of hydrogen ions in and out of the matrix pores allows for interaction with the dye. When this interaction occurs, the dye exhibits a visible color change.

Form Factors

We offer transmissive pH probes, self-adhesive pH patches and pH-sensitive cuvettes (see Smart Cuvettes on p. 179) to meet your pH sensing needs. While typical optical sensors are susceptible to changes in ionic strength, our pH sensors overcome this limitation and thus can be used in applications such as food and beverage processing and pharmaceutical production. Also available is a new reflective patch form factor.

Advantages of pH Sensors

- Are immune to ionic strength sensitivity
- Are compatible with alcohols and other organic solvents
- Have faster response time and better thermal performance than pH electrodes
- Are designed for use in the biological range (pH 5-9)
- Work well even in low salinity solutions
- Meet USP Class VI certification requirements for biocompatibility
- Are available in probe, patch or cuvette options
- Can be used for non-intrusive measurements

Ocean Optics' new non-intrusive reflective pH technology comes as the next evolution of our pH sensing product line. Previous pH sensor products have been based on colorimetric transmissive measurements, and have therefore fallen susceptible to ambient light interferences and sample color or turbidity effects.

Our new approach uses electroformed mesh to metallize the pH sensor material, providing an optically reflective yet ion permeable membrane between the sensor and the environment.

pH Sensor Specifications

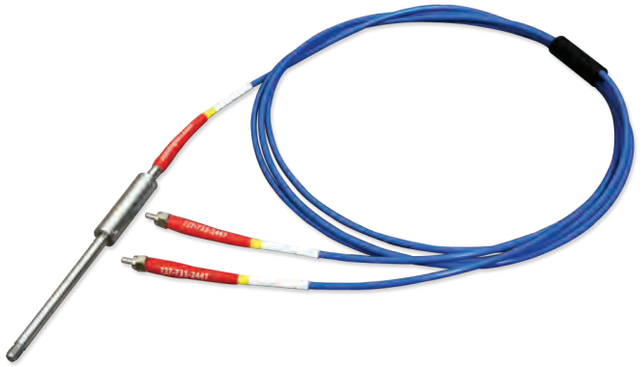
The pH Probes from Ocean Optics use a proprietary sol-gel formulation infused with a colorimetric pH indicator dye. This material is coated onto our exclusive patches to reflect light back through the central read fiber or to transmit light through the sample in order to sense the color change of the patch at a specific wavelength.

	Reflective
pH range:	5 – 9
Temperature range:	-6° to +60 °C
Analytical wavelength:	617 nm
Baseline correction wavelengths:	509 nm (isosbestic) or 800 nm
User calibration accuracy:	Up to 2% of reading
Factory reset accuracy:	0% at reset point 1% within 1 pH unit of reset Up to 4% at 3 pH units from reset
Resolution:	~0.03 pH unit in most cases
Response time (t90):	30 seconds
Calibration requirements (minimum):	Factory calibration: 3 buffers
User calibration:	5 or 6 buffers
Sterilization:	Gamma, EtO
Acceptable probes:	3-Around-1 Angled RE-BIFBORO Reflection probes (200 µm, 400 µm, 600µm)

	Transmissive
pH range:	5 – 9
Temperature range:	-5° to +70° C
Transmissive accuracy:	<1% of reading across range
Transmissive resolution:	0.02 pH
Transmissive response time:	30 seconds
Calibration requirements:	3 buffers
Sterilization:	Gamma, EtO, Autoclave
Chemical compatibility:	Aqueous, alcohols, some organic solvents, peroxides, ammonia, sodium hypochlorite
Drift (continuous stability):	1% per day
Discrete stability (life-time):	50 uses or more, dispose when absorbance at pH 11 <0.1 (assumes pH1 reference)
Storage conditions:	Dry or wet storage

Transmissive pH Probes

Dip Probe Accommodates pH Patches



Item	Specifications
Fiber type	T300: 300 µm solarization-resistant or VIS-NIR optical fiber
Outer diameter:	6.35 mm
pH range:	5 - 9
Temperature range:	-5° C - +70° C
Transmissive accuracy:	<1% of reading across range
Transmissive resolution:	0.02 pH
Transmissive response time:	30 seconds
Calibration requirements:	3 buffers
Sterilization:	Gamma, EtO, Autoclave
Chemical compatibility:	Aqueous, alcohols, some organic solvents, peroxides, ammonia, sodium hypochlorite
Drift (continuous stability):	1% per day
Discrete stability (lifetime):	50 uses or more, dispose when absorbance at pH 11 <0.1 (assumes pH1 reference)
Storage conditions:	Dry or wet storage

The Transmissive pH patches from Ocean Optics are integrated with transmissive dip probes and can be used with a desktop spectrometer as well as with the Jaz handheld spectrometer suite. The desktop system uses a module in our SpectraSuite software that allows for simplified calibration, convenient pH readings, customizable data logging and comprehensive exportation of data and calibration information. These disposable patches can be used with our dip probes.

For field measurements, the handheld Jaz offers an easy and portable solution. Jaz's SD card runs a script that allows you to use the factory calibration or a complete calibration. It also shows live pH values and gives you the ability to save data directly to the card.

Features

- Proprietary organically modified sol-gel formulation engineered to maximize immunity to ionic strength sensitivity
- Compatible with some organic solvents (acetone, alcohols, aromatics, etc.)
- Sol-gel material chosen over typical polymer method, allowing for faster response time, versatility in the desired dopants, greater chemical compatibility, flexible coating and enhanced thermal and optical performance
- Indicator molecule allows high-resolution measurement in biological range (pH 5-9)
- Simplified algorithm takes analytical and baseline wavelengths into account to reduce errors caused by optical shifts

Setup

- Spectrometer (350-1000 nm), slit options (25, 50, 100, 200 µm)
- Light Source (350-1000 nm)
- Transmissive Probe (T300-RT-UV-VIS or VIS-NIR)
- Transmissive Probe Cap (RT-2MM, RT-4MM, RT-5MM, RT-10MM)
- pH Patches (PH-BCG-TRANS) pack of 5

R1000-4 pH Probe

pH range:	5-9
Temperature range:	-5 - 60 °C
Analytical wavelength:	617 nm
Baseline correction wavelengths:	509 nm (isosbestic) or 800 nm
User calibration accuracy:	Up to 2% of reading
Factory reset accuracy:	0% at reset point 1% within 1 pH unit of reset Up to 4% at 3 pH units from reset
Resolution:	~0.03 pH unit in most cases
Response time (t90):	30 seconds depending on salinity of sample and liquid flow at sensor interface
Sterilization:	Gamma, EtO

The new R1000-4 pH Probe from Ocean Optics is designed to work with non-intrusive reflective pH patches (PH-BCG-REFLECT) but can also be used with our RedEye oxygen sensor patches.

This probe consists of four 100 µm plastic fibers arranged in a 3-around-1 configuration.

The three illumination fibers are angled at 25.5° to focus light to the center of the sensor patch.

The R1000-4's design greatly increases back reflection -- improving the signal-to-noise ratio. This is critical for ambient light and color immunity that makes our sensors so unique and efficient.

Smart pH Cuvettes

Turn Your Spectrometer into a Drift-free pH Meter

Our newest transducer materials are designed to encapsulate pH dyes for optical pH sensing. These materials can be applied to various sampling devices and combined with spectrometers and accessories for convenient, non-intrusive monitoring. A special pH measurement module can be added to the spectrometer operating software.

Consider our Smart pH Cuvette – a 1 cm x 1 cm cuvette, available in PMMA or quartz – that's embedded with pH sensing material. Smart pH Cuvettes are great for biological pH (5-9) range samples, are semi-disposable and require very little maintenance.

Each Smart pH Cuvette has an immobilized indicator dye that is encapsulated into a robust sol gel matrix, allowing for the diffusion of ions while preventing leaching of the dye. Unlike traditional pH electrode meters, Smart pH Cuvettes can be used for monitoring low-conductivity samples such as boiler water. In addition, fully integrated Smart Cuvette pH systems provide full spectral analysis to help eliminate errors from changes in turbidity, temperature and ionic strength. The physical properties of the immobilized indicator dye eliminate the need for frequent calibration.

Also, our pH-sensitive materials can be formulated as self-adhesive patches and integrated into various sample containers.

Smart pH Cuvettes	
Sensor type:	Colorimetric indicator dye coated onto 1-cm square cuvette
Dimensions:	1 cm x 1 cm
Materials:	PMMA (general-purpose use), quartz cuvettes (high-temperature measurements)
Sample volume:	4 mL PMMA cuvettes, 3.5 mL quartz cuvettes
pH range:	Biological range (5-9)
Temperature range (coating):	-5 °C to +70 °C
Measurement setup:	Recommend any UV-VIS spectrometer w/200 µm slit and either white light source (w/blue filter) or white LED
Sensor signal:	Absorbance at 620 nm and 750 nm
Accuracy:	<1% of reading
Resolution:	0.01 pH
Response time:	90% step response in 10 s
Factory calibration:	All cuvettes come with factory calibration
User complete calibration option:	Users perform complete calibration to generate all necessary coefficients
Usage lifetime:	Multiple uses possible; cuvettes should be discarded and replaced once the maximum absorbance at pH 11 falls below 0.1
Sterilization:	Gamma, EtO
Temperature compensation:	van't Hoff Correlation, used for both discrete measurement pH correction and continuous pH correction
Cuvette options:	SC-PH-CVFL -- BCG-coated 3.5 mL quartz cuvette
	SC-PH-VIS1M-SAM -- BCG-coated 4 mL PMMA cuvettes; 8-pack
	SC-PH-VIS1M-50 -- BCG-coated 4 mL PMMA cuvettes; 50-pack
	SC-PH-VIS1M-100 -- BCG-coated 4 mL PMMA cuvettes; 100-pack
Kit options:	Kit for use with USB Spectrometers: Pack of 8 PMMA cuvettes with 1-cm pathlength cuvette holder, two optical fibers and SpectraSuite software
	Kit for use with Jaz: Pack of 8 PMMA cuvettes with 1-cm pathlength cuvette holder, two optical fibers and Jaz pH software application

Note: We also can apply oxygen-sensitive RedEye patches to cuvettes. Options include a 2.5 mL quartz cuvette (SC-FOXY-CVFL) and 4 mL polystyrene cuvettes in packs of 8 (SC-FOXY-VIS1M-SAM) and 100 (SC-FOXY-VIS1M).

Application Notes

Optical Oxygen and pH Sensors for Monitoring of Biofermentation Processes

Compared with traditional electrochemical sensing techniques such as galvanic sensors, Ocean Optics oxygen and pH optical sensors can be made in small and customizable form factors, allow non-intrusive measurements and do not consume the sample.

Experimental Conditions

We placed oxygen- and pH-sensitive adhesive patches inside a bioflask in which red grape biofermentation occurred. Bioreactors are closed-environment systems where the cells are cultured under specific conditions to synthesize the final product. Such systems require constant monitoring of DO and pH to optimize bioprocesses. Our patches provided oxygen and pH measurements in both headspace and the liquid phase.

Our RedEye® oxygen patches were attached to the container with adhesive backing to monitor the oxygen in headspace and in solution. The pH patches were placed in solution to monitor pH changes during the fermentation process (Figure 1).

Red table grapes were mashed and the must was left untouched for 48 hours. The juice was drained and placed in a bioflask. Yeast cells and nutrients were added to begin fermentation. Non-intrusive oxygen and pH measurements during the aerobic and anerobic processes were monitored over a 60-hour period.

Oxygen and pH Measurements

To measure oxygen we used two NeoFox Phase Fluorometers equipped with bifurcated optical fibers for the excitation and detection of the RedEye patches. NeoFox measures the phase shift between a blue LED used to excite the oxygen indicator in the patch and the emission signal of the fluorescence. The fibers were situated normal to the outside surface of the flask pointing directly at the patches on the inside.

To measure pH we used the Jaz Spectrometer with integrated tungsten halogen light source and a bifurcated optical fiber. One leg of the fiber transmitted light to the patch inside the container and the other leg of the fiber read the response from the reflective patch inside the solution. Standard pH buffers were used for calibration. Absorbance curves were observed over time.

Results and Conclusions

In first two hours of fermentation, the RedEye oxygen sensor in the solution detected a quick drop from air saturation as soon as yeast cells and nutrients were added. The yeast cells had started consuming the oxygen through the liquid cell membrane interface by the diffusion process. The pH sensor in the solution measured a slight drop in absorbance as the oxygen decreased and CO2 was released. The same experiment can be extended to a single cell in a microfluidics well culture system.

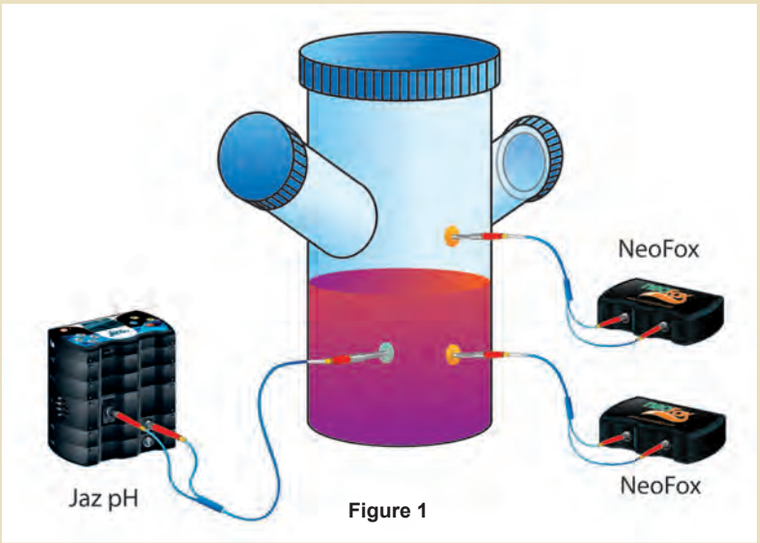


Figure 1

Headspace remained at air saturation for approximately the first 2.5 hours of fermentation. Once the oxygen in solution was completely quenched, the yeast cells and nutrients started consuming the oxygen.

Ocean Optics optical oxygen and pH patches can be integrated easily within a small-scale biosystem such as a bioflask and provide continuous monitoring of key system parameters (Figure 2). The ability to monitor DO and pH without perturbing a sealed environment can lead to an improved understanding of the processes in the bioreactor and, ultimately, help the development of new biological products and processes.

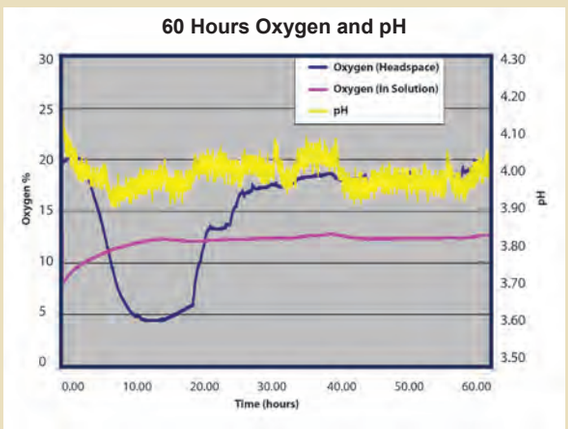


Figure 2

Education

The Ocean Optics Education Division provides cost-effective, easy-to-use spectrometers, software and accessories for your teaching lab. We also provide curricula, workshops and multimedia learning to help you bring excitement to the classroom. Our educational offerings take your students beyond traditional technology and into the possibilities of the future.

When you invest in Ocean Optics for your teaching lab or educational application, you tap into the collective power of over 150,000 spectrometers' worth of application know-how.

Tip

As a long-time supporter of science and spectroscopy in the classroom, Ocean Optics offers funding resources to public and private teaching institutions. Grant funds are available for promoting the use of spectroscopy measurement tools in science and engineering curricula. Hundreds of institutions have benefitted from our support.

CHEM4 Spectrometers

Smart Systems for Education

The CHEM4 Series Spectrometers from Ocean Optics are small, PC-based systems that are ideal for science and chemistry educators in the classroom or the teaching laboratory. These fully integrated systems include spectrometer, light source and cuvette holder and are available at reasonable pricing for qualified educators and learning institutions.

For bringing the excitement of learning to your classroom or teaching lab, nothing is easier.

USB for Easy Startup

The spectrometers feature a USB interface and are fully calibrated. Just plug and play.

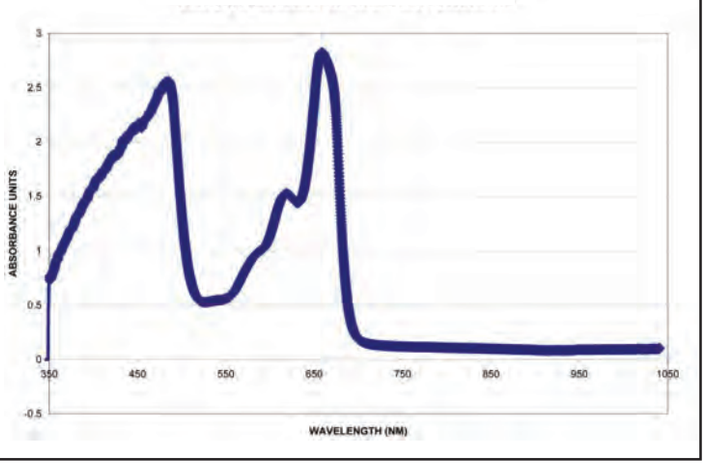
Programmable Microcontroller

CHEM4 Series Spectrometers feature an onboard microcontroller that delivers incredible flexibility and control with your system and accessories. Through a 22-pin connector, you can implement operating parameters in your software, control light sources, create processes and retrieve information on external objects.

Light Source and Sample Holders

CHEM4 Fiber Systems come with a spectrometer, an integrated sampling system and an optical fiber.

Chlorophyll Absorbance with CHEM Series Spectrometer



CHEM4-UV-FIBER

The CHEM4-UV-FIBER is ideal for absorbance measurements and combines a USB4000 Spectrometer with modular accessories including an ISS-UV-VIS Integrated Sampling System, a 300 µm solarization-resistant optical fiber and a 1-cm cuvette holder.

Item Code: CHEM-4-UV-FIBER

Spectrometer	USB4000
Wavelength range:	200-885 nm
Light source and sample holder:	ISS-UV-VIS integrated deuterium tungsten halogen light source and cuvette holder for 1-cm square cuvettes
Optical fiber:	Light source/sample holder connects to spectrometer via 300 µm solarization-resistant fiber
Software:	SpectraSuite (available for an additional charge) Overture (no charge)

CHEM4-VIS-FIBER

Our CHEM4-VIS-FIBER is perfect for relative irradiance and emission measurements. The CHEM4-VIS-FIBER combines our USB4000 Spectrometer with an ISS-2 Integrated Sampling System, a 400 µm optical fiber and a 1-cm cuvette holder. Add accessories like reflectance probes or dip probes for even more measurement options.

Item Code: CHEM4-VIS-FIBER

Spectrometer	USB4000
Wavelength range:	430-990 nm
Light source and sample holder:	ISS-2 integrated tungsten halogen light source and cuvette holder for 1-cm square cuvettes
Optical fiber:	Light source/sample holder connects to spectrometer via 400 µm fiber
Software:	SpectraSuite (available for an additional charge) Overture (no charge)

ChemUSB Spectrometer

Smart Systems for Education

Our CHEMUSB4 Spectrometer Systems are the ideal combination of our USB-interface spectrometer technology and modular accessories. This system is made up of our popular USB4000 spectrometer, a deuterium tungsten halogen or tungsten halogen and LED light source and 1-cm cuvette holder.

With its high-speed electronics and small footprint, the CHEMUSB4 makes a perfect teaching tool in the classroom or lab.

The CHEMUSB4-UV-VIS covers the 210-880 nm range at 1.0 nm (FWHM) optical resolution and the CHEM4-VIS-NIR covers 370-985 nm at 1.0 nm resolution.

- Fully integrated, preconfigured system
- Small footprint
- Fast, hassle-free spectrometer-to-PC connection

Item Codes: CHEMUSB4-UV-VIS, CHEMUSB4-VIS-NIR

CHEMUSB4-UV-VIS

Physical	
Spectrometer dimensions:	89.1 mm x 63.3 mm x 34.4 mm
Spectrometer weight:	190 g
Light source dimensions:	89.1 mm x 77.79 mm x 34.4 mm
Light source weight:	200 g
Detector Specifications	
Detector:	Toshiba TCD1304AP Linear CCD array
Pixels:	3648 pixels
Pixel size:	8 µm x 200 µm
Pixel well depth:	100,000 electrons
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm
Optical Bench	
Design:	f/4, Asymmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output
Entrance aperture:	25 µm wide slit
Spectroscopic	
Wavelength range:	210-880 nm
Optical resolution:	1.0 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	50 RMS counts
Integration time:	3.8 ms to 10 seconds
Dynamic range:	3.4 x 10^6 (system), 1300:1 for a single acquisition
Stray light:	<0.05% at 600 nm; 0.10% at 435 nm
Light Source/Sample Holder	
Light source:	Deuterium tungsten
Bulb life (hours):	800 deuterium; 2,000 tungsten

CHEMUSB4-VIS-NIR

Physical	
Spectrometer dimensions:	89.1 mm x 63.3 mm x 34.4 mm
Spectrometer weight:	190 g
Light source dimensions:	40.7 mm x 88.8 mm x 34.1 mm
Light source weight:	130 g
Detector Specifications	
Detector:	Toshiba TCD1304AP Linear CCD array
Pixels:	3648 pixels
Pixel size:	8 µm x 200 µm
Pixel well depth:	100,000 electrons
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm
Optical Bench	
Design:	f/4, Asymmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output
Entrance aperture:	25 µm wide slit
Spectroscopic	
Wavelength range:	370-985 nm
Optical resolution:	1.0 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	50 RMS counts
Integration time:	3.8 ms to 10 seconds
Dynamic range:	3.4 x 10^6 (system), 1300:1 for a single acquisition
Stray light:	<0.05% at 600 nm; 0.10% at 435 nm
Light Source/Sample Holder	
Light source:	Tungsten halogen and violet LED
Bulb life (hours):	2,000 (tungsten); 45,000 (LED)

Red Tide Spectrometers

Flexible, Low-Cost, Ideal for Education

USB-650 Red Tide Spectrometers are low-cost, small-footprint spectrometers designed especially for teaching labs and educational use. Red Tide Spectrometers are preconfigured with a 25 µm slit and gratings for UV-VIS (200-880 nm) or VIS-NIR (350-1100 nm) wavelengths. Red Tide models are available that couple to optical fibers and other accessories (USB-650 and USB-650-UV) and that include cuvette holder-light source combinations that attach directly to the spectrometer (USB-650-UV-VIS and USB-650-VIS-NIR).

Red Tide Spectrometers are comparable to our CHEMUSB Spectrometers, but with one significant difference: the Red Tide has fewer detector pixels – 650 active pixels – which results in approximately one data point per nanometer (CHEMUSBs have 2048-pixel detectors). This is one reason why Red Tide is not recommended for more demanding applications such as absolute irradiance measurements. For basic absorbance and other lab measurements, Red Tide is an excellent, economical choice.

Red Tide operates via Overture or SpectraSuite Spectroscopy Operating Software, which runs in OS X, Linux and Windows. The Chemistry module for SpectraSuite includes features for educational use, such as a Beer's Law calculator for absorbance experiments. Overture is a simplified software package aimed at beginners.

USB-650-UV/USB-650 Red Tide Spectrometers

- Can be easily coupled to fibers and accessories
- Compatible with PASCO's Xplorer GLX
- Compatible with Vernier's Logger Pro Software

Item Code: USB-650-UV, USB-650

USB-650-UV-VIS Red Tide Spectrometer

- Observe changes as small as 0.1 absorbance units
- Direct-attach deuterium tungsten light source and sample holder
- Plug and play operation

Item Code: USB-650-UV-VIS

USB-650-VIS-NIR Red Tide Spectrometer

- Complete system covering 350-1000 nm at 2.0 nm (FWHM) optical resolution
- Violet LED light source and sample holder
- Interfaces to PC via USB

Item Code: USB-650-VIS-NIR

Physical	
Dimensions (in mm):	89.1 x 63.3 x 34.4
Weight:	190 g
Detector	
Type:	Linear silicon CCD array
Pixels:	650 enabled pixels
Pixel size:	14 µm x 200 µm
Pixel well depth:	~62,500
Sensitivity:	75 photons/count @ 400 nm
Optical Bench	
Design:	f/4, asymmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output
Entrance aperture:	25 µm wide slit
Fiber optic connector:	SMA 905
Spectroscopic	
Wavelength range: USB-650 USB-650-UV USB-650-VIS-NIR USB-650-UV-VIS	 350-1000 nm 200-880 nm 350-1000 nm 200-880 nm
Optical resolution:	Model dependent
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	12 bit
Dark noise:	3.2 RMS counts
Dynamic range:	8.5 x 10^7 (system); 1300:1 for a single acquisition
Integration time:	3 ms to 65 s (15 s typical max)
Stray light:	<0.05% @ 600 nm; <0.10% @ 435 nm
Corrected linearity:	>99%
Computer	
Operating systems:	Windows XP/7, Mac OS X and Linux w/USB port
Operating software (required):	SpectraSuite Spectroscopy Software Overture Spectroscopy Software

EduPack Kits for Teaching

Complete Kits for Your Classroom or Lab

Our EduPacks give you a convenient tool for bringing the excitement of spectroscopy to your science classroom. Each kit contains the perfect combination of equipment and curricula to help you deliver a more interesting and memorable learning experience for your pupils.

EDU-CHEMPACK

Developed for Chemistry Labs
- USB650-VIS-NIR Red Tide Spectrometer
- SpectraSuite Spectroscopy Operating Software
- Applications in Spectroscopy Curricula on CD or Booklet

Item Code: EDU-CHEMPACK

EDU-CHEMPACK-UV

Developed for Chemistry Labs
- USB650-UV-VIS Red Tide Spectrometer
- SpectraSuite Spectroscopy Operating Software
- Applications in Spectroscopy Curricula on CD or Booklet

Item Code: EDU-CHEMPACK-UV

EDU-PHYSPACK

Developed for Physics Labs
- USB650 Red Tide Spectrometer
- P400-2-VIS-NIR Fiber
- SpectraSuite Spectroscopy Operating Software
- Applications in Spectroscopy Curricula on CD or Booklet

Item Code: EDU-PHYSPACK

EDU-PCPACK

Developed for Chemistry and Physics Labs
- USB650-VIS-NIR Red Tide Spectrometer
- Optical Fiber
- SpectraSuite Spectroscopy Operating Software
- Applications in Spectroscopy Curricula on CD or Booklet

Item Code: EDU-PCPACK

Beer's Law

Beer's law says that absorbance of a molecule or solution is: $A_\lambda = bc/\varepsilon_\lambda$

Beer's Law follows that: A_λ is the absorbance, **ε** is the absorptivity (mole per cm), **b** is the pathlength (in centimeters) and **c** is the concentration (molar). Absorbance is linearly proportional to the thickness of the sample, the concentration of the absorbing medium and the absorptivity, which is a measure of a given molecule's ability to absorb light.

Educational Accessories

Round Out Your Lab Right

Transmission Dip Probes

Our Transmission Dip Probes are perfect for absorbance and transmission measurements and are especially useful for embedding into process streams for in situ, real-time monitoring. More on page 143.

Item Code	Description
T300-RT-UV-VIS	Transmission Dip Probe with 300 µm diameter UV/SR optical fiber (200-1100 nm) in 6.35 mm diameter ferrule
T300-RT-VIS-NIR	Transmission Dip Probe with 300 µm diameter VIS-NIR optical fiber (400-2500 nm) in 6.35 mm diameter ferrule
T200-RT-VIS-NIR	Transmission Dip Probe with 200 µm diameter VIS-NIR optical fiber (400-2500 nm) in 6.35 mm diameter ferrule
RT-2MM	2 mm pathlength tip for T200-RT and T300-RT Transmission Probes
RT-5MM	5 mm pathlength tip for T200-RT and T300-RT Transmission Probes
RT-10MM	10 mm pathlength tip for T200-RT and T300-RT Transmission Probes

Miniature VIS-NIR Source

This compact, low-voltage tungsten halogen light source (400-2500 nm) with built-in 1-cm cuvette holder has a solid alloy housing that acts as a heat sink and in-line fiber ports for absorbance and fluorescence measurements. The unit has a very small footprint – 95 mm x 50 mm – and weighs just 250 g, making it attractive for lab environments where space is at a premium. The source is optimized for use with 50 µm SMA 905-terminated optical fibers. Also included is a universal power supply with multi-plug adapter and an Allen key for simple field replacement of the bulb.

Disposable Cuvettes

Our plastic CVD-UV cuvettes are for 220-900 nm applications while our CVD-VIS cuvettes handle 350-900 applications. Both types have a 1-cm pathlength and are perfect for use with Ocean Optics educational spectrometers and, since they are disposable, no cleaning is required.

Item Code: CVD-UV1S
CVD-VIS1S

Spectral Software Made Easy

Overture is the free, Windows-based software that is perfect for new users, educators and those who need basic spectroscopy functions without the added frills. Overture performs the basics such as absorbance, transmission and emission for 32-bit and 64-bit Windows systems (XP, Vista and Windows 7). Download your copy at **http://www.oceanoptics.com/Products/overture.asp.**

Curricula

Flexible, Low-Cost, Ideal for Education

Bringing the excitement of spectroscopy to your classroom or teaching lab has never been easier. With curricula from the Education Division of Ocean Optics, you have the ideal tools for teaching and lesson-building.

An Introduction to the Spectroscopy Lab	
EDU-SPEC-BOOK	Printed version of *An Introduction to the Spectroscopy Lab*
EDU-SPEC-BOOK-S	Printed version of *An Introduction to the Spectroscopy Lab* when purchased with a spectrometer
EDU-SPEC-CD	CD version of *An Introduction to the Spectroscopy Lab* (PDF file format) and includes how-to video for making basic measurements
EDU-SPEC-CD-S	CD version of *An Introduction to the Spectroscopy Lab* (PDF file format) and includes how-to video for making basic measurements; when purchased with a spectrometer
EDU-SPEC-D	Online version of *An Introduction to the Spectroscopy Lab* in PDF file format.

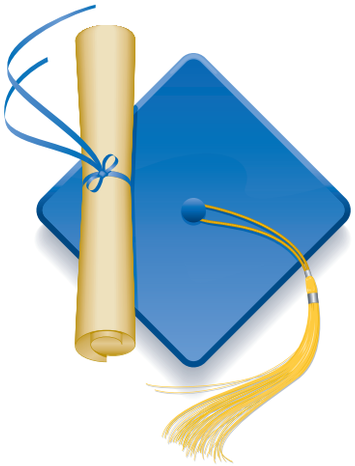
Spectroscopy 101 Workshop Manual - Biology and Life Sciences	
EDU-SPEC-B-BIO	Printed version of *Spectroscopy 101 Workshop Manual Using Ocean Optics Spectrometers*
EDU-SPEC-B-S-BI	Printed version of *Spectroscopy 101 Workshop Manual Using Ocean Optics Spectrometers* when purchased with a spectrometer
EDU-SPEC-CD-B	CD version of *Spectroscopy 101 Workshop Manual Using Ocean Optics Spectrometers* (PDF file format) and includes how-to video
EDU-SPEC-CD-S-B	CD version of Spectroscopy *101 Workshop Manual Using Ocean Optics Spectrometers* (PDF file format); when purchased with a spectrometer
EDU-SPEC-D-BIO	Online version of *Spectroscopy 101 Workshop Manual Using Ocean Optics Spectrometers*

Applications in Spectroscopy	
EDU-SPEC-B-APP	Printed version of *Applications in Spectroscopy*
EDU-SPEC-B-S-AP	Printed version of *Applications in Spectroscopy* when purchased with a spectrometer
EDU-SPEC-CD-AP	CD version of *Applications in Spectroscopy* (PDF file format) and includes how-to video for making basic measurements
EDU-SPEC-CD-S-AP	CD version of *Applications in Spectroscopy* (PDF file format); when purchased with a spectrometer
EDU-SPEC-D-APP	Online version of *Applications in Spectroscopy* (PDF file format)

Spectroscopy 101 Workshop Manual - SpectraSuite/Vernier Version	
EDU-SPEC-B-V	Printed version of *Spectroscopy 101 Workshop Manual Using Ocean Optics Spectrometers*
EDU-SPEC-B-S-V	Printed version of *Spectroscopy 101 Workshop Manual Using Ocean Optics Spectrometers* when purchased with a spectrometer
EDU-SPEC-CD-V	CD version of *Spectroscopy 101 Workshop Manual Using Ocean Optics Spectrometers* (PDF file format) and includes how-to video
EDU-SPEC-CD-S-V	CD version of Spectroscopy *101 Workshop Manual Using Ocean Optics Spectrometers* (PDF file format); when purchased with a spectrometer
EDU-SPEC-D-V	Online version of *Spectroscopy 101 Workshop Manual Using Ocean Optics Spectrometers*

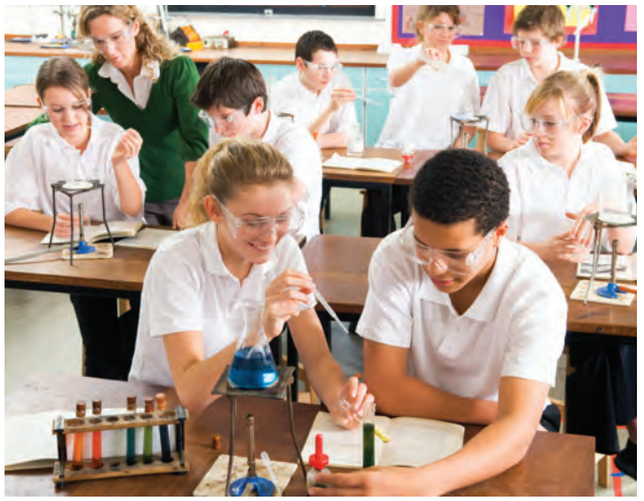
Educational Grant Program

Resources Promoting Spectroscopy in Curricula and Research



innovations in educational spectroscopy

The Innovations in Educational Spectroscopy Grant Program from Ocean Optics provides resources to public and private teaching institutions. The program strives to promote the use of spectroscopy as a general-purpose, broad-based measurement tool and to enable the use of modern instrumentation and technology in science and engineering curricula.



In the program's history, Ocean Optics has awarded several million dollars in funding to high schools and universities for a variety of miniature spectroscopy applications:

- Measuring the photoluminescence of polymers
- Detecting emission lines for various gas discharge tubes
- Recording absorption lines from interstellar phenomena
- Studying physiological characteristics of plants

Ocean Optics offers several grant funding options:

Program A: Funding toward proposals for extramural funds for purchasing science equipment

Ocean Optics offers funding in support of proposals to federal, state or private institutions for the advancement of research utilizing Ocean Optics products. Program A covers the customer who applies for funding from an institution such as NSF, NIH or similar body and needs to demonstrate that they have received an educational grant discount from Ocean Optics. Most awards represent a discount of approximately 5% of the order amount.

Program B: Funding for purchasing science equipment to develop science and engineering curricula

We offer educational discounts toward the purchase of Ocean Optics products to be used expressly for developing new science and engineering curricula. Funding levels will vary according to the product, but typically start at 5%. Higher percentage awards are available for grantees that develop curricula, experiments and related material and provide these materials to Ocean Optics for posting at our website and in other media. This provides other educators with free and unrestricted access to the information. Awards will be granted based on the strength of the applicant's technical proposal and the originality of the proposed curricula.

Grant Application Guidelines

All grant applicants must complete an Educational Grant Application. Applications are available at www.oceanoptics.com/corporate/grantapplication.pdf.

LIBS and Raman

Laser Based Spectroscopy

Laser Induced Breakdown Spectroscopy (LIBS) systems from Ocean Optics can help you analyze solids, liquids and gases with rapid results and little damage to your sample. Use our LIBS lineup for materials sorting, elemental analysis, elemental ratio monitoring, quality assurance, process control and more.

Raman spectroscopy is quickly becoming one of the preferred chemical identification techniques across a broad range of application areas. Ocean Optics provides modular probe- and cuvette-driven Raman spectroscopy along with a host of accessories and software.

Tip

To convert a spectrum into Raman shifts, convert the excitation (laser) wavelength, λ_{EX} and each pixel wavelength, λ_i, into wavenumbers: $Y = 10^7 / \lambda$, where Y is the value in wavenumbers (cm^{-1}). Once you have calculated both Y_{EX} and Y_i, simply subtract to get Raman shifts: $RS_i = Y_{EX} - Y_i$

Laser Induced Breakdown Spectroscopy

Reliable, Repeatable Identification and Analysis

LIBS technology is a powerful tool for rapid, real-time elemental analysis. With LIBS, there is virtually no sample preparation, excellent portability, real-time results and sensitivity down to parts-per-million and picogram levels.

With recent advances in broadband spectral detectors, LIBS is capable of detection and identification of a comprehensive range of metal and gemological materials, as well as biological and chemical agents, hazardous materials and more.

The application areas of LIBS are growing dramatically. From environmental monitoring to materials analysis and from forensics to pharmaceuticals, LIBS fits the bill when simple and straightforward techniques are required.

LIBS Benefits

- No sample preparation
- Very small samples required
- Trace element detection possible
- Modular and turnkey options available

LIBS Comparison to Other Technologies

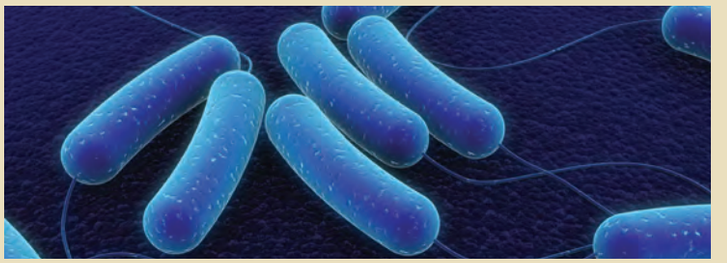
Parameter	LIBS	SEM/EDS	XRF	LA-ICP-MS	EPMA
Sample depth:	~50-100 µm	~5 µm	~100 µm	~80 µm	<1 µm
Sensitivity:	10-50 ppm	1000 ppm	100 ppm	<1 ppm	100 ppm
Precision:	Fair-good	Poor	Fair-good	Excellent	Fair
Accuracy:	Semi-quantitative	Qualitative	Semi-qualitative	Quantitative	Semi-quantitative
Analysis time:	Fast	Slow	Very slow	Slow	Slow
Sample consumption:	Almost non-destructive	Non-destructive	Non-destructive	Almost non-destructive	Non-destructive
Complexity:	Easy to use	Easy to use	Complicated	Complicated	Complicated
Discrimination:	Good	Poor	Good	Excellent	Fair

Application Note

LIBS for Defense

In an earlier LIBS application, closely related spores of the genus Bacillus were deposited on silver membrane filters for analysis using broadband Laser Induced Breakdown Spectroscopy. The observed spectral differences among the spores – Bacillus subtilis, Geobacillus stearothermophilus and Bacillus pumilus – provide evidence of the power of LIBS in resolving complex biological samples.

The presence of the spores' unique spectral lines, as well as different combinations of spectral lines, provide many opportunities for discrimination. While most of the unique peaks occurred in the G. stearothermophilus spectrum, spectral differences were observed in the spectra for all spores. Spore characteristics, such as surface profile and coat mineralization, may account for these differences.



The results reported for the Bacillus spores, along with others obtained for biological molecules (including nucleic acids and proteins), provide exciting evidence of the discriminating capability of Ocean Optics' LIBS systems.

The Insight LIBS System

High-Sensitivity Microanalysis

The Insight™ LIBS System is designed for the microanalysis of solid materials. The standard spectrometer within the Insight provides a broad spectral range (190-960 nm) and better than 0.1 nm resolution throughout the system.

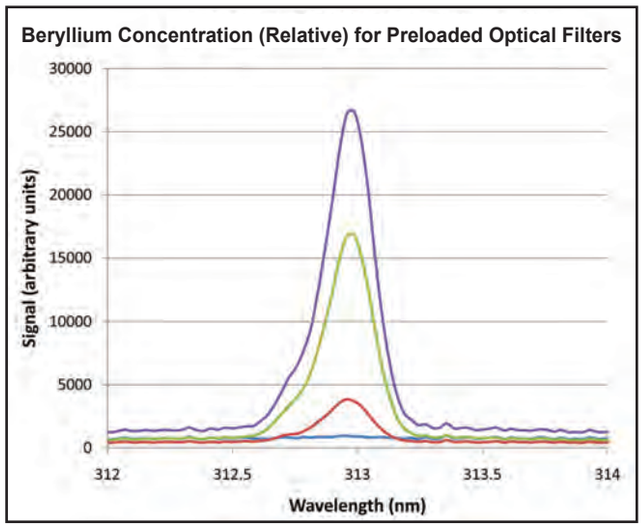
Major and minor elements can be resolved and the 30,000+ points in a typical spectrum can be expanded to reveal lines separated by less than 0.2 nm in the UV range. The band of Ocean Optics spectrometers used in the Insight has excellent sensitivity to low-light levels enabling the spectral detection of trace elements.

LIBS-INSIGHT-150MJ

High-end LIBS platform with 150 mJ laser, video, computer controlled XYZ, Chromium operating software and add LIBS quantitative software packages

LIBS-INSIGHT-50MJ

High-end LIBS platform with 50 mJ laser, video, computer controlled XYZ, Chromium operating software and add LIBS quantitative software packages



Build to High-Fidelity Measurements

- Rugged Nd:YAG laser, sensitive spectrometer
- Built-in timing control circuit synchronizes laser and spectrometer
- Confocal video and laser planes ensure measurement repeatability
- Overall timing jitter with respect to external synch signal <= 10 ns
- Purged sample chamber
- Rotometer-regulated flexible "assist" gas nozzle for N2, He or Ar
- Class 1 safety enclosure

Configurable

- Adjustable, coaxial lighting of sample
- Variable laser energy
- Variable spectrometer delay
- Software-selectable spot size from sub-5 µm to 2 mm

Powerful, Easy to Use

- Sample interrogation and analysis software tools
- Laser energy measurement and display
- User-selectable repetition rate
- User-selectable spot size of the laser beam via software control
- Single-shot, burst and continuous firing modes
- Color video microscope displays live sample images
- Computer connection: USB 2.0, OS: Windows XP or Windows 7
- Computer-controlled x/y stage for sample holding

Software That Brings it All Together

The addLIBS™ Software included with Insight is designed to make plasma emission spectroscopy analysis easy. addLIBS allows you to explore spectra using partial NIST or in-house spectral libraries, annotate spectra, develop calibration methods using known samples and apply calibrations manually or automatically to unknown spectra.

Once a method is developed, it can be repeatedly applied without further analysis or it can be modified at will.

For more complicated data analysis, chemometric methods such as PLS are being implemented, and data can also be exported to standard analysis software such as GRAMS® or Excel®. Spectra are automatically ported from the instrument control software to addLIBS™ as they are acquired.

Additional Software

Our SpecLine Software helps make the evaluation of spectra and identifying atomic lines simple and fast.

LIBS2500plus System

Qualitative Measurements in Real-Time

The small-footprint LIBS2500plus system is a more modular approach to Laser Induced Breakdown Spectroscopy. Built around our popular HR2000+ optical bench and electronics, the LIBS2500plus delivers superior functionality in a completely enclosed system.

While traditional LIBS detection systems have a small spectral range, the LIBS2500plus provides broadband spectral analysis and – because of its noninvasive performance – it allows you to perform real-time in situ measurements within hostile industrial, chemical and biochemical environments. The LIBS2500plus has the equivalent of seven HR2000+ spectrometers combined and can be configured in various setups rather easily.

The LIBS2500plus is easily interfaced to your PC or notebook computer via USB and is compatible with Windows operating systems.

Applications

- Environmental monitoring (soil contamination, particulates)
- Materials analysis (metals, plastics)
- Forensics and biomedical studies (teeth, bones)
- Military and safety applications (explosive particles, chemical and biological agents)
- Art restoration and conservation (pigments, precious metals)

Software

OOILIBS Application Software operates the LIBS2500plus as well as its firing laser. With OOILIBS, you have spectral saving and data-logging capabilities as well as material identification.

OOILIBSPLUS LIBS2500plus Windows-based Software

Specifications	
Spectrometer range:	200-980 nm
Resolution:	0.1 nm (FWHM)/ 0.05 peak
Detection:	CCDs with a combined 14,336 pixels
Frame rate:	500 Hz capability, computer-controlled
Integration time:	1 ms; variable in free-run mode
Trigger delay:	-121 µs to +135 µs in 500 ns steps, user-configured
Trigger jitter:	~20 ns
Trigger level:	TTL not to exceed 5.5 V
Interface:	USB 1.1 or USB 2.0
Operating systems:	Windows XP on desktop or notebook PCs
Software:	OOILIBS
Power requirement:	5 volts @ <1 amp, power supply included
Input optical fiber:	Sampling probe containing 7 fibers, 2 meters long (other lengths available) with 74-UV collimating lens and a sampling lens
Dimensions:	334 mm x 150 mm x 140 mm (spectrometer system only)
Weight:	6.36 kg (14 lb.)

LIBS Spectrometer Channels	
LIBS-CH-A	200-305 nm wavelength range
LIBS-CH-B	295-400 nm wavelength range
LIBS-CH-C	390-525 nm wavelength range
LIBS-CH-D	520-635 nm wavelength range
LIBS-CH-E	625-735 nm wavelength range
LIBS-CH-F	725-820 nm wavelength range
LIBS-CH-G	800-980 nm wavelength range

Systems

Item	Description	Fiber Bundle
LIBS2500-7PLUS	7-channel spectrometer system, includes channels A-G	LIBS-BUN-7
LIBS2500-6PLUS	6-channel spectrometer system, choose 6 channels from A-G	LIBS-BUN-6
LIBS2500-5PLUS	5-channel spectrometer system, choose 5 channels from A-G	LIBS-BUN-5
LIBS2500-4PLUS	4-channel spectrometer system, choose 4 channels from A-G	LIBS-BUN-4
LIBS2500-3PLUS	3-channel spectrometer system, choose 3 channels from A-G	LIBS-BUN-3
LIBS2500-2PLUS	2-channel spectrometer system, choose 2 channels from A-G	BIF600-2-UV/VIS
LIBS2500-1PLUS	1-channel spectrometer system, choose 1 channel from A-G	P600-2-UV/VIS
LIBS2500-1+UPG	1-channel HR2000+ upgrade	LIBS Controller Cables

LIBS2500plus System
The Modular Solution

Spectrometer

The LIBS2500plus is built around our HR2000+ high-resolution miniature spectrometer. This small-footprint spectrometer delivers excellent optical resolution and has a detector range of 200-1100 nm.

The HR2000+ boasts an impressive data transfer rate of a full scan to memory every 1-2 ms and an integration time of 1 ms to 65 seconds. For more information on the performance of the HR2000+, see page 30.

Laser Power Options

Because power requirements vary by sample type, we offer two laser power options from a leading laser supplier, Big Sky Laser Technologies. For most applications we employ a Q-switched 1064 nm Nd:YAG laser, and for maximum versatility, we recommend a 200 mJ laser with attenuator to adjust the laser power according to the sample matrix.

Item Code	Description	Best Use
LIBS-LAS200ICE-450-20HZ	LIBS Laser, 200 mJ Ultra Laser CFRB66101B1-072	Glass and high OH content materials
LIBS-LASER	LIBS Laser, 50 mJ Ultra Laser ul130C11, 20 Hz	Metal and thin film samples

Sample Chamber

Our LIBS-SC Sample Chamber is designed to function safely and provides clear view of the sample. The LIBS-SC features an eyewear-safe enclosure and a safety-interlock that prevents the laser from firing when the door is ajar. It houses a manually controlled x-y stage and provides illumination for the optional LIBS-IM-USB Imaging Module.

LIBS-SC	LIBS-SC-050	LIBS-SC-200
LIBS Sample Chamber utilized when Imaging Module is ordered	LIBS Sample Chamber utilized when 50 mJ laser is ordered - no Imaging Module	LIBS Sample Chamber utilized when 200 mJ laser is ordered - no Imaging Module

Imaging Module

Our LIBS-IM-USB Imaging Module attaches directly to the LIBS-SC Sample Chamber and enables you to magnify a sample image and establish your precise laser ablation target. The imaging module is an ideal option for forensic applications, semiconductor analysis, gemology, metallurgy and more. The LIBS-IM-USB requires no external power supply when PC-powered over USB.

LIBS-IM-USB	LIBS-IM-USB-050	LIBS-IM-USB-200
LIBS Imaging Module, color, USB connection	LIBS Color Imaging Module for use when LIBS-LASER is incorporated	LIBS Color Imaging Module for use when LIBS-LAS-200ICE-450-20HZ is incorporated

Fiber Bundles	
LIBS-BUN-3	Fiber Bundle for 3-Channel LIBS2500plus
LIBS-BUN-4	Fiber Bundle for 4-Channel LIBS2500plus
LIBS-BUN-5	Fiber Bundle for 5-Channel LIBS2500plus
LIBS-BUN-6	Fiber Bundle for 6-Channel LIBS2500plus
LIBS-BUN-7	Fiber Bundle for 7-Channel LIBS2500plus
LIBS-BUN-8	Fiber Bundle for 8-Channel LIBS2500plus
LIBS-COLL	LIBS Collimator

Raman Spectroscopy

Reliable, Non-Destructive Measurement

Ocean Optics offers a complete range of fully integrated Raman systems for handheld, laboratory and educational applications. Most of our Raman systems include a high-sensitivity spectrometer, a 532 nm or 785 nm laser, operating software and sampling accessories for probe- or cuvette-based analysis.

Raman analysis is nondestructive, requires very limited sample preparation, and allows for sample volumes in the microliter range. In fact, Raman techniques can be used to acquire data through vial walls, pill pack windows and bags – packaging forms that are frequently used in the biomedical and pharmaceutical industries.

Our Raman spectrometers are especially useful for identifying spectral features, or fingerprints, that are often distinct and clearly separated.

We offer off-the-shelf and modular approaches, sampling accessories for a variety of environments, cuvettes for solution measurements and a full range of probes for measuring solids and liquids.

Model	PeakSeeker 785	PeakSeeker Pro 785E	PeakSeeker Pro 785	PeakSeeker Pro 532	PinPointer	QE65000 for Raman
Laser Wavelength	785 nm	785 nm	785 nm	532 nm	785 nm	532 or 785 nm
System	Diode Laser Spectrometer Probe Laptop PC Software	Diode Laser Spectrometer Probe Laptop PC Software	Diode Laser Spectrometer Probe Laptop PC Software	Diode Laser Spectrometer Probe Laptop PC Software	Diode Laser Spectrometer Probe Software Embedded Computer with LCD Display	Choose from Laser Probes Sample Holders Configure QE65000
Applications	Teaching labs, general purpose, moderate resolution Raman applications	Lab, industrial (pharmaceuticals), forensics	Lab, industrial (pharmaceuticals), forensics	Lab, industrial, security	Handheld, field-portable for on-site QC, forensics and security/inspection	General-purpose lab setups (aqueous solutions, powders, gels, tablets and surface media)
Item Code:	RAM-PKR-785	RAM-PRO-785E	RAM-PRO-785	RAM-PRO-532	RAM-PINPTR-785	QE65000, QE65000-RAMAN

Technical Tip

Raman spectroscopy offers a number of benefits for testing and characterization. Like regular IR spectroscopy, it is rapid and non-destructive. Raman can capture data from a sample contained in plastic or other materials that are optically transparent to the wavelengths of interest.

Unlike IR spectroscopy, which falls spectrally within the water window, Raman spectroscopy can be used to capture data on aqueous samples or samples with high moisture content. And, with the emergence of economical diode lasers in the NIR spectral region, Raman is a more attractive option for a wider range of applications than ever before.

So, how to select between a Raman system with a 785 nm laser and one with a 532 nm laser? The 785 nm version is designed to minimize the fluorescence signal, making it useful for chemical identification and fingerprinting. What's more, the 785 nm version generates well defined peaks for use in chemometric analysis and can provide semi-quantitative data. Other wavelength options are available.

For applications where C-OH structural information is important, the 532 nm version is your best option. Such measurements are typical of biological and pharmaceutical sample analysis, where researchers study characteristics of active ingredients, binders, fillers and excipients.

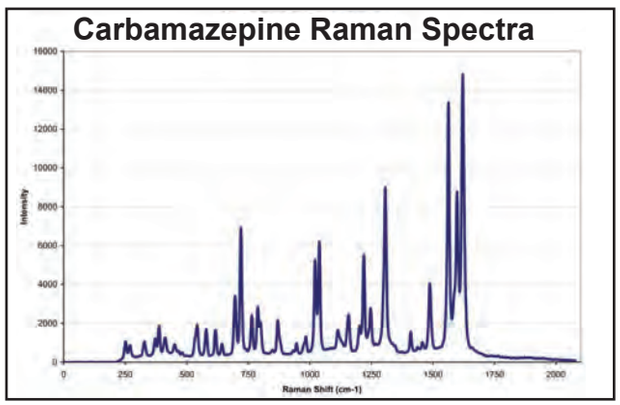
Benchtop Raman Systems

Meet the PeakSeeker Pro Family

The PeakSeeker Pro™ family of benchtop Raman systems is accurate, cost-effective and easy to use.

These remarkable instruments use TE-cooled, high-efficiency CCD detector arrays and can be configured with either a 532 nm or 785 nm wavelength excitation laser.

PeakSeeker Pro is extremely versatile for measuring multiple sample types and comes with sampling accessories, software and USB connectivity that enables true plug and play operation.



Versatility

You can sample solids, liquids and powders -- even when samples are inside transparent packaging and containers such as bags, bottles and vials.

Sensitivity

The PeakSeeker Pro fully meets the stringent requirements of USP Monograph 1120 for resolution, sensitivity and stability. The detector array is cooled to -20 ºC. Deep blocking laser rejection filters obstruct Rayleigh scatter and isolate Raman scatter for valuable molecular analysis.

Portability

The spectrometer is portable and lightweight. Rugged construction and ergonomic design allow it to be carried just about anywhere and set up for immediate use.

Simplicity

Each PeakSeeker Pro system includes a notebook computer pre-loaded with RSIQ™ software for true point-and-click operation. Sample spectra are acquired within seconds.

Specifications	RAM-PKR-785	RAM-PRO-785	RAM-PRO-785E	RAM-PRO-532
Laser wavelength:	785 nm	785 nm	785 nm	532 nm
Laser power:	5-300 mW	5-300 mW	5-300 mW	100 mW
Spectral range, Raman shift:	200-3000 cm-1	200-2000 cm-1	200-3900 cm-1	200-4500 cm-1
Resolution:	~12 cm-1	6 cm-1	10 cm-1	10 cm-1
Signal to noise ratio:	250:1 (at full signal)	1000:1 (at full signal)	1000:1 (at full signal)	1000:1 (at full signal)
Wavelength stability:	<1 cm-1 in 12 hours	<1 cm-1 in 12 hours	<1 cm-1 in 12 hours	<1 cm-1 in 12 hours
Photometric stability:	<4% in 12 hours	<1% in 12 hours	<1% in 12 hours	<1% in 12 hours
Optics:	0.22 NA, sample spot size 0.1-.03 mm	0.22 NA, sample spot size 0.1-.03 mm	0.22 NA, sample spot size 0.1-.03 mm	0.22 NA, sample spot size 0.1-.03 mm
Power input:	15 VDC from power adapter input = 11/240 VAC @ 50/60 Hz	15 VDC from power adapter input = 11/240 VAC @ 50/60 Hz	15 VDC from power adapter input = 11/240 VAC @ 50/60 Hz	15 VDC from power adapter input = 11/240 VAC @ 50/60 Hz
Operating temperature:	-25 ºC-+45 ºC	-25 ºC-+45 ºC	-25 ºC-+45 ºC	-25 ºC-+45 ºC
Dimensions (cm):	36 x 29 x 11	36 x 29 x 11	36 x 29 x 11	36 x 29 x 11
Weight (kg):	3.6	3.6	3.6	3.6

QE65000-Raman

Scientific-Grade Spectrometer for Raman

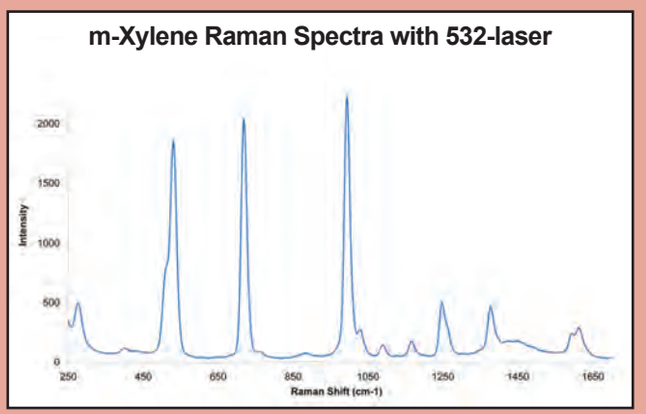
Our QE65000-Raman Spectrometer is a scientific-grade, preconfigured combination of detector, optical bench and electronics that provides you a remarkably sensitive system for demanding low-light level Raman applications.

The performance of the QE65000-Raman Spectrometer has been enhanced to provide lower stray light, improved efficiency in the UV and Shortwave NIR and better unit-to-unit reproducibility. The QE65000-Raman also delivers up to 90% quantum efficiency with high signal-to-noise and rapid signal processing speed. Also available are custom-configured QE65000 systems for Raman that take advantage of a broader range of gratings and accessories.

Item Code: QE65000-RAMAN

Physical	
Dimensions:	182 mm x 110 mm x 47 mm
Weight:	1.18 kg (without power supply)
Detector:	Hamamatsu S7031-1006
Detector range:	200-1100 nm
Pixel size:	24 µm²
Pixel well depth:	300,000 electrons/well, 1.5 m elec/column
Sensitivity:	22 electrons/count all λ; 26 photons/count @ 250 nm
Sensitivity:	~0.065 counts / e-
Quantum efficiency:	90% peak; 65% at 250 nm
Optical Bench	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input and output
Entrance aperture:	50 µm wide slit
HC6 grating:	Provides 123-170 nm range (bandwidth)
Detector collection lens option:	None
Collimating and focusing mirrors:	Standard only
UV enhanced window:	No
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Spectroscopic	
Wavelength range:	780 - 1100 nm (grating dependent)
Optical resolution:	~6-19 cm-1 (depending on slit)
Signal-to-noise ratio:	1000:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	3 RMS counts
Dynamic range:	7.5 x 10^9 (system), 25000:1 for a single acquisition
Integration time:	8 ms to 15 minutes
Stray light:	<0.08% at 600 nm; 0.4% at 435 nm
Corrected linearity:	>99.8%
Temperature and Thermoelectric (TE) Cooling	
Temperature limits:	0 ºC to 50 ºC; no condensation
Set point:	Software controlled; lowest set point is 40 ºC below ambient
Stability	+/-0.1 ºC of set temperature in <2 minutes

Raman spectroscopy is easily achieved with the QE65000-Raman setup. This powerful quantitative and qualitative tool is ideal for a wide range of analytical applications, both in the laboratory and in the field.



Examples of QE65000 Configurations for Raman

Sample Config.	Spectral Range	Excitation Source	Grating p. 46	Slit p. 42	Resolution (approx.)
1	150-4000 cm-1	532 nm laser	H6	10 µm	~8 cm-1
2	150-4000 cm-1	532 nm laser	H6	25 µm	~10 cm-1
3	150-7500 cm-1	532 nm laser	H14	10 µm	~16 cm-1
4	150-7500 cm-1	532 nm laser	H14	25 µm	~19 cm-1
5	150-2100 cm-1	785 nm laser	H6	50 µm	~6 cm-1
6	150-2100 cm-1	785 nm laser	H6	100 µm	~8 cm-1
7	150-3950 cm-1	785 nm laser	H14	50 µm	~13 cm-1
8	150-3950 cm-1	785 nm laser	H14	100 µm	~18 cm-1

Multimode Laser
High Power, Spectrum Stabilized

Our Multimode Laser Subsystem (LASER-785-IP-OEM) features high output power with a narrow spectral bandwidth. This unit's stabilized peak wavelength remains locked, regardless of case temperature.

Devices can be spectrally tailored to suit application needs and offer side mode suppression ratios better than 40 dB. This provides an extremely high signal-to-noise performance and makes this source ideal for Raman spectroscopy and pump laser applications.

We integrate this source with our high performance laser drive and temperature control M-Laser-Module for a truly turnkey solution for the laboratory. This module has a digital readout for easy set point adjustment, an independent master power key switch and laser enable switch, a remote interlock and an Emergency Power Off (EPO) button. Additional 785 nm and 532 nm laser options are available.

Specifications	
Dimensions:	110 mm x 89 mm x 53 mm
Weight:	600 g
Noise:	<0.5% RMS
Output fiber:	100 µm @ 0.22 NA
Warm-up:	15 minutes
Temperature:	-10 °C to 40 °C
Stability:	<3% peak-to-peak in 8 hours
Humidity:	5-95% non-condensing
Laser life:	10,000 hours
Power consumption:	3.0 A @ 5 VDC
Power output (CW):	>500 mW
Peak wavelengths:	785 +/- 0.3 nm
Spectral line width:	0.2 nm (typical)
Rise time:	<500 msec
Control:	TTL modulation -- 0 to 100 kHz
Connector:	SMA 905 or FC

Making Raman More Accessible

For decades, Raman spectroscopy was a cumbersome, expensive research tool relegated to laboratories and arcane experiments. But today's economical, compact lasers and detectors make Raman spectroscopy a practical solution for non-destructive chemical identification across a range of new markets, including pharmaceutical processing, forensics and law enforcement and homeland security.

Raman has been considered a high resolution application, but for many identification problems in commercial markets, such laboratory-level resolution is not necessary. A high-performance Raman system will typically achieve resolution of 2 to 4 cm^{-1}. Depending on choice of grating and entrance slit, lower-cost systems like the units in this section can still reach resolution of 6 to 11 cm^{-1}. In other words, it is possible to obtain a system with resolution only 2-3x that of a laboratory instrument, for a cost that is an order of magnitude lower.

Our Raman systems are robust enough to operate in a range of environments. Thermal drift in the excitation wavelength may compromise SNR over time, but regular yearly or monthly calibration will catch this. The Raman signature will still be emitted at the correct wavelengths. Likewise, possible variations in power stability over time will affect intensity but not the shape or positioning of the peak.

Handheld Raman Systems

Easy, Fast and Accurate

The PinPointer™ delivers a full-featured Raman spectroscopy system in a remarkably affordable, true handheld format.

The lightweight unit is controlled by a pocket-sized computer and features easy-to-use RSIQ software for fast point-and-click operation.

Many substances emit a characteristic light when illuminated with a laser, the so-called Raman effect, that uniquely identifies molecular structure.

With a touch of a button, the PinPointer collects this emitted light scattered from a targeted object. Optional RSIQ-QUAL software will search thousands of stored reference material spectra to identify unknown substances. Within seconds, the detected chemicals are identified and displayed to the system user.

Affordable, Compact, High Performance

The PinPointer provides the same performance as other handheld Raman spectrometers aimed at homeland security or on-site chemical identification but costs thousands less.

Extensive Spectral Library

The RSIQ-QUAL software database covers most organic and inorganic substances encountered in the field by law enforcement, first responders and Homeland Security personnel. A specialized chemical database can be added upon request. Users can also create their own custom spectral libraries.

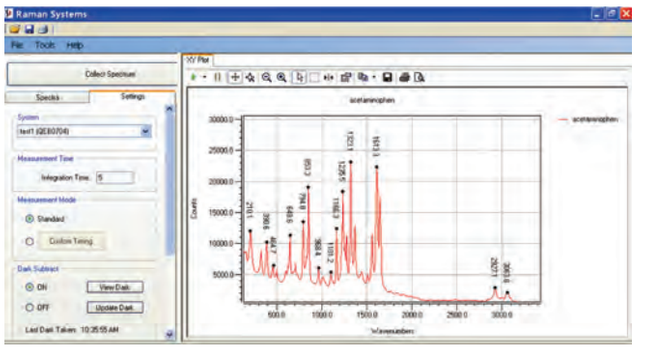
Substance Identification of Packaged Materials

Solid, powder or liquid samples can be analyzed while still contained in plastic bags or glass or plastic bottles.

Specifications	
Excitation wavelength:	785 nm
Laser power:	5-300 mW
Raman spectral range:	200-3000 cm-1
Spectral resolution:	~12 cm-1
Signal-to-noise ratio:	250:1 (at full signal)
Raman shift stability:	< 1 cm-1 in 12 hours
Photometric stability:	< 4% in 12 hours
Collection optics:	NA = 0.28, working distance = 5 mm spot size < 0.2 mm
Power:	Rechargeable battery, >4 hr. charge
Size:	216 mm x 109 mm x 63.5 mm (8.5” x 4.3” x 2.5”)
Weight:	1.4 kg. (3 lb.)
Operating temperature:	-25 °C-70 °C

RSIQ Software

PinPointer systems come with RSIQ software - a powerful database package with a simple interface and user-friendly operation. Its one-touch data acquisition and easy instrument verification make it the perfect companion for your Raman analysis. RSIQ features a comprehensive database of most organic and inorganic substances encountered in the field by law enforcement, first responders and Homeland Security personnel and you can add specialized chemical databases, or create your own, to suit your environment. The software is Windows compatible.



Add-On Modules for RSIQ (sold separately)

Item Code: RAM-RSIQ-CFR
Supports compliance with 21 CFR Part 11 “Electronic Records and Signatures”

Item Code: RAM-RSIQ-QUAL
Manages and searches user-created or purchased Raman spectral libraries

Item Code: RAM-RSIQ-QUANT
Multivariate analysis tool for calibration of PinPointer and PeakSeeker systems

Item Code: RAM-RSI-LIB
Database of Raman spectra; requires RAM-RSIQ-QUAL add-on

Raman Probes

Fiber Optic Probes for Raman Spectroscopy

We offer a number of fiber optic probes that are built specifically for Raman spectroscopy. The RIP-Series probes from InPhotonics provide optical filtering of the Rayleigh line and high-signal collection in a compact, rugged design. Compatible with Ocean Optics Raman systems, these probes are suitable for laboratory, industrial and environmental applications and are available for several excitation wavelengths.

RIP-RPS

RIP-RPB

General Purpose

Item Code	Description	Dimensions
RIP-785-0.26	Raman Probe for 785 nm laser, steel jacketed fibers	107 x 38 x 12.7 mm, 0.26 m steel-jacketed fiber
RIP-RPB-532	Laboratory probe for use with lasers up to 3 nm from specified operating wavelength	107 x 38 x 12.7 mm, 9.5 OD x 38 mm extension, 1.5-meter fiber
RIP-RPB-532-FC	Raman coupled fiber probe for 532 nm with FC connector	107 x 380 x 9.57 mm, 1.5-meter fiber
RIP-RPB-785-FC	Raman coupled fiber probe for 785 nm with FC connector 7.5 mm working distance	107 x 380 x 9.57 mm, 1.5-meter fiber
RIP-RPB-785-SS	Raman coupled fiber probe for 785 nm with SMA connector 7.5 mm working distance	107 x 380 x 9.57 mm, 1.5-meter fiber
RIP-RPS-532	Stainless-steel focused probe 12.7 mm diameter	12.7 OD x 108 mm, 5-meter fiber
RIP-RPS-532-IP	Stainless-steel focused probe for 532 nm excitation wavelength setups	12.7 OD x 108 mm, 5-meter fiber
RIP-RPS-785	Stainless-steel focused probe for 785 nm excitation wavelength setups	12.7 OD x 108 mm, 5-meter fiber
RPB-785-0.6	Raman coupled probe for 785 nm, steel jacketed fibers	107 x 38 x 12.7 mm, 0.6 m steel-jacketed fiber

Immersion Probes

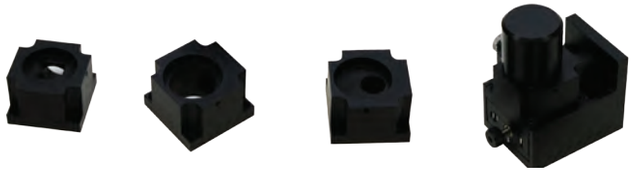
Item Code	Description	Dimensions
RIP-RP2-532	Stainless-steel immersion probe is immersible up to 200 °C and has adjustable working distance for 532 nm excitation wavelength setups	15.87 OD x 230 mm; 5-meter fiber
RIP-RP2-785	Stainless-steel immersion probe is immersible up to 200 °C and has adjustable working distance for 785 nm excitation wavelength setups	15.87 OD x 230 mm; 5-meter fiber
RIP-RPR-H-532	Hastelloy C immersion probe for use in process control applications up to 200 °C and 1500 psi; comes with sapphire window and has adjustable working distance for 532 nm excitation wavelength setups	15.87 OD x 230 mm; 5-meter fiber
RIP-RPR-H-785	Hastelloy C immersion probe for use in process control applications up to 200 °C and 1500 psi; comes with sapphire window and has adjustable working distance for 785 nm excitation wavelength setups	15.87 OD x 230 mm; 5-meter fiber
RIP-RPR-SS-532	Stainless-steel immersion probe for use in process control applications up to 200 °C and 1500 psi; sapphire window with adjustable working distance for 532 nm excitation wavelength setups	15.87 OD x 230 mm; 5-meter fiber
RIP-RPR-SS-785	Stainless-steel immersion probe for use in process control applications up to 200 °C and 1500 psi; sapphire window with adjustable working distance for 785 nm excitation wavelength setups	15.87 OD x 230 mm; 5-meter fiber

Process Probes

Item Code	Description	Dimensions
RIP-RPP-532	Stainless-steel probe with external optics for process control applications up to 500 °C and 3000 psi; comes with sapphire lens and has short working distance for 532 nm excitation wavelength setups	9.52 OD x 300 mm; 5-meter fiber
RIP-RPP-785	Stainless-steel probe with external optics for process control applications up to 500 °C and 3000 psi; comes with sapphire lens and has short working distance for 785 nm excitation wavelength setups	9.52 OD x 300 mm; 5-meter fiber

Raman Probe Accessories

Item Code	Description
OOA-RAMAN-SH	Raman Sample Holder
RAM-PR-I	Raman Immersion Measurement Tube
RIP-PA-SH	Compact Raman Sample Holder



For more on sample holders, see page 201.

Raman Accessories
RSM Video Raman Microscope

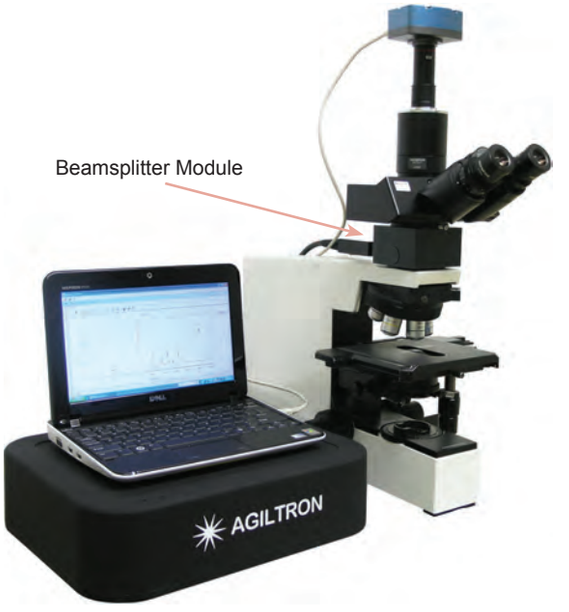
RSM Video Raman Microscope for PeakSeeker 532 Systems
Item Code: RAM-RSM-MIC-532
RSM Video Raman Microscope for PeakSeeker 785 Systems
Item Code: RAM-RSM-MIC-785

The Raman Systems RSM Video Raman Microscope is an upright laboratory microscope that couples to PeakSeeker Raman systems (sold separately). The RSM comes with a reflected light, Brightfield illuminator and a USB color video camera.

The USB color video camera facilitates precise sample positioning of the laser spot from the Raman spectrometer onto a solid sample surface.

Specifications	
Eyepiece:	Wide field 10X (22 mm) binocular
Objectives:	Infinity corrected
Magnification working distance:	4X 25 mm 10X 11 mm 20X 8 mm 50X 1.9 mm
Sample stage:	Dimensions: 190 mm × 150 mm
X-Y Range:	75 mm × 50 mm (manual)
Focusing:	Coaxial coarse and fine adjustment Fine focusing scale 0.002 mm
Illumination:	Brightfield Kohler 12V 30W brightness variable
Camera:	1.3 MP Color CMOS USB 2.0 C-mount 1.8 meter long USB cable 0.5X image reduction lens 0.01 mm line width stage micrometer Software CD

Raman Accessories
MSK Raman Microscope Kit



MSK Raman Microscope Kit for PeakSeeker 532 Systems
Item Code: RAM-MSK-MIC-KIT-532
MSK Raman Microscope Kit for PeakSeeker 785 Systems
Item Code: RAM-MSK-MIC-KIT-785

Turn your lab microscope into a Video Raman Spectroscope with the MSK Kit. The MSK has a Raman beamsplitter module that mounts below the eyepiece assembly and a USB color video camera that mounts onto a port above the eyepiece.

The Raman Beamsplitter Module works with Peak Seeker systems and mates to the external fiber optic probe. The Color Video Camera facilitates precise sample positioning of the laser spot from the Raman spectrometer.

The MSK Raman Microscopy Kit can be used with most modular upright microscopes fitted with reflected light illumination and infinite plan achromat objectives. The kit works with reflected light Kohler illuminators, fiber optic illuminators or a compact white LED Brightfield illuminator specially designed for the MSK (RAM-MSK-LED, sold separately).

Components

Color Video Camera (included with kit):
1.3 MP Color CMOS Camera
USB 2.0
C-mount
1.8-meter USB Cable
0.5X Image Reduction Lens
0.01 mm line width stage Micrometer

Raman Accessories
Sample Holders

The OOA-HOLDER-RFA is a multipurpose sampling fixture that acts as a holder for Raman, fluorescence, absorbance and reflection measurements. Unlike other Raman sample holders, the OOA-HOLDER-RFA can be adjusted for a variety of lab techniques. Here are other notable features:

- Mobile XY-axis stage makes it easier to adjust the focus of your Raman probe
- Holder adjusts to accommodate 6.35 mm (1/4″), 9.5 mm (3/8″) and 12.7 mm (½″) OD probes
- Includes mirror and cuvette plugs to increase signal in absorbance and reflection measurements
- Has 90-degree cross-angle design for fluorescence measurements

The OOA-HOLDER-RFA is compact, lightweight and easy to load and unload. The holder offers other advantages as well: making it easier to block the ambient light with cuvette measurements; protecting against the damage caused by contact between the probe and cuvettes; fixing the probe in place using a simple setscrew; and allowing more freedom in adjusting the focus of the excitation light.

Idem Code: OOA-HOLDER-RFA

OOA-HOLDER-RFA Specifications	
Dimensions:	110 mm x 70 mm x 130 mm LWH (standard); 155 mm x 70 mm x 162 mm (optional)
Material:	Aluminum
Mobile optical stage:	X axis = 10 mm
	Z axis = 12.5 mm
Probe sizes accommodated:	Raman probes = adjustable for 9.5 mm (3/8”) or 12.7 mm (1/2”) OD
	Reflection probes = 6.35 mm (1/4”) OD
Cuvette pathlengths accommodated:	1 cm and 0.1 cm
Cuvette plug dimensions:	15 mm x 5.7 mm x 45 mm for 0.1 cm pathlength cuvette
Mirror plug dimensions:	15 mm x 5.7 mm x 45 mm
Mirror plug wavelength range:	200-2500 nm; options available with better resistance to oxidization and fraying and with higher reflectivity at UV wavelengths

Raman Sample Holders

Our Raman-only sample holder is a handy tool for analyzing liquids (and other specimens) using Raman probes and cuvettes. Its modular design makes it capable of accommodating a variety of cuvettes and vials.

Item Code: OOA-RAMAN-SH

Raman Accessories
The Finishing Touch to Your Setup

Raman Caps

The RAM-MC-L Cap can be used for measurements through the walls of vials, bottles and other containers.

Item Code: RAM-MC-L

Our RAM-MC-S Cap is for direct contact with solids, tablets, powders, liquids and other samples.

Item Code: RAM-MC-S

The RAM-MC-VC is a verification calibration that is loaded with spectroscopic-grade Teflon.

Item Code: RAM-MC-VC

Substrates and Standards

Klarite substrates provide a unique solution for trace-level molecular analysis using Surface Enhanced Raman Spectroscopy (SERS). SERS can help increase the sensitivity of Raman by many orders of magnitude, extending the range of Raman measurements to as low as parts-per-billion levels.

Surface Enhanced Raman Substrates mounted on glass slides (set of 5)

Item Code: RAM-SERS-KLARITE-5

Surface Enhanced Raman Substrates unmounted (set of 5)

Item Code: RAM-SERS-KLARITE-OEM-5

Safety First

We offer laser safety goggles for use with 532 nm and 785 nm lasers.

Item Codes: RAM-GG-532, RAM-GG-785

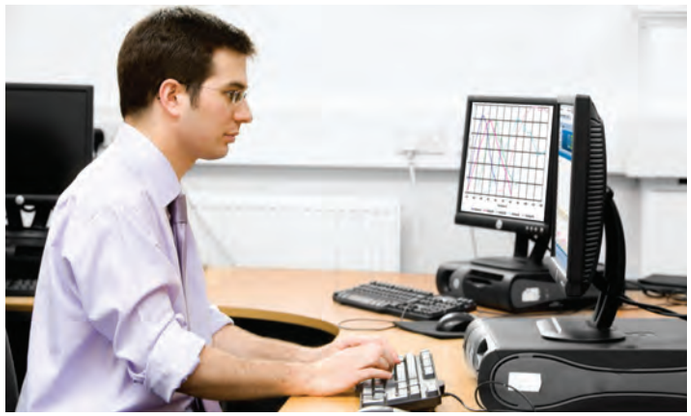
Analyze IQ Software

Accurate Analysis of Spectroscopic Data

Analyze IQ Lab is an analytical chemistry software package designed for use in commercial R&D, forensics labs and academic research labs. Analyze IQ is designed to supersede existing software packages for spectral analysis and chemometrics.

In addition to standard chemometric techniques Analyze IQ provides users with access to innovative machine learning techniques that have been designed for spectral analysis. Testing has shown that these proprietary methods are more accurate than standard techniques, particularly when analyzing complex mixtures.

Analyze IQ Lab is the perfect complement to Ocean Optics' Raman spectroscopy systems.



Analyze IQ Lab

The analytical chemistry software package designed for chemometric techniques such as PCR.

- Advanced spectral analysis
- Intuitive user interface
- Broad range of pre-processing options

Item Code: RAM-ANIQ-LAB

Spectra Manager

This spectral database and data management software allows you to easily manage your own library of spectra.

- Store CAS registry numbers and QA details
- Retrieve and list spectra by IUPAC and common names
- Track mixtures that use the same materials by lot numbers

Item Code: RAM-ANIQ-SPEC-MGR

Raman Spectra Library

Available as an option to Spectra Manager, the Raman Spectra Library is a curated library of 1,870 Raman spectra, including the exact composition of each material and all associated data. You can incorporate a wide range of additional data, including manufacturer, lot, appearance, purity, IUPAC name, common name and more.

Item Code: RAM-ANIQ-RAMAN-LIB

Predictor

Predictor is the embedded software module that deploys analytical models built using Analyze IQ Lab into third-party software packages. Its lower CPU and storage requirements make it perfect for integration into portable systems.

Metrology Systems and Accessories

Our Mikropack line of metrology products includes fully integrated systems and accessories for thin film measurement, plasma analysis and optical characterization. Systems take advantage of our miniature spectroscopy technology and a range of light sources, sampling devices and software to meet your metrology needs. Among the applications supported are semiconductor materials analysis, thin film thickness measurements and plasma monitoring.

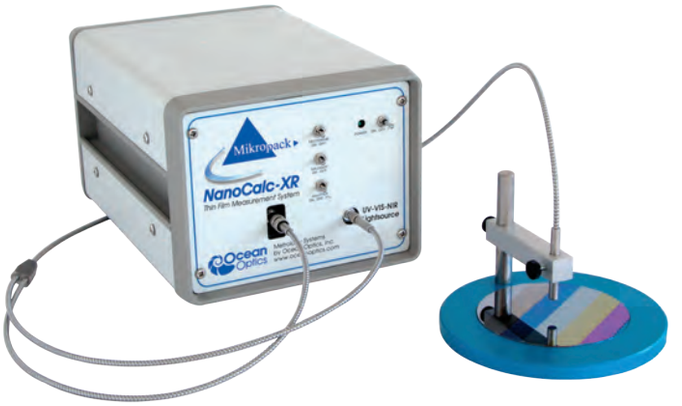
We offer three primary systems: the NanoCalc-series thin film reflectometer; the Spec-El-series ellipsometer; and the PlasCalc-series plasma monitoring system. Each system is complemented by accessories and software that provide a level of measurement flexibility often not available with comparable turnkey metrology systems. Replacement parts are also available.

Thin Film Metrology
Spectroscopic Reflectometry Systems

NanoCalc systems are versatile and configurable thin film measurement systems utilizing spectroscopic reflectometry to accurately determine optical and non-optical thin film thicknesses for applications in consumer, semiconductor, medical and industrial applications.

NanoCalc is part of the Mikropack line of thin film metrology systems. Options are available for measurements ranging from the deep UV to the shortwave NIR.

Preconfigured versions for VIS and XR are now available.



Sample NanoCalc Applications

- Transmission and reflection measurements of anti-reflective and hardness coatings
- Analysis of medical coatings and catheter balloon foils
- Testing of the hardness and wear of coatings
- Measurement of the thickness of thinned silicon wafers
- Determination of photoresist layers for masks
- Analysis of coatings applied for weather or dirt resistance (Lotus Effect)
- Measurement of coatings inside beverage containers
- Air gap measurements
- Analysis of optical disk coatings

NanoCalc Features

- Resolution to 0.1 nm
- Able to measure stacks of up to 10 layers
- Thickness and refractive index data
- Sophisticated algorithms for defect and roughness tolerance measurements
- Large database to ensure accuracy of a broad range of materials
- Adapters for complex geometries and accessories for thickness mapping

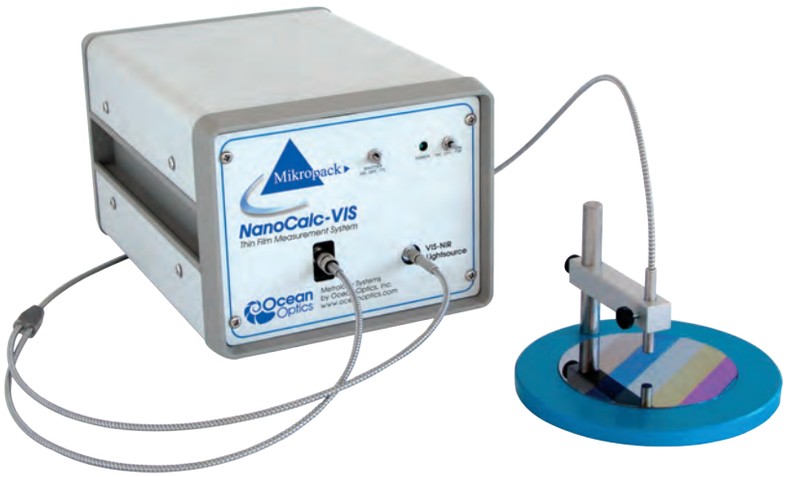
Specifications

Specification	NANOCALC-VIS-PRECON	NANOCALC-XR-PRECON	NANOCALC-DUV	NANOCALC-NIR
Wavelength range:	400-850 nm	250-1050 nm	~200-1100 nm	900-1700 nm
Thickness range:	50 nm-20 µm	10 nm-100 µm	1 nm-100 µm	100 nm-250 µm
Optical resolution:	0.1 nm	0.1 nm	0.1 nm	0.1 nm
Repeatibility:	0.3 nm	0.3 nm	0.3 nm	1.0 nm
Angle of incidence:	90°	90°	90°	90°
Number of layers:	Up to 10	Up to 10	Up to 10	Up to 10
Refractive index:	Yes	Yes	Yes	Yes
Test materials:	Transparent or semi-transparent thin film materials	Transparent or semi-transparent thin film materials	Transparent or semi-transparent thin film materials	Transparent or semi-transparent thin film materials
Reference needed:	Yes (bare substrate)	Yes (bare substrate)	Yes (bare substrate)	Yes (bare substrate)
Measurement modes:	Reflection and Transmission	Reflection and Transmission	Reflection and Transmission	Reflection and Transmission
Rough materials capable:	Yes	Yes	Yes	Yes
Measurement speed:	100 ms to 1 s	100 ms to 1 s	100 ms to 1 s	100 ms to 1 s
On-line capable:	Yes	Yes	Yes	Yes
Height adjustment:	with COL-UV-6.35 (10-50 mm)	with COL-UV-6.35 (10-50 mm)	with COL-UV-6.35 (10-50 mm)	with COL-UV-6.35 (10-50 mm)
Spot size:	200 µm or 400 µm standard; 100 µm available upon request	200 µm or 400 µm standard; 100 µm available upon request	400 µm standard; 200 µm available upon request	400 µm standard; 200 µm available upon request
Microspot:	Yes (w/microscope)	Yes (w/microscope)	Yes (w/microscope)	Yes (w/microscope)
CCD color:	Yes (w/microscope)	Yes (w/microscope)	Yes (w/microscope)	Yes (w/microscope)
Mapping option:	150 mm (6”) and 300 mm (12”) xy-scanning stages	150 mm (6”) and 300 mm (12”) xy-scanning stages	150 mm (6”) and 300 mm (12”) xy-scanning stages	150 mm (6”) and 300 mm (12”) xy-scanning stages
Vacuum capable:	Yes	Yes	Yes	Yes

Thin Film Metrology
Spectroscopic Reflectometry Systems

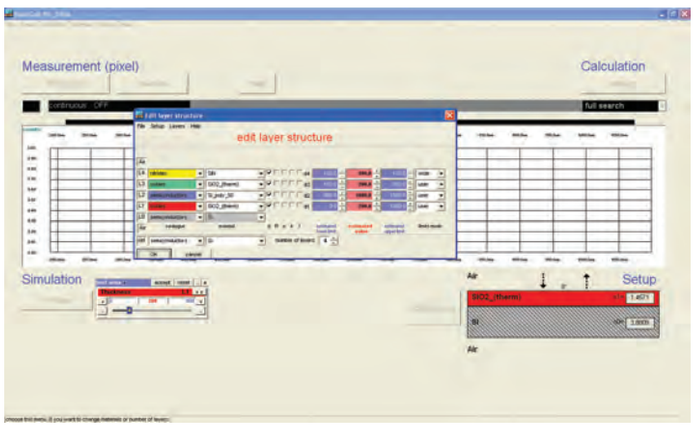
NanoCalc systems come with a spectrometer, light source and USB interface and require software and a reflection probe, which are available separately. Also available is an extensive range of add-on software, optical fibers and metrology accessories.

With NanoCalc systems, you can select from among four models, several software options, reflection probes and optical fibers, and more than a dozen accessories designed to accommodate microscopes, mapping stages and more. Preconfigured versions for VIS and XR are now available. Custom options for the thick and transparent films are also available. Here are your options:



Selecting Your NanoCalc System

Model	Wavelength Range	Optical Layer Thicknesses
NANOCALC-VIS-PRECON	400-850 nm	50 nm-20 µm
NANOCALC-XR-PRECON	250-1050 nm	10 nm-100 µm
NANOCALC-DUV	~200-1100 nm	1 nm-100 µm
NANOCALC-NIR	900-1700 nm	100 nm-250 µm



Selecting Your NanoCalc Software

Each NanoCalc system requires the purchase of NANOCALC10-N operating software. Add-on modules for functions such as spectrum simulation, mapping and external triggering are also available. Note: all NanoCalc preconfigured systems come with software.

Standard Operating Software (Required)

Item	Description	Required for
NANOCALC-10-N	Thin film measurement software for Windows; measurement, simulation and analysis of up to 10 layers; refractive index analysis also possible (refractive index for multiple layers requires SCOUT software)	Any NanoCalc measurement of thin films up to 10 layers

Add-on Software Options

Item	Description	Required for
SCOUT-FULL VERSION	Spectrum simulation program for Windows XP/7 (32 bit). Computes reflectance, transmittance, absorbance or ellipsometry spectra and fits your model to measured spectra by manual, graphical or automatic parameter variation. SCOUT can be controlled by OLE automation controllers.	Spectral simulation; use w/NANOCALC-10-N
NANOCALC-MAPPING	Mapping module software (needs NANOCALC -10-N) is 3D-mapping module with control of 150 mm and 300 mm mapping stages	Systems using mapping stages
NANOCALC-ONLINE	On-line module software (needs NANOCALC-10-N) includes external trigger and manual multipoint measurement with data transfer into Excel, plus statistical feature and 1D-Plot; also provides online display of XY-graphs and histograms of layer thickness and removal rate	On-line applications
NANOCALC-MULTI-POINT	Multipoint module software (needs NANOCALC -10-N) for manual multipoint measurement; provides result list with data transfer into Excel, CSV data, statistical and 1D-graphic; lets you measure on a mouse click, keyboard key or external trigger	Multipoint measurements
NANOCALC-REMOTE	Remote module (needs NANOCALC -10-N). Active-X functionality allows control of most NanoCalc functions from any other software.	Controlling NanoCalc functions w/other software

Thin Film Metrology
Spectroscopic Reflectometry Systems

Selecting Your Reflection Probe or Fiber Assemblies
For all NanoCalc systems you'll need to purchase a fiber assembly or reflection probe. Preconfigured NanoCalc systems include the fiber assembly.

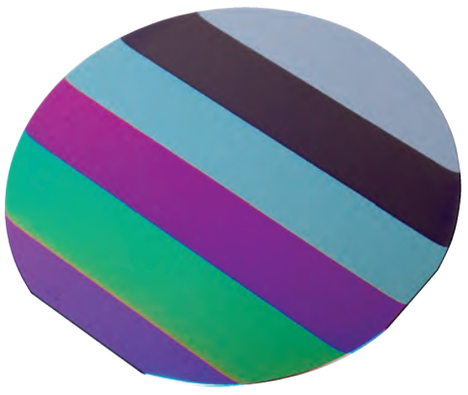
Fiber Assemblies for NanoCalc Systems

Item	Description	Use with NanoCalc Models
NC-2UV-VIS400-2	Bifurcated UV-VIS fiber, 400 µm, 2 m long, 2 x SMA 905 connectors, flexible metal jacketing, common end with stainless steel ferrule 6.35 mm x 50 mm	NANOCALC-VIS NANOCALC-XR
NC-7UVS400-2	NANOCALC-DUV reflection probe, 400 µm, 2 m long, 6 illuminated fibers, flexible metal jacketing, common end with stainless steel ferrule 6.35 mm x 50 mm	NANOCALC-DUV
NC-7VIS-NIR400-2	NANOCALC-NIR reflection probe, 400 µm, 2 m long, 6 illuminated fibers, flexible metal jacketing, common end with stainless steel ferrule 6.35 mm x 50 mm	NANOCALC-NIR

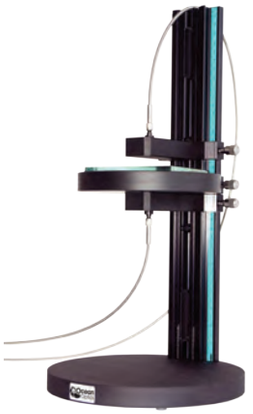
Reflection Probes for NanoCalc Systems

Item	Description	Use with NanoCalc Models
NC-7UV-VIS200-2	Reflection probe, 6 illumination, 1 read fiber, 200 µm UV-VIS fibers, 2 m long, flexible metal jacketing, stainless steel ferrule 6.35 mm x 50 mm, 2 x SMA 905 connectors	NANOCALC-VIS NANOCALC-XR
NC-7UV-VIS200-2-SMA	Reflection probe for use w/MFA-PT microscope adapter, 6 illumination, 1 read fiber, 200 µm UV-VIS fibers, 2 m long, with flexible metal jacketing, stainless steel ferrule 6.35 mm x 50 mm, 3 x SMA 905 connectors	NANOCALC-VIS NANOCALC-XR

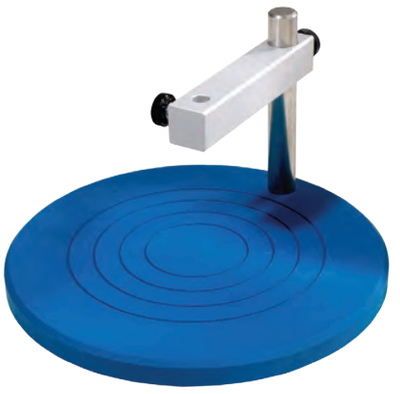
Additional Accessories
NanoCalc systems are available with accessories for use with microscopes, mapping stages and various mounting configurations. Here are some of our most popular accessories:



Reference Wafers
We offer two Si-SiO2 reference wafer options for measuring the thickness of thin, transparent films on substrates such as silicon wafers and optical layers. The STEP-WAFER covers UV-VIS wavelengths and the STEP-WAFER-600-1100 covers VIS-NIR wavelengths. Each wafer is a 100 mm diameter, 5-step wafer with calibrated thickness range of 0-500 nm or 600-1100 nm.



Reflection-Transmission Stage
The versatile STAGE-RTL-T is a handy tool for reflection and transmission measurements of various substrates (for transmission setups you'll need two extra optical fibers). The STAGE-RTL-T consists of a variable rail, fiber holder, sample holder and light trap and comes with two collimating lenses.



Single-point Stage
The STAGE is a Single-point Reflection Stage for measurement of non-transparent samples. It's a good option if you're also using a reference wafer, as the wafer fits nicely on the base plate of the stage.

Thin Film Metrology
SpecEl-2000 Ellipsometry System

The SpecEl-2000 is a benchtop thin film measurement system utilizing spectroscopic ellipsometry to measure multilayer, semi-transparent samples such as flat wafers or glass plates. The Spec-El-2000 is affordable, compact (52 cm x 33 cm x 24 cm) and convenient, with easy placement of the sample and one-button operation. SpecEl is part of the Mikropack line of thin film metrology systems. Models are available for 300-1000 nm (SPECEL-2000-UV-VIS-NIR) and 400-1000 nm (SPECEL-2000-VIS-NIR). SpecEl systems include an integrated spectrometer, broadband light source and controller; software is available separately.

SpecEl Features

- Film thickness accuracy to 1.0 nm
- Resolution to 0.1 nm
- Multi-layer stack measurements up to 25 layers
- Single film thickness up to 10 µm
- Spectral ranges from 300-1000 nm
- Standard spot size 0.4 mm x 1.2 mm
- Ideal for flat, semi-transparent samples such as wafers, glass, films and foils
- 3D mapping, reference wafers, accessories and other options available
- Accompanying software allows generation and recall of measurement recipes for one-step, repetitive measurements
- Accessories for thickness mapping

Software for SpecEl-2000 Systems

Powerful SpecEl software offers a range of modeling possibilities such as Cauchy, OJL, Tauc-Lorentz, Drude, EMA and different types of oscillators. The software also stores specific measurement routines, reducing the tedium of repetitive measurements and easing integration.

Specifications

System Performance	
Thickness range:	1 nm-10 µm
Resolution:	0.1 nm
n and k analyzer:	Values calculated for complete spectral range
Mathematical models:	Extensive range of options includes constant refractive index, harmonic oscillator and imported dielectric functions
Measurement speed:	7-13 seconds
Repeatibility:	70 nm for SiO2 on Si, cos(Delta) ±0.0003, tan(Psi) ±0.0002
Sample size:	Desktop up to 150 mm diameter; mapping up to 300 mm diameter
Sample thickness:	5 mm (maximum)
Optical	
Wavelength range:	(UV-NIR) 300-1000 nm or (VIS-NIR) 400-1000 nm
Optical resolution:	1.0 nm
Beam diameter:	400-1200 µm
Angle:	70°
Computer	
Software:	Windows XP/7 (32bit) software; also, recipe structure, administrator-user compatible
Hardware:	PC with Windows XP/7 (32bit)

Standard Operating Software (required)	
SPECEL-ELLICALC	User-friendly 32-bit Windows software for ex situ direct measurement of thickness and n and k coefficients; recipe structure and administrator/user capabilities
SCOUT-FULL VERSION	SCOUT software. Spectrum simulation program for Windows XP/7 (32 bit). Computes reflectance, transmittance, absorbance or ellipsometry spectra and fits your model to measured spectra by manual, graphical or automatic parameter variation. SCOUT can be controlled by OLE automation controllers.

Add-on Software Option	
SPECEL-MAPPING	Mapping module software (must be used with SPECEL-ELLICALC software). Complete mapping module with software control of 150 mm and 300 mm mapping stages; includes XYZ controls and 3D-graphics

Accessories for SpecEl-2000 Systems

We offer reference wafers and mapping stages for use with SpecEl systems. Mapping stages must be purchased at time of SpecEl system order. Replacement parts are also available.

MAPPING-6-INCH-SE	150 mm x 150 mm XY-scanning stage; fully automatic w/vacuum chuck, 2 motors with encoders, control system integrated 2-axis CNC controller, RS-232 interface; portal structure
MAPPING-12-INCH-SE	300 mm x 300 mm XYZ-scanning stage; fully automatic w/vacuum chuck, 2 motors with encoders, control system integrated 2-axis CNC controller, RS-232 interface; portal structure
STEP-WAFER	Reference Si-SiO2-step-wafer, 5 steps from 0-500 nm, calibrated, 100 mm diameter
STEP-WAFER-600-1100	Reference Si-SiO2-step-wafer, 5 steps from 600-1100 nm, calibrated, 100 mm diameter

Thin Film Metrology

PlasCalc-2000 Plasma Monitoring and Control System

The PlasCalc-2000 system provides real-time, in situ analysis of the optical emission spectra acquired during plasma processes. The system has all the tools necessary for monitoring and controlling a running process, with sophisticated algorithms for data acquisition and signal treatment. Wavelength, recipe and formula editors allow quick creation of efficient recipe functions for data handling and easy combination of many recipes to build comprehensive strategies for system response during monitoring. PlasCalc-2000 (item PLASCALC-2000-UV-VIS-NIR) is part of the Mikropack line of thin film metrology systems.

The PlasCalc-2000 is 257 mm x 152 mm x 263 mm and includes a spectrometer (200-1100 nm) with 16-bit D/A converter and 12 VDC power supply. Operating the system requires PlasCalc software and 400 µm optical fibers, which are available separately.

Sample Plasma Monitoring Applications

- Plasma etching
- Plasma chamber health control
- Planarization of blanket polysilicon
- Application of protection coatings
- Abnormal process phenomena
- Process optimization
- Surface cleaning processes

Spectroscopic	
Spectral range:	200-1100 nm
Optical resolution:	1.0 nm (FWHM)
Fiber optic connector:	SMA 905
Electronics	
Power supply:	12 VDC, 1.25 A
Power requirements:	90-240 VAC, 50/60 Hz
D/A converter:	14 bit I/O
Digital I/O:	8x TTL
Analog output/voltage sign:	4x [0-10V]
Computer	
Software:	PlasCalc software (basic operating software); also, SpecLine atomic emission line analysis software (add-on package)
Hardware:	PC with Windows XP/7 (32 bit)

Software for PlasCalc-2000-UV-VIS-NIR System

Standard Operating Software (required)

PLASCALC-SOFTWARE	Real-time and in situ access to all functions via easy menu-oriented software interface. Multiple plasma species can be picked by a mouseclick, mathematically calculated, subtracted and monitored in real time and in situ. Capabilities: four digital inputs/outputs, 4 analog output channels; display messages with tone signal can be set up for end point, start, stop and limit.

Add-on Software Option

SPECLINE	Software for spectroscopy, astrophysics, plasma science or plasma processing. This tool supports and makes it easy to evaluate spectral data, e.g. finding specific lines in spectra, identifying unknown peaks, identifying atomic lines and molecular bands or comparing data from different measurements in spectra data. Almost instantly detects peaks of lines and bands using several powerful filter functions. Extensive database for atoms and molecules included; only for Windows XP/7 (32 bit).

The Mikropack name for our line of thin film metrology systems has its origins in a partnership that first blossomed more than a decade ago. Mikropack was a German photonics company that became an Ocean Optics distributor in 1996 and was known for its metrology systems and spectroscopic accessories. When Mikropack became part of Ocean Optics several years later, we retained the Mikropack name for our metrology systems and accessories. Today, Mikropack systems are developed and supported by our thin film metrology team in Ostfildern, Germany.

Software

SpecLine Software for Compound ID

Identifies Elements and Compounds

SpecLine Software is a powerful tool designed for identifying atomic emission lines and molecular bands in spectral data. SpecLine's advanced evaluation, search, compare and identify functions -- and its extensive library of over 100 elements and over 400 compounds -- enable you to quickly identify unknown lines, peaks and bands. SpecLine was designed for scientists, engineers and researchers using emission spectroscopy in fields such as astrophysics, the plasma sciences and plasma processing.

Searching and Comparing Data

In the Line Identification window, you can define all the parameters for your search in a Periodic Table screen (top right), and begin the process with just a single click. SpecLine can analyze even the most complex spectral data, including spectra with double lines, line shoulders and complex band structures. Up to 12 separate spectra, even if they are in different file formats, can be combined for comparative purposes.

Identification

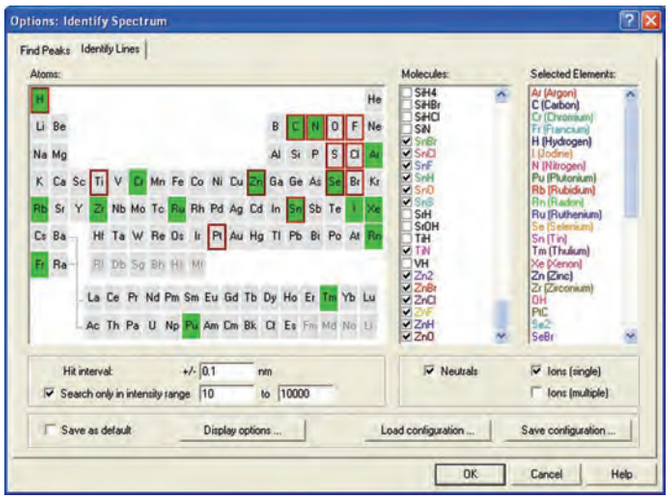
SpecLine applies a variety of sophisticated filter functions such as Wiener-Fourier and polynomial noise removal to identify the elements and compounds in your spectra. After SpecLine applies comparative searches to its extensive atomic, ionic and molecular database of over 100 elements in several ionization states and over 400 elemental compounds, it provides detailed data on each identified peak and line, such as the name of the element, the peak's wavelength, the electron voltage and its transition state and quantum number.

Opening Spectra and Saving Data

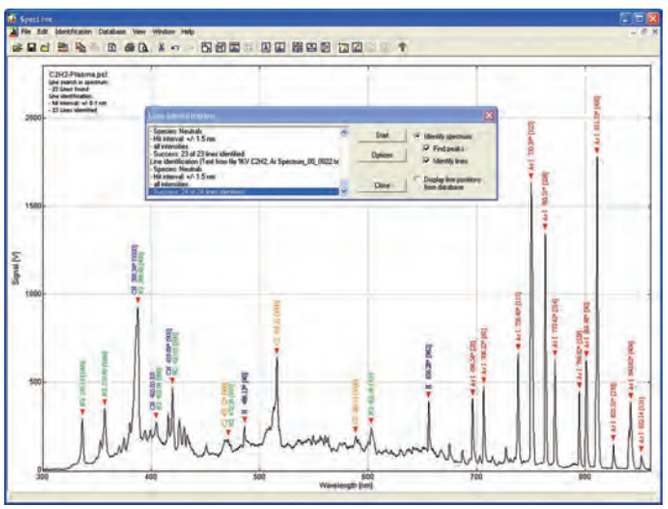
SpecLine can analyze spectral data from various spectroscopy software applications; it also can open all Ocean Optics software file formats as well as SPC and ASCII file formats. In addition, you can save all of SpecLine's identification data in its native file format or export it into various applications, such as Excel.

Hardware Keys

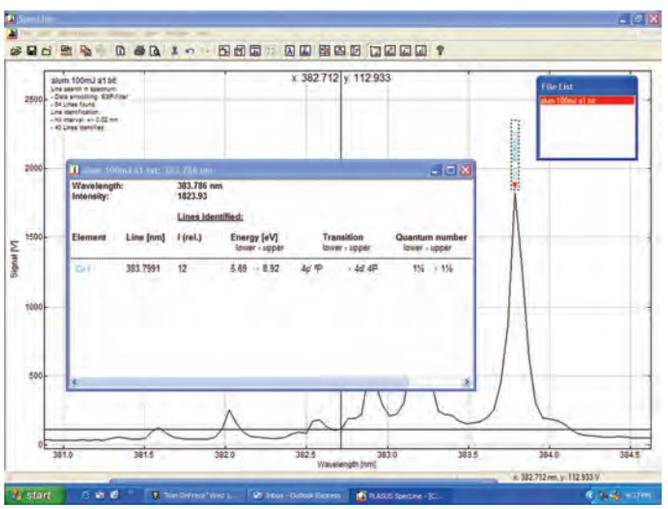
SpecLine Software comes with a USB or parallel-port (printer port) hardware key. The key is a security device to protect against unlicensed copies. It connects to an input/output port on your computer and must be used to run the software. SpecLine-U comes with a USB dongle for use with Windows XP, Vista and Windows 7 (32-bit). SpecLine-P comes with a feed-through parallel port hardware key.



In the Identify Lines window, you can search atoms from a Periodic Table, molecules from an extensive list, and elements in single or multiple ionization states.



In this window, a search on the peaks and lines in a spectrum has been completed and identified successfully.



This window demonstrates SpecLine's ability to provide detailed data on just one emission line.

Thin Film Metrology

Additional Accessories and Replacement Parts

Additional Accessories and Parts

NanoCalc Accessories	
MFA-PT	Microscope fiber adapter for phototube outlet and SMA 905-terminated optical fibers
MFA-C-Mount	Microscope fiber adapter for C-mount outlet and 6.35 mm ferrule-terminated optical fibers (standard NanoCalc bifurcated fibers)
NC-CMOUNT-ADP	Universal microscope fiber adapter for C-mount outlet and 6.35 mm ferrule-terminated optical fibers; suitable for all common microscopes including beam splitter and multiple objectives for exact images at camera and fiber outlet
NC-MIK-VIS	Microscope for use with NANOCALC-VIS; covers 400-850 nm and includes light source, video microscope for 20 µm spot size with 10x magnification, CCD-USB camera, manual xy-sample-stage
CSH	Probe holder for curved samples; used with reflection probes with cylindrical 6.35 mm ferrule and rubber ring as contact element
COL-UV-6.35	UV/VIS/NIR collimating lens with connector for 6.35 mm ferrule
MAPPING-6-INCH	XY-scanning-stage with 150 mm vacuum chuck, 150 x 150 mm travel range, RS-232, 90-240VAC (needs software NANOCALC-MAPPING)
MAPPING-12-INCH	XY- scanning-stage with 300 mm vacuum chuck, 300 x 300 mm travel range, for sample diameter of up to 300 mm, RS-232, 90-240VAC (needs software NANOCALC-MAPPING)

NanoCalc and SpecEl Spare Parts	
RB-VIS-NIR	Replacement bulb for NANOCALC-VIS; 1,500-hour lifetime (red and black wires)
RB-VIS-NIR-LL	Replacement bulb for NANOCALC-VIS; 10,000-hour lifetime (yellow and black wires)
RB-UV-VIS-NIR-2	Replacement high-power bulb (yellow) NANOCALC-XR. Lifetime: 1,000 hours
SPECEL-2000-BM	SPECEL-2000-VIS-NIR replacement light source module complete with bulb, housing, optics and shutter, for plug and play replacement on customer side
SPECEL-2000-BM-UV	SPECEL-2000-UV-VIS-NIR replacement light source module complete with bulb, housing, optics and shutter, for plug and play replacement on customer side
COL-UV-30	Collimating lens UV/VIS/NIR, fused silica Suprasil® 1, 200-2000 nm, d=30 mm, f=30 mm, 200 °C, SMA 905, ad=35 mm

Other Accessories	
STAGE	Single point reflection measurement for non-transparent samples
STAGE-RTL-T	Reflection and transmission stage with variable rail, fiber holder, sample holder and light trap, 2x collimating lenses for different substrate materials (order for transmission setup, 2x fibers extra).
COL-UV-6	Collimating lens UV-VIS-NIR, fused silica Suprasil, 200-2000 nm, 6 mm diameter, 10 mm focal length, 200 °C, SMA 905, 3/8-24 thread
STEP-WAFER	Reference Si-SiO2-step-wafer, 5 steps from 0-500 nm, calibrated, 100 mm diameter
STEP-WAFER-600-1100	Reference Si-SiO2-step-wafer, 5 steps from 600-1100 nm, calibrated, 100 mm diameter

Resources

Plant science researchers Jay Kalous (above left) and William Duke Pauli, graduate students at Montana State University in Bozeman, Montana, are using our Jaz Spectrometer to investigate new methods for increasing resource efficiency in current crop varieties. The goal is to improve agricultural production of food crops to keep pace with an increasing population.

Pauli describes their work:

"Here we are measuring the amount of light reflected off the canopies of the plants. By better understanding this relationship we can identify plants that are better able to use their resources. By using these plants in subsequent breeding projects, we are able to improve the overall capabilities of wheat and barley crops. This is an ambitious project, but we hope that stable food production systems can be put in place to help combat world hunger."

Tip

Need a quick answer? Try our Live Chat online at www.oceanoptics.com.

Resources

Setup: Solutions Absorbance

Overview

Absorbance measurements are used to quantify the concentration of gases and solutions (the latter is described here) that absorb light in a media that transmits light. The signal in absorbance units is proportional to the molar absorptivity, pathlength and concentration of the sample (see Beer's Law, page 185).

Spectrometer

The USB4000-UV-VIS Spectrometer is ideal for absorbance measurements from 200-850 nm. The spectrometer is configured with Grating #1, which has peak efficiency at 300 nm. This configuration provides adequate resolution (~1.5 nm FWHM) for most solutions absorbance measurements. The built-in order-sorting filter eliminates second- and third-order effects that otherwise yield false peaks in absorbance spectra. The preferred light source is the DH2000-BAL Deuterium Tungsten Halogen Light Source. The DH2000 is a less expensive source, but lacks the filtering technology that eliminates problems associated with the D-alpha line in the deuterium source.

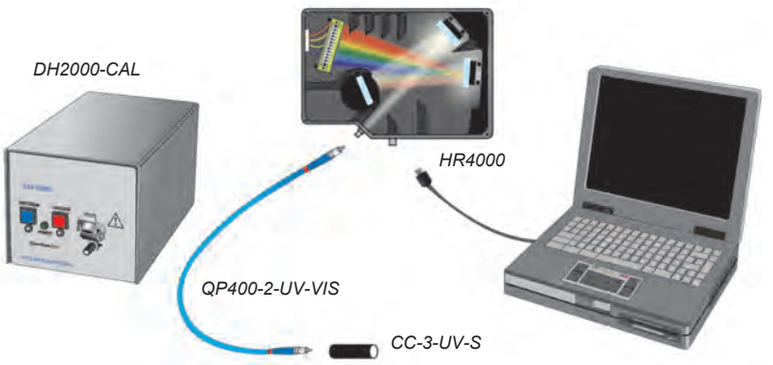
Sampling Optics

For absolute absorbance measurements, use the 1-cm pathlength CUV-UV Cuvette Holder and the CV-Q-10 Quartz Cuvette. For relative absorbance, direct-attach USB accessories, dip probes and flow cells are available. We recommend QP400-025-SR Premium-grade Solarization-resistant Optical Fibers as illumination and read fibers. Use NIST-traceable Photometric Absorbance Standards to provide certifiable results.

Setup: Upwelling/Downwelling

Overview

Upwelling radiation is either reflected solar or emitted terrestrial, directed upward from the earth's surface. Downwelling radiation is radiation that is directed toward the earth's surface from the sun or atmosphere. The relationship between the two can be used to derive spectral information from vegetation, forest canopies, seabeds and more.



Spectrometer

An HR4000 Spectrometer with an HC-1 grating provides an excellent solution for upwelling and downwelling measurements. The HC-1 is a variable-blazed grating that covers the 200-1050 nm wavelength range; optical resolution is ~1.5 nm (FWHM) with a 50 µm slit as the entrance aperture. An order-sorting filter eliminates second- and third-order effects.

Sampling Optics

The spectrometer connects to a patch cord that screws into the CC-3-UV-S Cosine Corrector. The CC-3-UV-S can be used as part of a configuration for measuring absolute spectral irradiance. You'll need a DH2000-CAL (or HL-2000-CAL for 300-1050 nm only) to calibrate the absolute spectral response of the system and SpectraSuite Spectroscopy Operating Software to calculate spectral intensity and photopic data in lumens, lux or candela. An alternative to the CC-3-UV-S is a Gershun tube, which has fixtures for adjusting the area of light from 1° to 28° and attaches directly to the spectrometer or to an optical fiber.

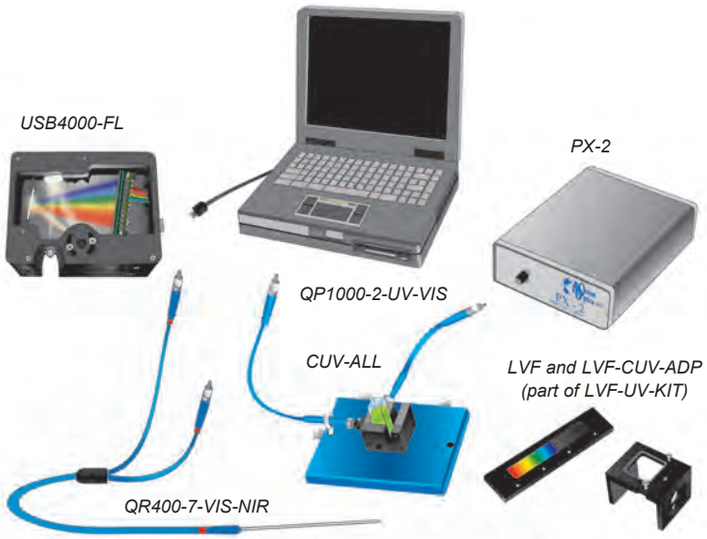
Resources

Setup: Fluorescence

Overview
Fluorescence measurements require a sensitive detector and an effective filter for discriminating between powerful excitation source wavelengths and weak spectral emissions from the sample.

Spectrometer
We offer several spectrometers that are useful for fluorescence, but recommend the high-sensitivity, preconfigured USB4000-FL Spectrometer for most general fluorescence applications. The USB4000-FL is set to 360-1000 nm and comes with a 200 µm slit and an L4 Detector Collection Lens for increased light throughput.

Sampling Optics
Your standard excitation source option is our PX-2 Pulsed Xenon Source. Our proprietary LVF Linear Variable Filters are excellent tools for spectrally shaping the excitation energy from broadband sources used for fluorescence. Various sampling optics are available for detecting picomolar-range concentrations of fluorophores from surfaces and in solutions and powders.



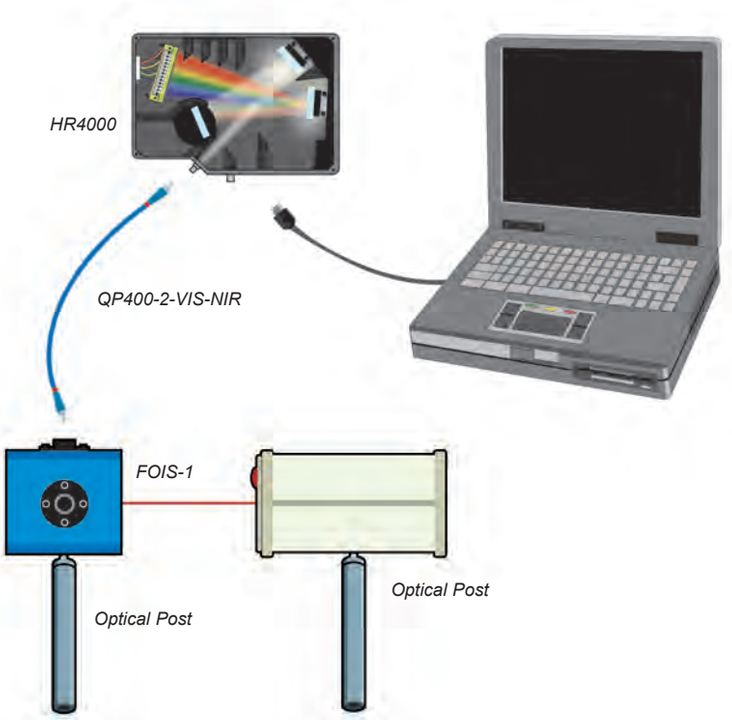
Setup also requires USB-ADP-PX2 adapter (not shown).

Setup: Laser Analysis

Overview
Our HR4000 High-resolution Spectrometer is ideal for measuring the spectral characteristics and intensity of continuous-wave and pulsed lasers. For high-power lasers, an integrating sphere or cosine corrector attenuates the light to avoid saturating the CCD array.

Spectrometer
The HR4000 Spectrometer uses the "HR" Optical Bench, which was designed to yield high optical resolution for resolving fine spectral features. For laser characterization, we recommend a grating with a high groove density, such as the H6 1200 mm^{-1} grating set to a 750-925 nm wavelength range and with a 5 µm Slit as the entrance aperture. This configuration provides ~0.12 nm resolution (FWHM). For better resolution, consider an 1800 mm^{-1} or 2400 mm^{-1} grating.

Sampling Optics
There are several possible sampling setups: a CC-3-UV Cosine Corrector with an optical fiber; FOIS-1 Integrating Sphere with a fiber; or fiber assembly coupled to the laser. Optical posts are used to hold fixtures in place.



Measurements
Use our spectrometer operating software to obtain values such as peak, centroid and central wavelength.

Resources
Setup: Metrology

Overview
A thin film on a substrate can act as an etalon, creating an interference pattern that is superimposed on the surface reflectivity when viewed in reflection. The spacing of the pattern's sinusoidal peaks, when combined with the refraction index of the material, can be used to calculate the thickness of the material.

Spectrometer
The USB4000-VIS-NIR (350-1000 nm) is ideal for reflectometry of thin films. The spectrometer is preconfigured with Grating #3, which is blazed at 500 nm; an order-sorting filter to eliminate second- and third-order effects; and a 25 µm slit for optical resolution of ~1.5 nm (FWHM).

Sampling Optics
The QR400-7-VIS-NIR Reflection Probe positioned at 90° measures specular reflectance from surfaces such as thin films. An HL-2000 Tungsten Halogen Source and a STAN-SSH High-reflectivity Specular Reflectance Standard complete the sampling setup.

Measurements
Spectra observed in our operating software reveals oscillations caused by optical interference within the layers of the thin film substrate. Analysis of the wavelength position of the minima or maxima can determine either the thin film's thickness (with the known refractive index of the film) or its refractive index (with the known film thickness). Keep in mind that the thickness of samples may not be uniform. Therefore, we recommend measuring several locations on the film.

Setup: UV-VIS Reflection

Overview
Diffuse reflection measurements can be used to determine information about the chemical content or color of a sample.

Spectrometer
The USB4000-UV-VIS (200-850 nm) is ideal for most UV-VIS reflectometry. The spectrometer is preconfigured with Grating #1, which is efficient in the deep UV; an order-sorting filter to eliminate second- and third-order effects; and a 25 µm slit for optical resolution of ~1.5 nm (FWHM).

Sampling Optics
The QR400-7-UV-VIS Reflection Probe measures diffuse or specular reflectance from surfaces, or backscattering from translucent materials and fluids. The RPH-1 Probe Holder positions the QR400-7 at either 45° for diffuse reflection or 90° for specular reflection (for reflection measurements with an integrating sphere). For illumination, we recommend the DH2000-BAL Deuterium Tungsten Halogen Light Source. If your application requires portability, use the smaller DT-MINI-2-GS Deuterium Tungsten Halogen Light Source. Because the DT-MINI-2-GS is a low-power source, configure your spectrometer with a 50 µm slit and an L4 Detector Collection Lens.

Measurements
Reflectance standards include the WS-1 Diffuse Reflectance Standard for diffuse measurements and the STAN-SSH Specular Reflectance Standard for specular measurements. Use our software to correct data for deviations from 100% reflectivity of standards, field tiles or NIST-traceable materials.

Resources

Setup: Reflected Color

Overview
Color measurement involves determining the reflection spectrum of a sample and applying it to a standard illuminant. The amount of light energy the sample reflects is manipulated and reduced to tristimulus values X, Y and Z. These values correspond to the physiological response of the three types of color receptors in the human eye. X, Y and Z values are combined into uniform colorspace values such as L*, a* and b*.

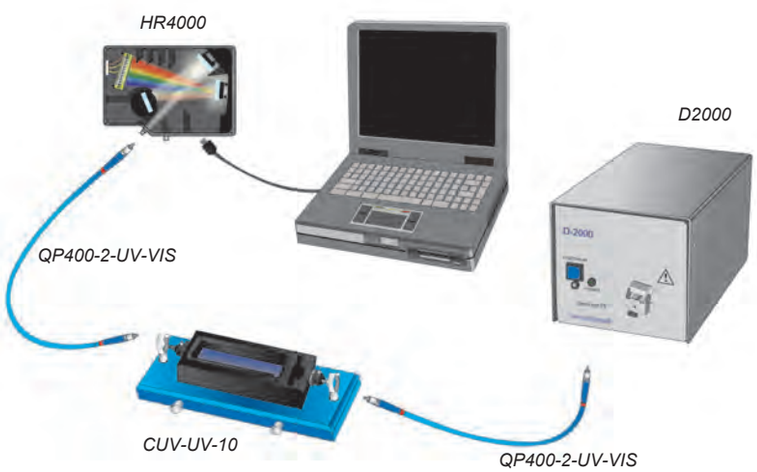
Spectrometer
A USB4000 with a 25 µm slit and Grating #2 (350-1000 nm) works well for color analysis. For those using an integrating sphere as the sampling optic, we recommend an L4 Detector Collection Lens to improve sensitivity.

Sampling Optics
When taking reflective-color measurements, your data depends on sampling geometry. The QR400-7-VIS-NIR Reflection Probe provides illumination and detection from the same direction. If you use the probe at a 45°, it measures diffuse reflection. If you use the probe at a 90°, it measures specular reflection. The distance from the probe to the surface determines the sample size. An alternative is the ISP-REF Integrating Sphere, which provides 180° illumination and detection from flat surfaces for measuring specular and diffuse reflection.

Measurements
Reflectivity is measured against a reference standard such as the WS-1 Diffuse Reflectance Standard. SpectraSuite Spectroscopy Operating Software calculates a variety of color-space values from the reflection spectra.

Setup: Gas Absorbance

Overview
Absorbance measurements are used to quantify the concentration of solutions and gases (as described here) that absorb light in a media that transmits light. The signal in absorbance units is proportional to the molar absorptivity, pathlength and concentration of the sample. (See more on Beer's Law on page185.)



Spectrometer
A setup for measuring benzene gas, for example, would call for an HR4000 High-resolution Spectrometer with an H7 grating and a 200-300 nm wavelength range. Optical bench accessories include an L4 Detector Collection Lens for increased light throughput, and a UV4 Detector Upgrade to transmit light in the UV. With a 5 µm slit, optical resolution of ~0.07 nm (FWHM) is possible. The preferred light source for work in the ultraviolet is the D-2000 Deuterium Light Source.

Sampling Optics
The 10-cm pathlength CUV-UV-10 Cuvette Holder, the CV-Q-10 Cylindrical Cell and QP400-025-SR Premium-grade Solarization-resistant Optical Fibers (one fiber illuminates, the other reads signal) comprise the system's sampling optics. For applications requiring shorter pathlengths or open-air monitoring, use an optical fibers-and-collimating lenses configuration.

Resources
Optical Resolution

How to Calculate Optical Resolution

Optical resolution of a spectrometer, measured as Full Width Half Maximum (FWHM), depends on the groove density (mm-1) of the grating and the diameter of the entrance optics (optical fiber or slit).

Formula for Calculating Optical Resolution

1. Determine the spectral range of the grating. Look at the grating charts within this catalog or on our website and note the value in the spectral range column in the chart. For example, Grating #3 has a spectral range of ~650 nm. Please note that the spectral range can vary by starting wavelength, which is why 650 nm is an approximation.

2. Determine the number of pixel elements in the spectrometer's detector. For a USB2000+ Spectrometer, this number is 2048. Divide the grating spectral range by the number of pixel elements in the detector. This is your dispersion value. For our example, 650 nm/2048 pixels = 0.32 nm/pixel.

3. Choose a slit width. Each slit has a pixel resolution value that can be found in the applicable bench accessory section of this catalog or on our website. For a USB2000+ with a 10 µm slit, this value is ~3.2 pixels. Multiply the dispersion from Step 2 (0.32 nm/pixel) * the pixel resolution value (~3.2) for optical resolution (in nm). So, 0.32 * 3.2 = 1.02 nm.

Convenient Online Resources

Technical Information
By clicking the Technical link on our website, you have access to information about our products, manuals, operating instructions, software and system specifications.
oceanoptics.com/technical.asp

Operating Instructions
We provide hundreds of pages of easy-to-use operating instructions and specifications for our products so that you read before you buy or simply get up to speed quickly.
oceanoptics.com/technical/operatinginstructions.asp

Software Downloads
Quickly download the latest operating and application software, device drivers, utilities and code for your Ocean Optics spectrometer or system.
oceanoptics.com/technical/softwaredownloads.asp

Spectrometer System Specifications
The performance of your Ocean Optics spectrometer depends on a host of factors. Learn more about the detector, optical bench, grating and more by viewing our system specification information.
oceanoptics.com/technical/systemspecifications.asp

Application Blog
Read real-world experiments and applications that use Ocean Optics spectrometers, sensors and systems. Filled with useful information, our Applications Blog is a great place to discover how Ocean Optics equipment is changing the world.
oceanoptics.com/app_blog

Spectroscopy TV
We offer video tutorials for use with our spectrometers and systems online at Spectroscopy TV. Get helpful, step-by-step instructions for setup, basic measurements and configuration.
spectroscopytv.com

The Ocean Optics eNewsWire
Sign up to receive our monthly newsletter via email. You'll get the inside scoop on product updates, new applications and more. Subscribe online and never miss a beat.
oceanoptics.com/news.asp

Keeping it Social
Don't forget to friend or follow Ocean Optics on your favorite social network. It will help you keep an eye on the latest news, product developments and more. And be sure to follow the Ocean Optics channel at YouTube.com.

World-Class Warranty

Unparalleled Protection for Your New Purchase

Our exclusive 3-Year Warranty* covers your Ocean Optics miniature spectrometer, light source and sampling accessories from manufacturing defects – regardless of the application. We also cover fibers and probes for a full 12 months. To enhance this warranty, we also offer optional Annual Service Package Protection.

This comprehensive warranty is the only one of its kind and it ensures you of the highest level of craftsmanship and reliability for years to come.

Add an Annual Service Package for Additional Protection
- Concierge yearly factory calibration and preventive maintenance
- Extended SpectraSuite software support (additional year of license updates and support)
- Labor charge waiver for factory modifications
- Preferred pricing on trade-ins and allowances for new equipment

*Some exclusions apply. Excludes OEM products. Fibers should be inspected immediately upon arrival. Fibers are only warranted for in-transit damage for seven days upon receipt. After seven days, the expressed warranty is void.

But that's not all. For even greater peace of mind, consider one of our Total Technical Services (TTS) protection plans. Our TTS protection plans cover your spectrometer for one year for any contingency – not just manufacturing defects -- no matter what the circumstances, including total loss. Under these plans, Ocean Optics will repair or replace your instrument with no deductible or any other out-of-pocket expense required from you. It's that simple! Additional details are on the next page.

Spectrometer Wavelength Calibration

Regular Maintenance Ensures Best Results

We have designed and manufactured our instruments to provide you with dependable and trouble-free operation. However, as with any scientific instrument, you can prolong its life by performing regularly scheduled preventive service and maintenance.

Our instrument calibration and scheduled maintenance services are designed to provide you with long-term reliability to ensure that you receive the highest quality measurement results for your application. We strongly recommend yearly recalibration for all Ocean Optics instruments. This service includes the following

- Re-focusing and optical bench alignment
- Wavelength calibration (with certificate)
- Linearity calibration
- Optical resolution evaluation
- Stray light measurement
- Baseline uniformity evaluation and adjustment
- Noise analysis
- Electronics verification
- Cleaning
- Firmware upgrades (if available)

A certification report is included along with a diskette containing calibration and linearity coefficients. For USB2000+ and HR2000+ Spectrometers, these coefficients will be loaded in the unit's EEPROM.

If your company requires scheduled calibration or maintenance for scientific instruments, we can design a custom contract to support your specific needs.

Item Code	Description
WAVECAL-USB	USB series spectrometers preventive maintenance and certified wavelength calibration package.
WAVECAL-HR	HR series spectrometers preventive maintenance and certified wavelength calibration package.
WAVECAL-CHEM	CHEM series spectrometers preventive maintenance and certified wavelength calibration package.
WAVECAL-QE	QE spectrometers preventive maintenance and certified wavelength calibration package. Includes thermo-cooling system evaluation.
WAVECAL-NIR	OOI NIR series spectrometers preventive maintenance and certified wavelength calibration package. Includes thermo-cooling system evaluation.

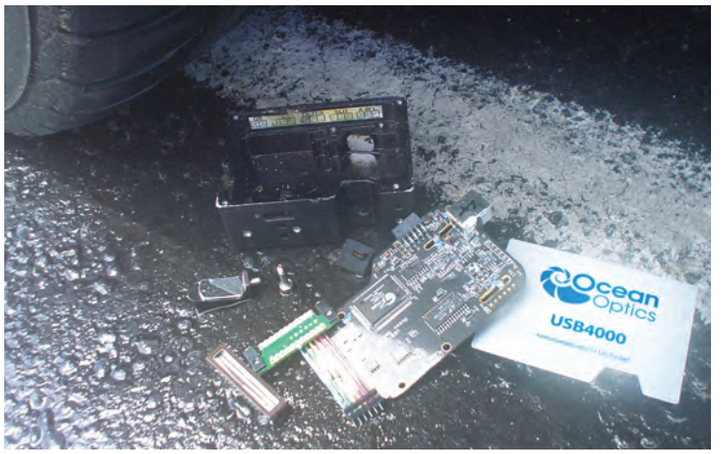
Total Technical Services

When the Unthinkable Happens

Our Total Technical Services protection plans protect your spectrometer for one year for any contingency – no matter what the circumstance – including total loss.

Under these comprehensive plans, Ocean Optics will repair or replace your instrument with no deductible or any other out-of-pocket expense required.

We recommend that you protect your investment from the date of purchase. However, if you already own an Ocean Optics spectrometer, this service is available to you as well, after a 30-day vesting period.



Ocean Optics Warranty and Product Protection Plans

	Standard Warranty	Annual Service Package (ASP) -- Standard	Annual Service Package (ASP) -- Gold	TTS Product Protection Plan
Applies to	Spectrometers, light sources, optical fibers, probes, sampling accessories	Spectrometers	Preconfigured Spectrometers	Spectrometers
Duration	3 years on spectrometers, light sources and sampling accessories	1-year and 2-year packages (renewable) on spectrometers only	1 year (renewable) on preconfigured spectrometers only	1 year (renewable) on spectrometers only
	1 year on optical fibers and probes	Not available	Not available	Not available
Terms	Covers parts and labor needed to repair manufacturing defects	Covers parts and labor needed to repair manufacturing defects under warranty	Covers parts and labor needed to repair manufacturing defects under warranty	Repair or replacement of the unit for any contingency, including total loss
		Includes additional concierge service (see Service entry below)	Includes additional concierge service (see Service entry below)	
			Includes use of loaner spectrometer for duration of repair process.	
Availability Window	Effective at time of purchase	Concierge service package (see Service entry below) effective at time of spectrometer purchase	Effective at time of preconfigured spectrometer purchase	Effective at time of spectrometer purchase
		As renewal option effective upon completion of original ASP terms		As renewal option effective upon completion of original TTS terms
		As post-sale option for spectrometers purchased prior to Apr. 1, 2008; coverage is effective at time of ASP purchase		As post-sale option for spectrometers purchased prior to Apr. 1, 2008; coverage begins 30 days from purchase of TTS plan
Service	Standard service	Concierge service includes yearly calibration and preventive maintenance, free labor on spectrometer modifications (change slit, gratings and so on), free software and firmware upgrades	Concierge service includes yearly calibration and preventive maintenance, free labor on spectrometer modifications (change slit, gratings and so on), free software and firmware upgrades	Not applicable
Exclusions	OEM configurations	OEM configurations	OEM preconfigured spectrometer setups	OEM configurations
	Bulbs, batteries, memory cards and consumables	Bulbs, batteries, memory cards and consumables	Bulbs, batteries, memory cards and consumables	Bulbs, batteries, memory cards and consumables
	Breakage in optical fibers and probes unless reported within 1 week of customer receipt			

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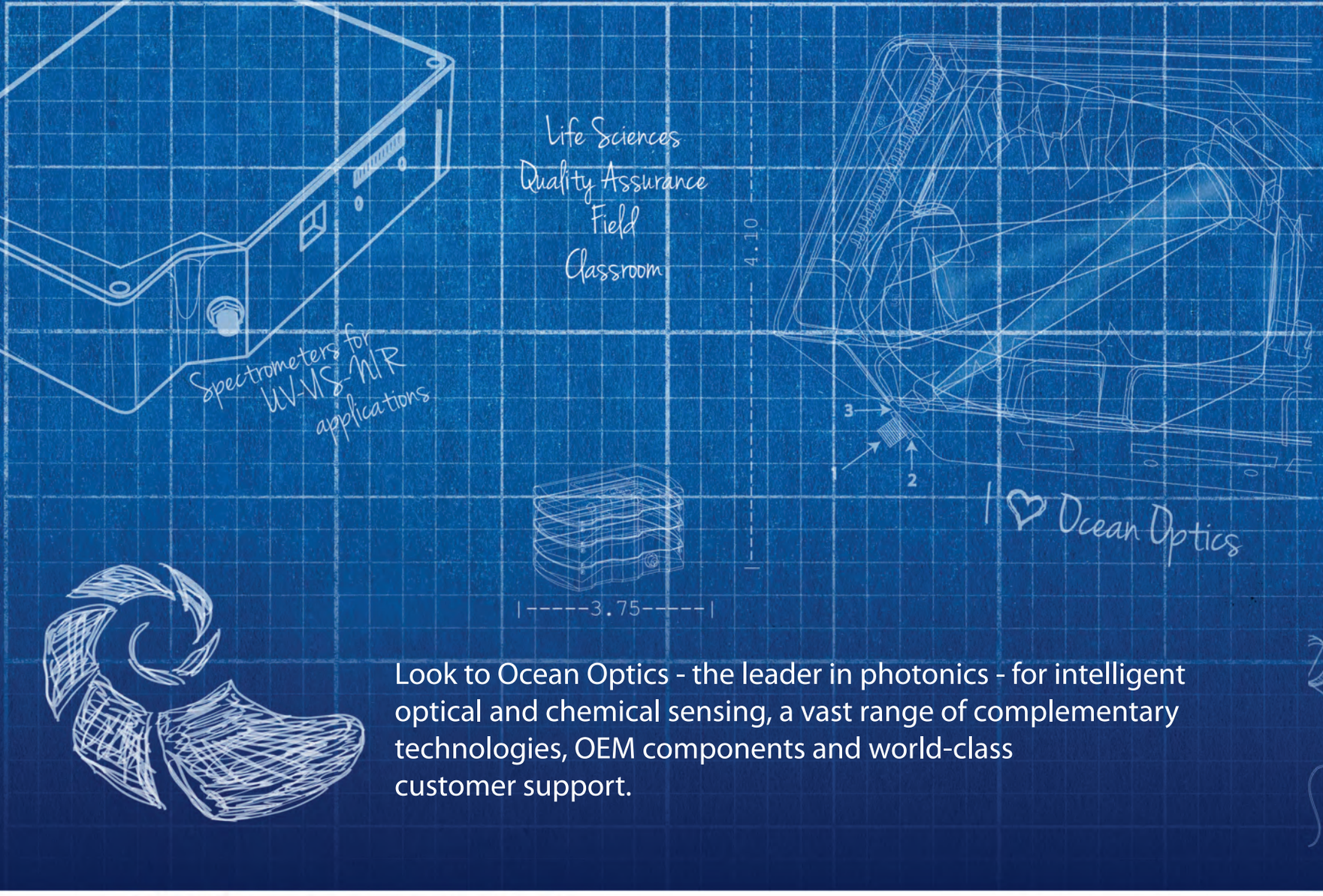
Application Notes

Technical Tips



Look to Ocean Optics - the leader in photonics - for intelligent optical and chemical sensing, a vast range of complementary technologies, OEM components and world-class customer support.

Ocean Optics 20 YEARS OF INNOVATION

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