Spectrometer
Systems & Setups

Systems and Setups are either turnkey spectrometers or complete setups necessary for a specific measurement technique, such as fluorescence, or a specific application, such as measuring LEDs.

UV-VIS & VIS-NIR Spectrometers

Great Versatility

We offer general-purpose UV-VIS and VIS-NIR spectrometers that are preconfigured -- where all of the optical bench options are already selected. By switching out light sources and sampling accessories, these spectrometers can measure absorbance in solutions or reflectance of solids.

200-850 nm UV-VIS Preconfigured Spectrometer

The USB4000-UV-VIS utilizes the "USB" (also called the "S") Optical Bench. It has a 200-850 nm wavelength range and comes with a detector upgrade for working in the UV, a variable longpass detector filter for second- and third-order rejection, and a 25-µm slit as the entrance aperture. Optical resolution is ~1.5 nm (FWHM).

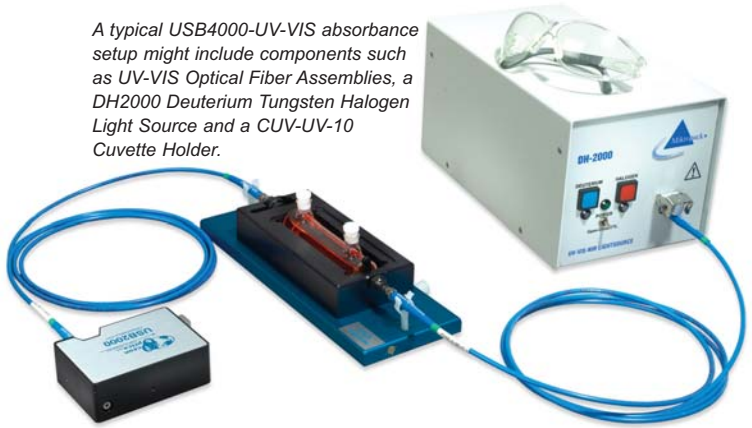
350-1000 nm VIS-NIR Preconfigured Spectrometer

The USB4000-VIS-NIR spectrometer also utilizes the "USB" (also called the "S") Optical Bench. It has a 350-1000 nm wavelength range and comes with a 25-µm entrance slit and a variable longpass detector filter for second- and third-order rejection. With this optical bench configuration, the USB4000-VIS-NIR achieves ~1.5 nm optical resolution (FWHM).

Accessorize

To complete your spectrometer system, select from our comprehensive line of fiber optic accessories -- light sources, sensors and probes, sample holders, flow cells, optical fiber assemblies and more.

USB4000-UV-VIS: $2,649
USB4000-VIS-NIR: $2,499



A typical USB4000-UV-VIS absorbance setup might include components such as UV-VIS Optical Fiber Assemblies, a DH2000 Deuterium Tungsten Halogen Light Source and a CUV-UV-10 Cuvette Holder.

A reflection setup with the USB4000-VIS-NIR could include these components: an R200-VIS-NIR Reflection Probe, an LS-1 Tungsten Halogen Light Source and an RPH-1 Reflection Probe Holder.

Specifications

	USB4000-UV-VIS	USB4000-VIS-NIR
PHYSICAL		
Dimensions (in mm):	89.1 x 63.3 x 34.4	89.1 x 63.3 x 34.4
Weight:	190 grams	190 grams
DETECTOR		
Detector:	Toshiba TCD1304AP linear CCD array (page 17)	Toshiba TCD1304AP linear CCD array (page 17)
Pixels:	3648 pixels, size of each is 8 µm x 200 µm	3648 pixels, size of each is 8 µm x 200 µm
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
OPTICAL BENCH		
Design:	f/4, Asymmetrical crossed Czerny-Turner	f/4, Asymmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output	42 mm input; 68 mm output
Entrance aperture:	25 µm wide slit (page 15)	25 µm wide slit (page 15)
Grating:	Grating #1, 600 lines per mm grating, blazed at 300 nm (page 17)	Grating #3, 600 lines per mm grating, blazed at 500 nm (page 17)
Order-sorting filters:	OFLV-200-850 (page 17)	OFLV-350-1000 (page 17)
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber	SMA 905 to 0.22 numerical aperture single-strand fiber
SPECTROSCOPIC		
Wavelength range:	200-850 nm	350-1000 nm
Optical resolution:	~1.5 nm FWHM	~1.5 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)	300:1 (at full signal)
Dynamic range:	2 x 10^8 (system); 1300:1 for a single spectrum	2 x 10^8 (system); 1300:1 for a single spectrum
Integration time:	3.8 ms to 10 seconds	3.8 ms to 10 seconds
ELECTRONICS		
Power consumption:	250 mA @ 5 VDC	250 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 5 ms with USB 2.0 port	Full spectrum to memory every 5 ms with USB 2.0 port
Inputs/Outputs:	8 onboard digital user-programmable GPIOs	8 onboard digital user-programmable GPIOs
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port

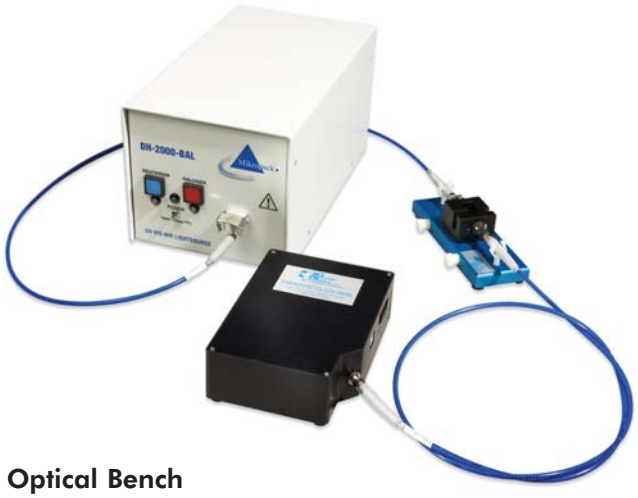
HR4000CG Spectrometer: UV-NIR

200-1100 nm Range, 0.75 nm Resolution

The HR4000CG Composite-grating Spectrometer utilizes a proprietary grating and order-sorting filter to provide a 200-1100 nm wavelength range and 0.75 nm optical resolution (FWHM). The revolutionary HR4000CG is a preconfigured HR4000 Spectrometer -- where all of the optical bench options are already selected for you.

Composite-grating & Order-sorting Filter

The HR4000CG uses the HC-1 grating, which is a revolutionary and proprietary variable blazed grating designed to provide a 200-1100 nm wavelength range. (Though the spectrometer is configured for 200-1100 nm, its best efficiency is from 200-1050 nm. See the grating efficiency curve for the HC-1 on page 23.) In addition to this new composite grating, the HR4000CG has an OFLV-200-1100 variable longpass order-sorting filter to eliminate second- and third-order effects. Both are installed at the time of manufacture and are fixed in place.



Optical Bench

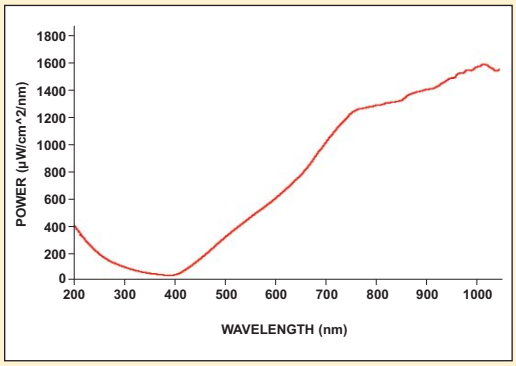
The HR4000CG Spectrometer uses the "HR" Optical Bench, comes with a 5 µm entrance slit, and has a UV4 Detector Upgrade to enhance the performance of the spectrometer in the UV. The HR4000CG is an upgrade from the HR2000CG. The HR4000CG comes with a 3648-element linear-array CCD detector that provides better optical resolution throughout the UV-NIR range.

USB 2.0 Compatibility and New Digital I/Os

The HR4000CG interfaces to a PC via a USB port. Software reads programmed data unique to each spectrometer for easy setup. The HR4000CG also offers 10 user-programmable digital inputs/outputs, 1 analog input and 1 analog output.

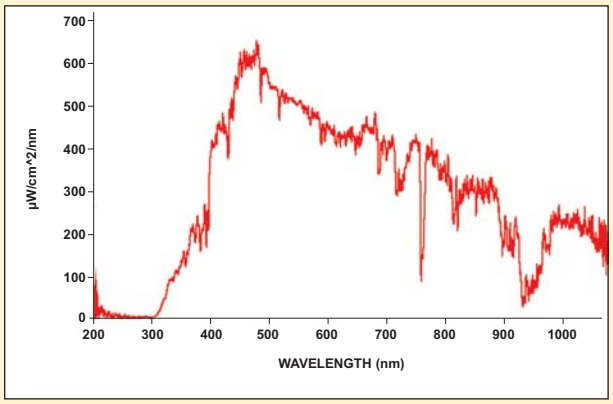
HR4000CG-UV-NIR: $4,999

Sample Spectrum



An irradiance spectrum of the DH2000 Deuterium Tungsten Halogen Light Source taken with the HR4000CG.

Sample Spectrum



A solar irradiance spectrum taken with the HR4000CG.

Specifications	
PHYSICAL	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
DETECTOR	
Detector:	Toshiba TCD1304AP linear CCD array (page 24)
Pixels:	3648 pixels, pixel size of 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, 101.6 mm output
Entrance aperture:	5 µm wide slit (page 22)
Grating:	HC-1, 300 lines per mm grating (page 23)
Order-sorting filters:	Installed OFLV-200-1100 (page 24)
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
SPECTROSCOPIC	
Wavelength range:	200-1100 nm, best efficiency 200-1050 nm
Optical resolution:	0.75 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)
Dark noise:	12 RMS counts
Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition
Integration time:	3.8 ms to 10 seconds
ELECTRONICS	
Power consumption:	450 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 4 ms with USB 2.0 port, 18 ms with USB 1.1 port
Inputs/Outputs:	10 onboard digital user-programmable GPIOs*
Analog channels:	One 13-bit analog input, One 9-bit analog output
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; any 32-bit Windows OS using serial port

** Programming the GPIOs requires SpectraSuite or OmniDriver. See pages 80-82 for details.*

CHEM4 Systems for Education

Instructional Materials for Teaching Labs

We've begun to develop a rich library of spectroscopy educational materials for both students and educators. Our first effort, *Introduction to Spectroscopy in the Teaching Lab Using Ocean Optics Spectrometers*, is a handy reference tool for introducing Ocean Optics to the modern teaching lab. Included are experiments and sample lab exercises for our spectrometer and PASCO Scientific's GLX Explorer dataloggers. Here's a sampling of featured exercises:

- Absorbance of Light vs. Concentration (Beer's Law)
- Kinetics of Crystal Violet Bleaching
- Spectrophotometric Determination of an Equilibrium Constant
- Spectrophotometric pH Determination Using Bromocresol Green

With so many lab exercises built around use of the old Spec20, these Ocean Optics spectrometer experiments -- all of which come from recipients of our educational grants -- are great for getting started in your new lab setup, or for use with any post-dispersive spectrometer.

Item	Description	Price
EDU-SPEC-BOOK	Print version of Educational Spectroscopy Handbook	$100
EDU-SPEC-BOOK-S	Print version of Educational Spectroscopy Handbook; when purchased with a spectrometer	$75
EDU-SPEC-CD	CD version of Educational Spectroscopy Handbook in PDF format; includes how-to video for making basic measurements	$45
EDU-SPEC-CD-S	CD version of Educational Spectroscopy Handbook in PDF format; includes how-to video for making basic measurements; when purchased with a spectrometer	$25
EDU-SPEC-D	Online version, educational spectroscopy handbook	$20
EDU-SPEC-D-S	Online version, educational spectroscopy handbook; when purchased with a spectrometer	Free

Unique Teaching Tool = More Data, Faster

Our CHEM4-series Spectrophotometers for Education are small-footprint, PC-based systems designed for professors, teachers and others who use spectroscopy as a teaching tool. These fully integrated systems -- including spectrometer, light source and cuvette holder -- are available at dramatic discounts with the trade-in of an old lab instrument. Acquire and display real-time complete spectral data (3648 wavelengths) in <1 second with our convenient, PC-based systems.

Sampling Optics: Direct-attach or Fiber

Each CHEM4 system comes with a fully integrated light source and cuvette holder that attaches to the spectrometer, either directly or via fiber, for a small-footprint system.

Direct Attach: The CHEM4-UV-VIS has a state-of-the-art, miniature RF-excited deuterium tungsten source. The CHEM4-VIS-NIR has a direct-attach combination tungsten and blue LED source. You can separate each spectrometer from its integrated light source to couple the spectrometer to any of our fiber optic accessories and light sources.

Fiber: The CHEM4-UV-FIBER and CHEM4-VIS-FIBER include a light source and cuvette assembly that attaches to the spectrometer with an optical fiber. The advantage of this design is that the light source can be easily coupled to other fiber optic accessories such as reflection probes or transmission dip probes. The CHEM4-UV-FIBER uses a deuterium tungsten source and the CHEM4-VIS-FIBER comes with a tungsten source.

USB Interface for Easy Startup

All of our CHEM4 systems interface to a PC via USB. All you need is to install the software and connect the included USB cable to your PC to be up and running. Wavelength calibration data are loaded automatically upon startup, and spectrometer power is supplied through the USB.

Software for Linux, Macintosh & Windows

All CHEM4 systems come with student-friendly software, which includes functions for absorbance, transmission, relative irradiance and kinetics measurements. Our new SpectraSuite Spectroscopy Operating Software (pages 80-81) works in Linux, Macintosh and Windows operating systems.

Discount Pricing & Cost Sharing

Any learning institution qualifies for trade-in prices for CHEM4 systems. Save $1,500 by trading in your old monochromator or spectrometer. See the facing page for retail and trade-in prices. Our *Innovations in Education Spectroscopy Grant Program* rewards educators and researchers for utilizing fiber optic spectroscopy in curricula or in research. See page 8 for more.

CHEM4 Systems for Education

		Spectrometer & A/D Converter	Wavelength Range*	Light Source & Sample Holder	Optical Fiber	Retail Price	Trade-in Price
CHEM4-UV-VIS		USB4000-UV-VIS	210-880 nm	USB-ISS-UV-VIS integrated deuterium tungsten halogen light source and cuvette holder for 1-cm square cuvettes	None -- integrated light source and sample holder directly attaches to spectrometer	$3,999	$2,499 (save $1,500)
CHEM4-VIS-NIR		USB4000-VIS-NIR	370-985 nm	USB-ISS-VIS integrated tungsten bulb with a violet LED and cuvette holder for 1-cm square cuvettes	None -- integrated light source and sample holder directly attaches to spectrometer	$2,999	$1,499 (save $1,500)
CHEM4-UV-FIBER		USB4000-UV-VIS	200-885 nm	ISS-UV-VIS integrated deuterium tungsten halogen light source and cuvette holder for 1-cm square cuvettes	Lamp and sample holder attach to spectrometer via 1-meter long P300-1-SR assembly with 300 µm diameter solarization-resistant fiber	$3,999	$2.499 (save $1,500)
CHEM4-VIS-FIBER		USB4000-VIS-NIR	430-990 nm	ISS-2 integrated tungsten halogen light source and cuvette holder for 1-cm square cuvettes	Lamp and sample holder attach to spectrometer via 2-meter long P400-2-UV-VIS assembly with 400 µm diameter fiber	$2,999	$1,499 (save $1,500)

Specifications

	CHEM4-UV-VIS	CHEM4-VIS-NIR	CHEM4-UV-FIBER	CHEM4-VIS-FIBER
SYSTEM				
Wavelength range*:	210-880 nm	370-985 nm	200-885 nm	430-990 nm
Optical resolution:	~1.0 nm FWHM	~1.0 nm FWHM	~1.0 nm FWHM	~1.0 nm FWHM
Integration time:	3.8 ms to 10 seconds	3.8 ms to 10 seconds	3.8 ms to 10 seconds	3.8 ms to 10 seconds
Dimensions (in mm):	89.1 x 63.3 x 34.4 (USB4000) 198 x 105.1 x 40.6 (USB-ISS-UV)	89.1 x 63.3 x 34.4 (USB4000) 40.7 x 88.8 x 34.1 (USB-ISS-VIS)	89.1 x 63.3 x 34.4 (USB4000) 198 x 104.9 x 40.9 (ISS-UV-VIS)	89.1 x 63.3 x 34.4(USB4000) 155 x 50 x 53.3 (ISS-2)
DETECTOR & OPTICAL BENCH				
Detector:	Toshiba CCD array (page 17)	Toshiba CCD array (page 17)	Toshiba CCD array (page 17)	Toshiba CCD array (page 17)
Pixels:	3648 pixels	3648 pixels	3648 pixels	3648 pixels
Optical bench design:	f/4, crossed Czerny-Turner	f/4, crossed Czerny-Turner	f/4, crossed Czerny-Turner	f/4, crossed Czerny-Turner
Entrance aperture:	25 µm wide slit (page 15)	25 µm wide slit (page 15)	25 µm wide slit (page 15)	25 µm wide slit (page 15)
Grating:	Grating #1 (page 16)	Grating #2 (page 16)	Grating #1 (page 16)	Grating #2 (page 16)
Order-sorting filters:	OFLV-200-850 (page 17)	OFLV-350-1000 (page 17)	OFLV-200-850 (page 17)	OFLV-350-1000 (page 17)
LIGHT SOURCE/SAMPLE CHAMBER				
Bulb(s):	Deuterium and tungsten halogen	Tungsten halogen and violet LED	Deuterium and tungsten halogen	Tungsten halogen
Bulb lifetime:	800 hours	45,000 hours	800 hours	900 hours
Cuvette pathlength:	1 cm	1 cm	1 cm	1 cm
Optical fiber:	N/A	N/A	300 µm solarization-resistant, 1 m	400 µm diameter fiber, 2 m
ELECTRONICS & COMPUTER				
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port			
Computer interfaces:	USB 2.0 @ 480 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud			

** The actual ranges may exceed these listed here. Ranges listed are where you will see changes as small as 1.0 absorbance units.*

Red Tide Spectrometer for Education

At just $999, the Red Tide is a great general-purpose spectrometer for budget-strapped teaching labs. Combine the Red Tide with Ocean Optics light sources, accessories and software to create a fully integrated, small-footprint system.

Specifications	
PHYSICAL	
Dimensions (in mm):	89.1 x 63.3 x 34.4 (USB-650); 89.1 x 104 x 34.4 (USB-650-VIS-NIR)
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:	350-1000 nm (USB-650); 370-980 nm (USB-650-VIS-NIR)
Optical resolution:	~2.0 nm FWHM
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	12 bit
Dark noise:	3.2 RMS counts
Dynamic range:	2 x 10^8; 1300:1 for a single acquisition
Integration time:	4 milliseconds to 10 seconds
Stray light:	<0.05% @ 600 nm; <0.10% @ 435 nm
Corrected linearity:	>99.8%
COMPUTER	
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux w/USB port
Operating software:	SpectraSuite Spectroscopy Operating Software

World's Most Amazing $999 Spectrometer

The Red Tide Spectrometer is a low-cost, small-footprint lab spectrometer that's ideal as a general-purpose instrument for budget-conscious teaching and research labs. The Red Tide has a wavelength range of 350-1000 nm, and utilizes a detector with 650 active pixels; that's 650 data points in one full spectrum, or one data point per nanometer. Configured with a 25 µm entrance slit, the Red Tide offers ~2.0 nm optical resolution (FWHM).

Flexible Platform, Convenient Interface

The Red Tide is a preconfigured, off-the-shelf spectrometer where all of the optical bench options, such as grating and entrance slit size, are already selected. The Red Tide can be used with various Ocean Optics accessories, light sources and sampling optics, to create application-specific systems for various absorbance, reflection and emission applications. With its small footprint, convenient USB interface, and four millisecond integration time, the Red Tide is a great tool for basic lab measurements.

Spectrometer Alone or with Sampling System

The USB-650 Red Tide comes without a light source or sample system, allowing you the freedom to choose the accessories that best fit your setup. The USB-650-VIS-NIR (at right) comes with a direct-attach light source and sample holder. The light source includes an LED-boosted tungsten source and a sample holder for 1-cm cuvettes that connects to the front of the spectrometer. In this configuration, the system has a wavelength range of 370-980 nm.

Operable with PCs or Dataloggers

The Red Tide interfaces to PCs via its USB port, which streamlines start-up and supports hot swapping of the spectrometer. What's more, the Red Tide interfaces to Pasco's Xplorer GLX, a unique combination of datalogger and lab analysis tool that eliminates the need for a PC. For details, see the facing page. The Red Tide also works with Vernier's Logger Pro Software. Visit www.vernier.com/soft/lp.html for details.

Cross-platform Spectrometer Software

Red Tide operates via SpectraSuite Spectroscopy Operating Software, the first spectroscopy software to run in Macintosh, Linux and Windows. The Chemistry module for SpectraSuite includes features specifically designed for educational use, such as a Beer's Law calculator for absorbance experiments.

USB-650: $999
USB-650-VIS-NIR: $1,499
SpectraSuite: $199

Xplorer GLX Handheld Datalogger

The World's First Graphing Datalogger for Science

The new Xplorer GLX from PASCO captures, analyzes, annotates and stores data quickly and seamlessly, without being connected to a desktop computer. The Xplorer GLX has been designed to function with our line of Spectrometers for Education: the CHEM4 Spectrophotometers (pages 36-37) and the USB-650 Red Tide Spectrometer (page 38). The Xplorer GLX is a science lab wherever you need it, whether you are in the lab or out in the field. When combined with the Xplorer GLX, our Spectrometers for Education become powerful measurement, display and analysis tools for students. The Xplorer GLX can display real-time intensity, absorbance, transmission or relative irradiance spectra in less than one second.

The PS-2636 Xplorer GLX (in blue) easily connects via USB cable to the USB-650 Red Tide Spectrometer for capturing, displaying and analyzing real-time spectroscopic data.

For those who already own an Xplorer GLX, you only need to purchase the PS-2555 License Key and an Ocean Optics spectrometer; the key will enable the Xplorer to work with our line of education spectrometers.

Stand-alone Computing Power

The Xplorer GLX is built for the demanding university teaching environment. It incorporates an easy-to-use, icon-based operating system as well as navigation buttons and a numeric/alphanumeric keypad. With 10 MB of internal memory, the Xplorer can be used as a stand-alone computer but also can interface to traditional desktop computers. If more memory is needed, save Xplorer data to a flash drive. For traditional navigation and annotation, you can plug in an optional USB mouse and keyboard. The Xplorer's rechargeable NiMH battery enables field portability and its large backlit LCD screen is visible in both sunlight and low-light conditions. In addition, a USB port allows students to print graphs and tables directly from the Xplorer GLX to select Hewlett-Packard printers.

Built for Science

The Xplorer GLX includes helpful student features such as a built-in graphing calculator with an expression editor for analyzing trends. The datalogger also includes statistical and mathematical tools to easily review data and perform basic data analysis, such as linear curve fits. Students can annotate data points with either text notes or recorded voice messages (the GLX has a built-in speaker for sound output). The Xplorer GLX has four universal sensor ports as well as ports for two Temperature Sensors, a Sound Sensor, and a Voltage Sensor (included).

Ordering Information

Order the PS-2555 License Key if you already own an Xplorer GLX but want it to work with an Ocean Optics Spectrometer. The PS-2555 is a License Key only; it does not include a spectrometer or the Xplorer GLX. The PS-2636 comes with the Xplorer GLX and the License Key (an Ocean Optics spectrometer is sold separately). The License Key also includes a feature set from our SpectraSuite Spectroscopy Operating Software; however, if you wish to download data from the Xplorer GLX and utilize it on a desktop PC, you may want to purchase the full SpectraSuite Software.

PS-2636 Xplorer GLX & License Key: $425
PS-2555 License Key: $129

The Xplorer GLX comes with software, a power supply, a USB cable, two temperature sensors, a sound sensor, a voltage sensor and easy-to-use instructions.

Specifications	
Dimensions (in mm):	89.1 x 63.3 x 34.4
Display screen:	320 x 240 backlit transflective LCD grayscale display
Sampling rate:	50,000 Hz maximum
Internal memory:	10 MB
Battery:	Rechargeable NiMH battery
Xplorer with USB-650 Red Tide:	Supports basic functions
Xplorer with CHEM4 units:	Supports triggering functions and digital user-programmable GPIOs

MEMS-based NIR Spectrometer

We recommend our VIS-NIR Optical Fiber Assemblies in diameter sizes greater than 500 µm for use with the DTS Spectrometers.

Compact, Low-Cost NIR Spectrometers

Digital Transform Spectroscopy (DTS) NIR Spectrometers by Polychromix are compact, low-cost NIR systems powered by MEMS architecture. Available in 0.9-1.7 µm, 1.7-2.5 µm and 1.1-1.3 µm wavelength ranges, the spectrometers have no moving parts, and feature a single-element InGaAs detector. The fully programmable spectrometers can be configured to operate in various scanning modes for a variety of general-purpose NIR applications that include quality control, education, R&D and industrial process control. The DTS-series NIR Spectrometers are compact and portable, interface to PCs via USB, and require no external power.

Digital Transform Spectroscopy (DTS)

Polychromix's DTS-series Spectrometers use a grating and an innovative MEMS spatial light modulator to disperse light onto the the system's single-element InGaAs detector. Each wavelength of light can be modulated on and off with differing time sequences. The resulting time-varying signal is processed to create a spectrum.

Spectrometer Models and Accessories

Ocean Optics offers three Polychromix DTS NIR Spectrometer models that vary by wavelength range. Each DTS Spectrometer includes a protective cover, DTS software, a USB cable and documentation.

DTS-1700: $7,199
DTS-2500: $10,999
DTS-NB: $7,199

Specifications

	DTS-1700	DTS-2500	DTS-NB
Dimensions:	105 mm x 85 mm x 145 mm	105 mm x 85 mm x 145 mm	105 mm x 85 mm x 145 mm
Weight:	1.8 kg	1.8 kg	1.8 kg
Spectral range:	~930-1690 nm	~1710-2460 nm	1100-1350 nm
Detector:	Single-element InGaAs	Single-element InGaAs	Single-element InGaAs
Optical resolution:	12.0 nm	22.0 nm	4.0 nm
Photometric stability:	<0.05% over 6 hours	<0.05% over 6 hours	<0.05% over 6 hours
Measurement time:	<1 second per spectrum	<1 sec. per spectrum	<1 sec. per spectrum
Operating systems:	Windows Me, 2000, XP	Windows Me, 2000, XP	Windows Me, 2000, XP
Operating temp:	-5 °C to 40 °C	-5 °C to 40 °C	-5 °C to 40 °C

Phazir MEMS-based NIR Material Analyzer

Specifications

Dimensions:	254 mm x 292 mm x 152 mm
Weight:	1.7 kg
Light source:	Tungsten light bulb
Wavelength range:	DTS-PHAZIR-1016: 1000-1600 nm; DTS-PHAZIR-1624: 1600-2400 nm
Resolution (FWHM):	DTS-PHAZIR-1016: 8.0 nm; DTS-PHAZIR-1624: 12.0 nm
Security:	Password protection, multiple security levels
Operating temp.:	5 °C to 45 °C (40 °F to 115 °F)
Batteries:	Rechargeable 5-8 hour lithium-ion battery pack
Included:	Waterproof carrying case, reference/calibration cap, PC interface cable, 110/220 VAC battery charger/adapter, documentation CD, spare bulb, bulb replacement tools

Point-and-shoot NIR Measurement Tool

The handheld Phazir NIR Material Analyzer enables real time and instantaneous qualitative and quantitative material analysis and provides both material ID and concentration levels via its onboard color LCD screen. This non-destructive measurement tool stores all data into memory, which allows the user to transfer the data to a PC for logging or additional processing.

Applications

Designed for the technician, the point-and-shoot Phazir requires minimal training to operate. The Phazir is perfect for use in materials identification, incoming material inspection, quality control, quality assurance and portable field use.

Portability & Durability

The Phazir is a portable and handheld device weighing only 1.7 kg. Its rechargeable batteries allow 5-8 hours of continued use. The instrument is housed in injection-molded plastic that can withstand harsh environments.

DTS-PHAZIR-1016: $20,000
DTS-PHAZIR-1624: $24,000

Process-2000 Process Control Systems

Multichannel Spectrometer Systems for Process Control

Process-2000 Multichannel Spectrometer Systems are designed for the process control environment. The custom experiment feature allows you to configure custom experiment methods for your process. Once you save a custom method, you need only select the method file to execute your custom experiment. The systems allow you to have full access, remotely if needed, to all software and hardware functions via easy-to-use monitoring and control software. Your spectral data (absorbance, transmission, reflection or emission) can be acquired in 3.8 milliseconds, and mathematically calculated, subtracted and monitored in situ and in real time.

Inputs/Outputs Provide Full Control

A Process-2000 system interfaces to a computer via a USB cord and can be controlled remotely. These systems interface to other process equipment and control hardware via digital and analog inputs/outputs. You have access to 16 digital inputs/outputs per spectrometer channel and eight analog outputs per spectrometer channel. Some ways the inputs/outputs can be used:

- A digital input could come from the process control setup
- A digital output can display the upper and lower limits you have set for a monitoring cycle, or could stop a process under special circumstances, such as when an abnormal phenomena are detected
- An analog output can read out measurement specifications or control a pressure or liquid flow valve

Multichannel Spectrometer Systems

Process-2000 systems provide the ultimate flexibility. Detector options for each spectrometer channel include a 1024-, 2048- or 3648-element linear CCD array. Choose all of your spectrometer options from the size of the bench's entrance aperture to the wavelength range of the channel for a true application-specific system. Specify from two to six spectrometer channels.

Included Process-2000 Software

Process-2000 systems come with sophisticated software tools. The Recipe Editor tool allows you to easily and rapidly configure, build and save experiment methods even for the most difficult and complex processes. After creating a "recipe," you select it to execute the experiment. The Integrated Formula Editor provides easy access to a full range of mathematical and algorithmic functions. The Wavelength Editor allows you to optimize signal-to-noise. A dual-window interface shows the actual spectrum and all process control information.

Additional Software: SpecLine Software for Compound ID

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 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. For more on SpecLine, see page 83.

Process-2000 systems can make absorbance, transmission, reflection and emission measurements. Application-specific measurements include:

- Light emission
- Peak detection
- Particle densities
- Electron densities
- Electron temperature
- Planarization
- Contamination
- Failure analysis
- Pulsed magnetron sputtering
- Quality control (pollutants, discharges, etc.)
- Endpoint detection
- Film/layer monitoring
- Thin film thickness
- Etching and deposition
- Plasma chamber health control
- Protection coatings

Item	Description	Price
PROCESS-2000-2	2-channel spectrometer system with housing; select detector, wavelength range, entrance slit for each channel	$19,998
PROCESS-2000-3	3-channel spectrometer system with housing; select detector, wavelength range, entrance slit for each channel	$22,678
PROCESS-2000-4	4-channel spectrometer system with housing; select detector, wavelength range, entrance slit for each channel	$25,358
PROCESS-2000-5	5-channel spectrometer system with housing; select detector, wavelength range, entrance slit for each channel	$28,038
PROCESS-2000-6	6-channel spectrometer system with housing; select detector, wavelength range, entrance slit for each channel	$30,718

Deep Well for High S:N

Sensitivity to 0.00001 Absorbance Units

The S1024DW Deep Well Detector Spectrometer has a 1024-element photodiode array detector for applications requiring high signal-to-noise ratio measurements. With the S1024DW, you can observe absorbance changes of less than 0.00001 absorbance units -- performance that makes the spectrometer ideal for high light-level applications.

"X" Option: Extra-deep Well Detector

The S1024DW is our standard deep well detector spectrometer. Its photodiode-array detector has a signal-to-noise ratio of 2500:1. Also available is the S1024DWX, with a detector distinguished by both its deeper well depth and S:N of 8000:1.

Bench Ideal for High Light-level Applications

The S1024DW uses the "USB" (also called the "S") Optical Bench, which allows you to configure the bench for your application. You can choose an entrance aperture size, detector accessories, filters, a grating and more (see pages 15-17). The S1024DW bench operates much like the USB4000 bench seen on page 15. The bench accepts light energy via an optical fiber and disperses it across a very sensitive 1024-element photodiode array, instead of the 3648-element CCD array that's used in the USB4000.

Stackable System for Multipoint Sampling

You can add up to seven S1024DW Spectrometer channels to your master S1024DW Spectrometer channel to measure multiple samples, expand your wavelength range or monitor a reference. All channels operate from a single ADC1000-USB A/D Converter, which has a channel rotator function that enables simultaneous acquisition of data from up to eight spectrometer channels. The ADC1000-USB interfaces the S1024DW to your PC via a USB port. You can purchase the S1024DW and the ADC1000-USB separately, or buy them as one item (S1024DW-USB) and save $99. See page 84 for more on the ADC1000-USB.

S1024DW-USB:	$3,099
S1024DW (master channel):	$2,599
S2-1024DW (additional channel):	$1,399
S1024DW X (master channel):	$3,999
S2-1024DWX (additional channel):	$2,899
ADC1000-USB:	$599

Detector Options for S1024DW-series

Features	S1024DW	S1024DWX
Detector:	Hamamatsu S3903 linear photodiode array	Hamamatsu S3904 linear photodiode array
Number of Elements:	1024 pixels	1024 pixels
Pixel Size:	25 µm x 500 µm	25 µm x 2500 µm
Well Depth:	31,000,000 electrons	156,000,000 electrons
S:N (at full signal):	2500:1	8000:1
A/D Resolution:	12 bit	16 bit
Dark Noise:	2 RMS counts	2 RMS counts
Corrected Linearity:	>99%	>99%

Detector Accessories for S1024DW-series

Item	Description	Price
L2 Detector Collection Lens	Cylindrical lens placed on the detector for increased light-collection efficiency	$150
OFLV-DW	Variable longpass filter removes second- and third-order effects for systems from 200-850 nm	$150
OFLV-350-DW	Variable longpass filter removes second- and third-order effects for systems from 350-1000 nm	$150

Specifications

Dimensions:	153.4 mm x 105.2 mm x 65.6 mm (when housed with the ADC1000-USB A/D Converter)	Order-sorting filters:	Installed bandpass and longpass filters (page 17)
		Focal length:	42 mm (input); 68 mm (output)
Power consumption:	180 mA @ 5 VDC (master channels for S1024DW & DWX) 140 mA @ 5 VDC (additional channels for S1024DW & DWX)	Optical resolution:	~0.3-10.0 nm FWHM (depending on grating and size of entrance aperture)
Detector:	Linear photodiode array (see above)	Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Detector range:	200-1100 nm	Relative sensitivity:	Compared to CCD detector in USB2000, S1024DW is ~30x less sensitive in the UV and ~80x less sensitive in the VIS
Gratings:	14 gratings; UV through Shortwave NIR (page 16)		
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits (page 15) or fiber (no slit)	Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
		Integration time:	31 milliseconds to 65 seconds

Flow Injection Analysis System

Automated System for Assays

The FIA-LAB-2500 is a flow injection analysis system from FIAlab Instruments, a longtime Ocean Optics partner. The FIA-LAB-2500 was designed for automation of common environmental and agricultural assays such as nitrate, phosphate and ammonia. A complete, automated FIA-LAB-2500 system -- including a USB4000 Spectrometer, light source, flow cell, accessories and optional XYZ autosampler -- can be configured for about $20,000. Affordability and flexibility make the system ideal for teaching, research and commercial labs, especially where routine analyses demand a robust, easy-to-use system. Commonly measured analytes include ammonia, chloride, copper, iron, nitrate, nitrite and phosphate.

Built-in Flexibility, Affordability

The standard FIA-LAB-2500 consists of an automated flow injection system with a four-channel peristaltic pump, a six-port injector valve with fittings and tubing, a flow cell, an LED light source and software. (Other light sources are available at additional cost.) A spectrometer does not come with the FIA-LAB-2500; we recommend the USB4000-VIS-NIR (page 34). A range of accessories is available, including the FIA-ASX260 Autosampler with 180-sample capacity, the flow-through FIA-HEATER for elevated-temperature assays, and flow cells of varying optical pathlengths. Longpath flow cells are available for ultra-low concentration assays.

Ease of Use Tops List of Benefits

The FIA-LAB-2500 automates the handling of sample and reagent solutions, so that messy, awkward and inexact manual handling of solutions is unnecessary. Ease of operation is one of several benefits:

- There is no need to purchase separate expensive manifolds for each type of analytical method.
- Wavelength selections are made through software; no additional filters or lamps are required.
- Monitoring multiple wavelengths (up to four) substantially extends the system's dynamic range.
- Reference wavelengths are utilized for compensation of colored matrices and index of refraction effects.
- The system automatically corrects for response drift.

Example Applications

Nitrate/Nitrite Assay. This method performs FIA assays for soil testing and analysis of potable water and ground, surface, domestic and industrial wastewaters.

Phosphate Assay. A phosphate measurement method based on U.S. EPA protocols, best suited for agricultural and environmental testing.

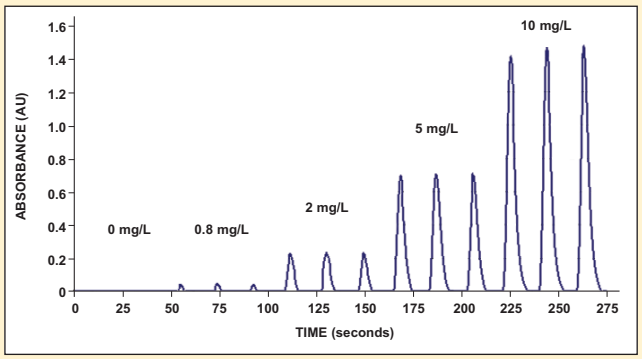
Ammonia Assay. An FIA assay for low ammonia concentrations using the salicylate method. Ideal for agricultural and environmental testing.

FIA-LAB-2500:	**$10,500**
FIA-ASX260:	**$5,800**
FIA-HEATER:	**$450**

Assay	Throughput	Working Range*
Nitrate	180 samples/hour	0.03 mg-200 mg/liter
Nitrite	220 samples/hour	0.005 mg-100 mg/liter
Ammonia	120 samples/hour	0.5 mg-200 mg/liter
Phosphate	120 samples/hour	0.1 mg-25 mg/liter
Chloride	120 samples/hour	1.0 mg-50 mg/liter
Iron	140 samples/hour	0.1 ppm-100 ppm

** Lower working ranges available with long pathlength flow cells, please contact Ocean Optics for details.*

Nitrate Run: Raw Data of Triple Injections

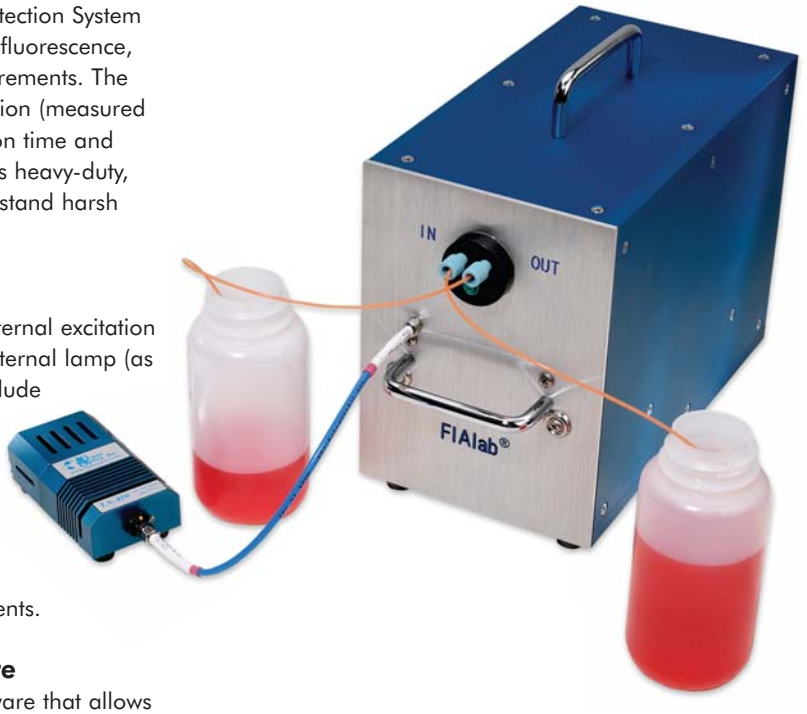


Specifications	
Accuracy (typical):	2%-3%
Precision (typical):	1%-2%
Pump:	4-channel standard, 6-channel available
Dimensions:	24 cm height x 24 cm depth x 16.5 cm width
Weight:	6.75 kg
Recommended light source:	LS-1 Tungsten Halogen Light Source (360-2000 nm), see page 128
Recommended spectrometer:	USB4000-VIS-NIR (350-1000 nm), see page 34
Autosampler (optional):	180, 270 or 360 samples; 10 standards
Flow-through heater (optional):	Ambient up to 50 °C (accuracy is +/- 0.5 °C)

PMT for Fluorescence Flow Analysis

Parts-per-trillion Sensitivity

The FIA-PMT-FL Photomultiplier Flow-through Detection System provides parts-per-trillion sensitivity for ultra-low fluorescence, chemiluminescence and bioluminescence measurements. The system can achieve sensitivity of 10 parts per trillion (measured with fluorescein with a 200 millisecond integration time and using an internal LED light source). Because of its heavy-duty, chemically resistant housing, the system can withstand harsh industrial environments.



Modular Design

The FIA-PMT-FL is built to order with either an internal excitation lamp or with an optical fiber interfacing to an external lamp (as seen at right). Excitation lamp source options include tungsten, mercury vapor, ultraviolet and visible LEDs, and laser diodes. Emission and excitation filters are mounted in slots in the enclosure, allowing for easy removal or exchange. Though the system uses a 25 μL flow-through cuvette, you can also use standard 1-cm pathlength cuvettes for manual measurements.

Easy PC Interface & Optimized Software

Included with the system is Windows-based software that allows you to set the integration time and acquisition rates, and to obtain time histories of the measurements, both plotted and tabulated. The software can also automatically create calibration curves, as well as controlling a host of additional devices such as FIAlab's FIA/SIA systems, syringe and peristaltic pumps, injection valves, selection valves, and autosamplers (please inquire for details). For users who desire to control the PMT-FL from their own software project, included is an ActiveX control for use with Visual Basic, VC++, LabVIEW, or nearly any other ActiveX-compatible development environment.

Example Assays Applications for the PMT-FL

- Fluorometric ammonium analysis: ultra low level assays, parts per billion sensitivity.
- F4551: Fluorescein di(b-D-glucuronide) hydrolyzes to fluorescent fluorescein. It has been used to detect ß glucuronidase activity, an assay for lysosomal enzyme release from neutrophils.
- M8639: 2'-(4-Methylumbelliferyl)-a-D-N-acetylneuraminic acid sodium salt hydrate, which is a fluorometric assay of neuraminidase.
- L9009: Luciferase Photinus pyralis. The bioluminescent reaction of this enzyme with luciferin, ATP, and O_2 results in the emission of light. Luciferase can be used to detect trace amounts of ATP.
- GUS-A: b-Glucuronidase Fluorescent Activity Detection Kit. The substrate used in this kit is MU-GlcA (4-methylumbelliferyl b-D-glucuronide), a widely used fluorogenic substrate for determining glucuronidase activity.

FIA-PMT-FL: $6,495

Specifications	
Dimensions:	~13 cm x 18 cm x 25.4 cm
Spectral range:	310-750 nm (filter/lamp selection dependent)
Detector:	Photo-counting photomultiplier tube
PMT dynamic range:	2 x 10^6
Responsivity:	5 x 10^{17} cps/watt (@ 400 nm)
Detection limits:	10 parts per trillion measured with fluorescein @ 200 msec integration time and internal LED light source
Pulse-pair resolution:	10 ns
Flow cell pathlength:	10 mm
Flow cell volume:	25 µL with standard flow-through cuvette
Filters:	Each FIA-PMT-FL includes your waveband choice of 1 excitation filter and 1 emission filter (call for options)
Computer interface:	RS-232
Operating systems:	Windows 98/Me/2000/XP operating systems
Flow through heater:	Heated flow cell (optional), ambient to 60 °C, +/- 0.5 °C accuracy.

Internal Excitation Source Options:

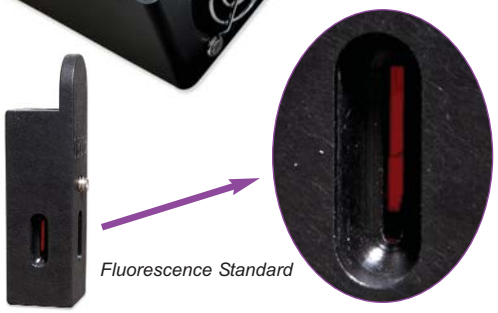
- Laser Diodes (532 nm, 635 nm or 650 nm)
- Quartz tungsten lamp (440-750 nm)
- Mercury Vapor lamps (350-400 nm)
- UV LED lamp (270-410 nm)
- Various visible LED lamps

External Excitation Source Options:

- Laser Diodes (532 nm, 635 nm or 650 nm)
- Quartz tungsten lamp (440-750 nm)
- Mercury Vapor lamps (350-400 nm)
- UV LED lamp (270-410 nm)
- Various visible LED lamps
- Deuterium lamp (200-400 nm)

QE65000 Configured for Fluorescence

QE65000 Scientific-grade Spectrometer



Fluorescence Standard

Specifications

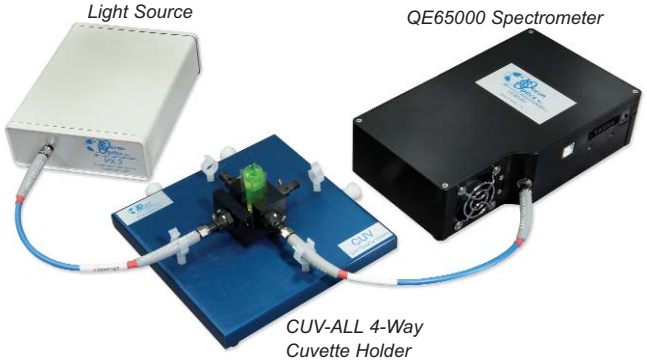
PHYSICAL	
Dimensions (in mm):	182 x 110 x 47
Weight:	1.05 kg
DETECTOR	
Detector:	Hamamatsu S7031-1006 back-thinned CCD (page 28)
Detector range:	200-1100 nm
Pixels:	1024 x 58 (1044 x 64 total)
Pixel size:	24.6 µm square size
Signal-to-noise ratio:	1000:1 (at full signal)
Dark noise:	2.5 RMS counts
Sensitivity:	400 nm: 22 electrons/count, 250 nm: 26 photons/count
OPTICAL BENCH	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input, 101.6 mm output
Entrance aperture:	5, 10, 25, 50, 100, or 200 µm wide slits (page 27)
Gratings:	14 gratings, UV through Shortwave NIR (page 28)
Filters:	OFLV-QE and OF-1 order sorting filters (page 27)
SPECTROSCOPIC	
Wavelength range:	Grading dependent
Optical resolution:	~0.14-7.7 nm FWHM
Integration time:	8 milliseconds to 15 minutes
Dynamic range:	25000:1 a single acquisition; 7.5 x 10^9 (system)
Stray light:	<0.08% at 600 nm, <0.4% at 435 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
ELECTRONICS	
Power consumption:	500 mA @ 5 VDC no TE cool; 3 A @ 5 VDC with TE cool
Data transfer speed:	Full spectrum to memory every 8 ms with USB 2.0 port, 8 ms with USB 1.1 port
Inputs/Outputs:	10 onboard digital user-programmable GPIOs
TEMPERATURE & THERMOELECTRIC (TE) COOLING	
Temperature limits:	0 °C to 50 °C for spectrometer, no condensation
Temperature range:	13 °C maximum range between the high and low
Set point:	Software controlled
Lowest set point:	40 °C below ambient, to -15 °C
Stability:	±0.1 °C of set temperature in <2 minutes
COMPUTER	
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; 32-bit Windows OS when using the serial port
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115K baud
Peripheral interfaces:	SPI (3-wire); I^2C inter-integrated circuit

Scientific-grade Spectrometer

The QE65000 Spectrometer is a unique combination of detector and optical bench technologies that provides users with high spectral response and high optical resolution in one scientific-grade spectrometer package.

Demanding Low Light-level Applications

The QE65000 was designed for low-light level applications such as fluorescence, Raman spectroscopy, DNA sequencing, astronomy and thin-film reflectivity. For a complete fluorescence system, combine the QE65000 with a PX-2 Pulsed Xenon Light Source (page 127) to excite your sample in a CUV-ALL 4-Way Cuvette Holder (page 90). In addition, we offer LVF Linear Variable Filters (page 114) to spectrally shape excitation energy from broadband sources such as the PX-2. A solid secondary fluorescence standard, the STAN-FL-RED, can be used for quick and easy calibration, stability, and performance checks of your fluorescence system.



PX-2 Pulsed Xenon Light Source

QE65000 Spectrometer

CUV-ALL 4-Way Cuvette Holder

Quantum Efficiency to 90%

The Hamamatsu FFT-CCD detector used in the QE65000 achieves up to 90% quantum efficiency (defined as how efficiently a photon is converted to a photoelectron). Most of our other detectors are linear CCDs, but with this "2D" area detector we can bin a vertical row of 64 pixels that offers significant improvement in the signal-to-noise ratio (1200:1) and signal processing speed of the detector compared with a linear CCD, where signals are digitally added by an external circuit.

Increased System Sensitivity

QE65000 system sensitivity is improved because the 2D detector allows us to take advantage of the height of the entrance slit. In our spectrometers, you regulate the light entering the bench according to the slit's width. Most of our other spectrometers use linear detectors; in those spectrometers, slit height doesn't matter because linear detectors cannot efficiently collect the light from the entire height of the slit. But with the 2D detector in the QE65000, we can better take advantage of this additional light, extremely useful in low-light fluorescence applications.

QE65000:	$9,999
PX-2:	$769
CUV-ALL:	$809
STAN-FL-RED:	$179

Fluorescence Spectrometers

USB4000-FL

Preconfigured Spectrometers for Use with Sensors

Our high-sensitivity, preconfigured fluorescence spectrometers -- the USB4000-FL, USB4000-FL-450 and USB4000-FL-395 -- were conceived for use with fluorescence-based sensors. Each unit is set to 360-1000 nm and comes with a 200-µm entrance aperture and an L4 Detector Collection Lens for increased light throughput for fluorescence applications.

USB4000-FL: Excitation Source not Included

The USB4000-FL does not include an excitation source; this allows you the flexibility of choosing from several compact, low-cost, modular excitation sources available, such as one of our LEDs (pages 130-131). The excitation sources produce pulsed or continuous output and couple easily to our spectrometers, optical fibers and accessories.

USB4000-FL-450

USB4000-FL-450 & USB4000-FL-395: Excitation Source Included

The USB4000-FL-450 and USB4000-FL-395 Spectrofluorometers are spectrometers configured the same as the USB4000-FL, but each comes with a direct-attach excitation source. The USB4000-FL-450 comes with a 470 nm LED and the USB4000-FL-395 comes with a 395 nm LED Excitation source. (When using these Spectrofluorometers with one of our sensor probes, we recommend the USB4000-FL-450 with FOXY and HIOXY sensing formulations and the USB4000-FL-450 with the FOSPOR sensing formulation. See pages 65-68 for details.) The spectrometer provides power to the LED and enables synchronization functions and I^2C communications. In addition, these sources connect to temperature sensors and contain onboard memory that can be programmed to store temperature and oxygen calibration coefficients.

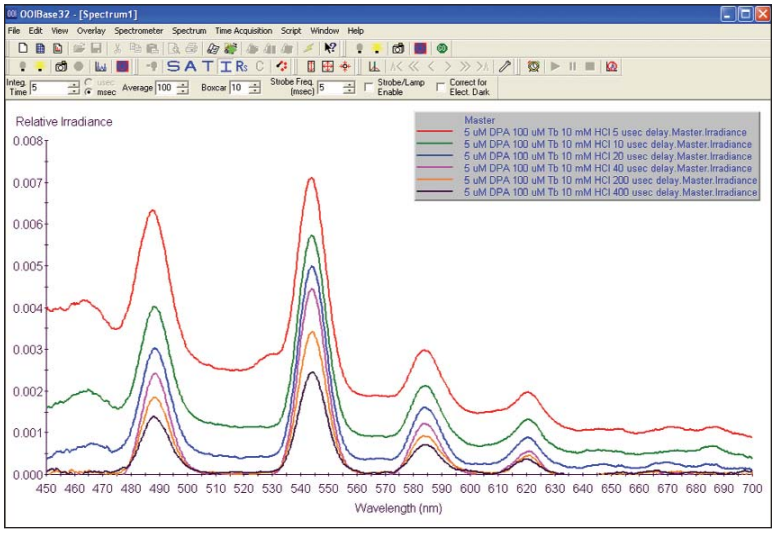
USB4000-FL: $2,499
USB4000-FL-450: $3,049
USB4000-FL-395: $3,049

Specifications

	USB4000-FL	USB4000-FL450	USB4000-FL395
PHYSICAL			
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm	89.1 mm x 120.3 mm x 34.4 mm	89.1 mm x 120.3 mm x 34.4 mm
Weight:	190 grams	310 grams	310 grams
DETECTOR			
Detector:	Toshiba TCD1304AP linear CCD array (see page 17 for detector specifications)	Toshiba TCD1304AP linear CCD array (see page 17 for detector specifications)	Toshiba TCD1304AP linear CCD array (see page 17 for detector specifications)
OPTICAL BENCH			
Design:	f/4, Asymmetrical crossed Czerny-Turner	f/4, Asymmetrical crossed Czerny-Turner	f/4, Asymmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output	42 mm input; 68 mm output	42 mm input; 68 mm output
Entrance aperture:	200 µm wide slit	200 µm wide slit	200 µm wide slit
Grating:	Grating #3, groove density of 600 lines set to 360-1000 nm, blazed at 500 nm	Grating #3, groove density of 600 lines set to 360-1000 nm, blazed at 500 nm	Grating #3, groove density of 600 lines set to 360-1000 nm, blazed at 500 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture fiber	SMA 905 to 0.22 numerical aperture fiber	SMA 905 to 0.22 numerical aperture fiber
SPECTROSCOPIC			
Wavelength range:	360-1100 nm	360-1100 nm	360-1100 nm
Optical resolution:	~10.0 nm FWHM	~10.0 nm FWHM	~10.0 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)	300:1 (at full signal)	300:1 (at full signal)
A/D resolution:	16 bit	16 bit	16 bit
Dark noise:	50 RMS counts	50 RMS counts	50 RMS counts
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
Corrected linearity:	>99.8%	>99.8%	>99.8%
ELECTRONICS			
Power consumption:	250 mA @ 5 VDC	250 mA @ 5 VDC and 60 mA @ 5 VDC	250 mA @ 5 VDC and 60 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 5 ms with USB 2.0 port, 18 ms with USB 1.1 port	Full spectrum to memory every 5 ms with USB 2.0 port, 18 ms with USB 1.1 port	Full spectrum to memory every 5 ms with USB 2.0 port, 18 ms with USB 1.1 port
Inputs/Outputs:	Yes, 8 digital user-programmable GPIOs	Yes, 8 digital user-programmable GPIOs	Yes, 8 digital user-programmable GPIOs
COMPUTER			
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud
Peripheral interfaces:	I^2C inter-integrated circuit; SPI (3-wire)	I^2C inter-integrated circuit; SPI (3-wire)	I^2C inter-integrated circuit; SPI (3-wire)
LIGHT SOURCE			
Stability:	n/a	±1.0% drift after 2-minute warm-up period	±1.0% drift after 2-minute warm-up period
Wavelength range:	n/a	460-490 nm	380-410 nm
Power consumption:	n/a	60 mA @ 5 VDC	60 mA @ 5 VDC
Power output:	n/a	60 µW (minimum) into a 600 µm optical fiber	60 µW (minimum) into a 600 µm optical fiber

Gated Spectrometer for Fluorescence

In addition to the USB2000-FLG, a common fluorescence setup may include products like those shown above: the PX-2 Pulsed Xenon Source, the CUV-ALL-UV Cuvette Holder, LVF Linear Variable Filters, and optical fibers.



Terbium-dipicolinic acid (Tb-DPA) photoluminescence spectra acquired with the USB4000-FLG while in the Gated Mode, with the data acquisition delay set at a range of values. Analysis of samples with long emission lifetimes such as Tb-DPA improves when data acquisition is delayed until the energy from the lamp pulse is no longer observed in the spectrum, resulting in a cleaner, more resolved Tb-DPA spectrum -- achieved without using optical filters. At delay times below 40 microseconds, lingering excitation energy and background fluorescence overlap the Tb-DPA photoluminescence spectrum.

Specifications	
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm
Weight:	190 g
Power consumption:	90 mA @ 5 VDC
Wavelength range:	380-1050 nm
Detector:	2048-element linear silicon CCD array
Grating:	Grating #3 -- 600 lines per millimeter, blazed at 500 nm
Entrance aperture:	200 µm wide slit
Optical resolution:	~10.0 nm FWHM
Stray light:	~0.05% at 600 nm, <0.10% at 435 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
Integration time:	Gated mode - 5 milliseconds, normal mode - 3 milliseconds to 60 seconds
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux operating systems when using the USB port; any 32-bit Windows OS when using the serial port

Ultimate Fluorescence Spectrometer

The USB2000-FLG Spectrofluorometer is a preconfigured spectrometer for fluorescence applications from 380-1050 nm. We utilize a proprietary thin film technology and a time-gated spectrometer to provide a spectro-fluorometer that is 20 percent more sensitive than the standard USB4000 Spectrometer.

Avoiding Scattered Light

In addition to detecting fluorescence from a sample, a spectrofluorometer will also detect scattered excitation light from the light source and the sampling compartment. (Scattering is especially prevalent in turbid samples.) The USB2000-FLG uses two features to avoid detecting scattered light: special mirrors in the optical bench to absorb ultraviolet light and improve sensitivity and -- for fluorophores with long fluorescence lifetimes -- a time-gated mode that delays the start of spectral data acquisition by 5-500 microseconds after the excitation source is turned on (or pulses).

Gated Fluorescence Mode

The USB2000-FLG is preloaded with variable-delay gating microcode, which allows you to select a delay (from 5-500 microseconds) in our software between the light turning on and the start of the spectrometer's integration time, when the detector "sees" the sample. In this Gated Mode, the spectrometer only detects the sample light when the source is off. In order to use the Gated Mode, your fluorophore must have a long fluorescence lifetime. Those working with lanthanides and photoluminescent materials will find this mode very useful. The best excitation source to use with the Gated Mode is our PX-2 Pulsed Xenon Source.

SAG+ High-reflectivity Mirrors

In the USB2000-FLG, we replaced our standard mirrors with proprietary Ag-coated mirrors to increase reflectance, which increases the sensitivity of the spectrometer by more than 20 percent. They also absorb nearly all ultraviolet light, virtually eliminating the excitation source's spectra from interfering with the sample spectra.

Application Flexibility

The USB2000-FLG can detect fluorophores in solutions and powders, and from surfaces. The USB2000-FLG has been used to measure fluorescence in coral, fruit and other flora and fauna.

USB2000-FLG: $2,999

LIBS2500 Spectrometer & Accessories

Above is a LIBS2500-7 Spectrometer System with a LIBS-BUN-7 Fiber Bundle. This seven channel spectrometer system provides elemental analysis from 200-980 nm. A LIBS2500 system requires a laser to ablate the sample (see page 49) and a sampling system, such as our LIBS-SC Sample Chamber, to collect the emitted light.

Specifications*	
Dimensions:	33.4 cm X 15 cm x 14 cm maximum (spectrometer system)
Weight:	6.4 kg (spectrometer system only)
Power consumption:	1 A @ 5 VDC (spectrometer system only)
Detector:	(7) 2048-element linear silicon CCD arrays
Wavelength range:	Channel dependent
Optical resolution:	~0.1 nm (FWHM)
Frame rate:	10 Hz capability (PC-controlled)
Integration time:	2.1 ms; variable in free-run mode
Trigger delay:	-121 µs to +135 µs in 500 ns steps (PC-controlled)
Trigger jitter:	± 250 nanoseconds (± 20 nanoseconds optional)
Trigger level:	TTL not to exceed 5.5 volts

** For seven-channel LIBS2500-7 system.*

Instant Elemental Analysis from 200-980 nm

We offer a full range of systems and components for laser-induced breakdown spectroscopy, a noninvasive technique for real-time, qualitative and semi-quantitative spectral analysis of elements in solids, solutions and gases. The LIBS2500-7 is a broadband (200-980 nm), high-resolution detection system with optical resolution of ~0.1 nm (FWHM). Sensitivity to parts-per-billion and picogram levels is possible.

How the LIBS Systems Work

A high-intensity, pulsed laser beam is focused on the sample area. A single 10 nanosecond-wide laser pulse ablates the sample and generates plasma. As the plasma decays or cools, excited atoms in the plasma emit light at wavelengths distinct to each element. The emission is collected by a probe and sent to the spectrometer system. The system provides full spectral analysis in less than a second. OOILIBS Operating Software includes a library of elemental emission lines and enables automatic identification of all elements present in the sample.

High-resolution Spectrometers

Our LIBS2500-7 Spectrometer System uses seven linear CCD-array detectors for broadband 200-980 nm analysis. All spectrometers are triggered to acquire and read out data simultaneously. The detection system can be portable and is interfaced to a PC via a USB port. As lower-cost options, LIBS2500 Systems are available with fewer than seven channels (see table below), with a narrower wavelength range for element-specific analyses. Depending on the range of your analyses, you may require a system with less than seven channels at a significantly lower cost.

LIBS2500 Uses in Diverse Applications

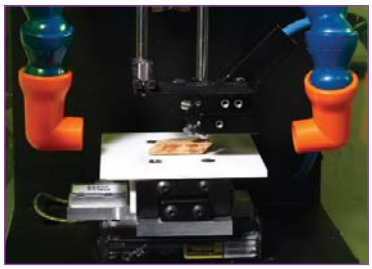
- Environmental: soil, particulates, sediments
- Materials Analysis: metals, slag, plastics, glass
- Forensics & Biomedical: teeth, bones
- Metrology: silicone wafers, semiconductor materials
- Bioresearch: plants, grains
- Safety & Military: explosives, chemical and biological warfare agents
- Art Restoration & Conservation: pigments, paints
- Gemology & Metallurgy: precious metals, gems

Item	LIBS System Description	Price of LIBS System	Optical Fiber Bundle Required	Price of Fiber Bundle
LIBS2500-7	7 channel LIBS System, includes all channels (A-G) below	$29,999	LIBS-BUN-7	$985
LIBS2500-6	6 channel LIBS System, choose 6 channels from A through G	$25,740	LIBS-BUN-6	$885
LIBS2500-5	5 channel LIBS System, choose 5 channels from A through G	$21,450	LIBS-BUN-5	$785
LIBS2500-4	4 channel LIBS System, choose 4 channels from A through G	$17,160	LIBS-BUN-4	$685
LIBS2500-3	3 channel LIBS System, choose 3 channels from A through G	$12,870	LIBS-BUN-3	$485
LIBS2500-2	2 channel LIBS System, choose 2 channels from A through G	$8,580	BIF600-2-UV/VIS	$385
LIBS2500-1	1 channel LIBS System, choose 1 channel from A through G	$4,290	P600-2-UV/VIS	$205
OOILIBS	LIBS System Software (includes elemental emission lines library)	$500	n/a	n/a
LIBS2500 Spectrometer Channels				
LIBS-CH-A	Spectrometer channel with 200-305 nm wavelength range			
LIBS-CH-B	Spectrometer channel with 295-400 nm wavelength range			
LIBS-CH-C	Spectrometer channel with 390-525 nm wavelength range			
LIBS-CH-D	Spectrometer channel with 520-635 nm wavelength range			
LIBS-CH-E	Spectrometer channel with 625-735 nm wavelength range			
LIBS-CH-F	Spectrometer channel with 725-820 nm wavelength range			
LIBS-CH-G	Spectrometer channel with 800-980 nm wavelength range			

Ordering a LIBS2500 System is easy. Components are offered to give you maximum flexibility so that you order only what you need. Select the Spectrometer Channels (LIBS-CH-X) for your LIBS2500 System depending on the wavelength ranges needed for your application. Channels (A, B, C, etc.) do not have to be consecutive. You will also need to specify the fiber bundle that corresponds to the number of channels being ordered. For additional accessories, see the following page.

Additional LIBS Components

LIBS Sample Chamber



The LIBS-SC includes an evacuation system that removes material from the sample area. You also can feed gases such as argon into the chamber. Flooding the chamber with an inert gas provides greater sensitivity for many elements.

The LIBS-SC Sample Chamber is a key component of a LIBS system and is designed to perform various functions safely and in clear view of the sample. The LIBS-SC has an eyewear-safe enclosure. The chamber has a safety-interlock so the laser will not fire when the door is open. It houses a manually controlled x-y-z stage and provides illumination for the optional LIBS-IM-USB Imaging Module. The LIBS-SC has an inert gas induction port and a suction nozzle to remove particulates. In addition, you have the ability to focus the laser to a 40 µm spot size. The sample chamber is designed for use with the Big Sky Lasers we resell (see below for laser details). If you wish to use the LIBS-SC with a different laser, please contact Ocean Optics.

LIBS-SC: $9,800

Specifications	
Stages:	Manual x-y-z stage
Sample size:	6.5 cm x 6.5 cm x 4 cm max.
Laser safety shield:	OD 6 for 1.064 mm laser energy (call for other wavelengths)
Internal optics:	25 mm diameter focusing lens, 75 mm focal length supplied
Ablation spot size:	approximately 40 µm

LIBS Imaging Module for Pinpoint Analysis

This image is the "O" in the text "Quarter Dollar" on a U.S. coin.

The LIBS-IM-USB Imaging Module directly attaches to the LIBS-SC Sample Chamber to enable users to magnify a sample image and to establish a laser ablation target on the sample. The camera is also useful when you want to adjust the laser focus at the surface of the sample, or above or below the sample surface. When used with the LIBS-SC and laser, the LIBS-IM-USB and laser are in the same focal plane enabling precise, rapid and convenient laser focus. The USB-enabled color camera captures pre- and post-ablation images of the sample and provides up to 1280 x 1024 pixel resolution.

LIBS-IM-USB: $8,000

Specifications	
Interface:	USB 2.0 (480 Mb/sec)
Power:	USB 5 VDC, max. 180 mA
Frame size:	1280 x 1024, 640 x 480, 320 x 240, 160 x 120
Data output:	RGB 24 bit
Requirements:	-- Windows XP Professional SP1 -- Support of Direct X -- Driver compatible Windows driver model (WDM) -- SDK iREZ WDM library -- 3.2 GHz or higher processor -- 1 GB recommended memory -- 10 GB free hard disk space -- Rocket-fast GeForce 4200Ti or better video card recommended

LIBS Laser Options

We offer two LIBS25000 laser power options from industry leader Big Sky Laser Technologies. Laser ablation and plasma formation are very specific to the sample matrix, and therefore the power requirements will vary by sample type. 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. The choice of laser power and wavelength depend on the material being analyzed and the sample's tolerable damage threshold. The LIBS-LASER is a 50 mJ CFR Nd:YAG laser for metal and thin film samples. The LIBS-LAS200MJ is a 200 mJ CFR Nd:YAG laser for most all other materials.

LIBS-LASER: $14,500
LIBS-LAS200MJ: $22,500

LIBS Versus 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-quantitative	Quantitative	Semi-quantitative
Analysis time:	Fast	Slow	Very slow	Slow	Slow
Sample consump:	almost non-destructive	non-destructive	non-destructive	almost non-destructive	non-destructive
Complexity:	Easy to use	Easy to use	Easy to use	Complicated	Complicated
Discrimination:	Good	Poor	Good	Excellent	Fair
Cost:	$60,000	$120,000	$120,000	$250,000	$600,000

LIBS-ELITE Laser Ablation System

Highly Refined Sampling System for LIBS

Laser-induced Breakdown Spectroscopy is a noninvasive technique for real-time, qualitative and semi-quantitative spectral analysis of elements in solids, solutions and gases. The LIBS-ELITE, developed by New Wave Research and Ocean Optics, is a high-quality LIBS sampling system with unparalleled sample imaging and control. The LIBS-ELITE consists of a laser head, sample chamber, software-controlled X-Y positioner and a high-resolution imaging system in a single housing. New Wave Research developed the LIBS-ELITE to work with the LIBS2500 System (page 48).

200 mJ Nd:YAG Laser

The LIBS-ELITE-200 comes with New Wave Research's Tempest 200 mJ Nd:YAG laser. The Tempest delivers high-energy densities to the sample to create plasma from even the most challenging materials. The accuracy and precision of the system results from the 98% pulse-to-pulse stability of the Tempest. A laser power meter located adjacent to the sample and a software-controlled attenuator are standard features that help enable quantitative sample analysis. Another laser option is available; the LIBS-ELITE-90 comes with a 90 mJ laser.

Sample Chamber: Unprecedented Control

The open architecture of the sample chamber allows the sample and ablation plume to be viewed easily through its Class 1 shield. The sample chamber includes a quick-loading sample drawer, and can accommodate samples up to two inches in diameter. A gas port on the rear of the housing enables the chamber to be purged with argon, which is useful for increasing sampling sensitivity, or with nitrogen or helium, which is useful when measuring emissions of elements such as oxygen that are found in ambient environments. An integrated rotometer regulates the gas flow in the chamber.

Exact Positioning & High-resolution Imaging

The ELITE's software-controlled X-Y stage allows you to precisely control the target location, to create reproducible maps, and to automate sample mapping, patterning and rastering for testing sample homogeneity or for bulk analysis. The spot size controller sets the ablation spot size from 20 µm to 1200 µm. The LIBS-ELITE's high-resolution sample magnification capability (see software screen capture at right) allows you to view an exact spot before and after the ablation event.

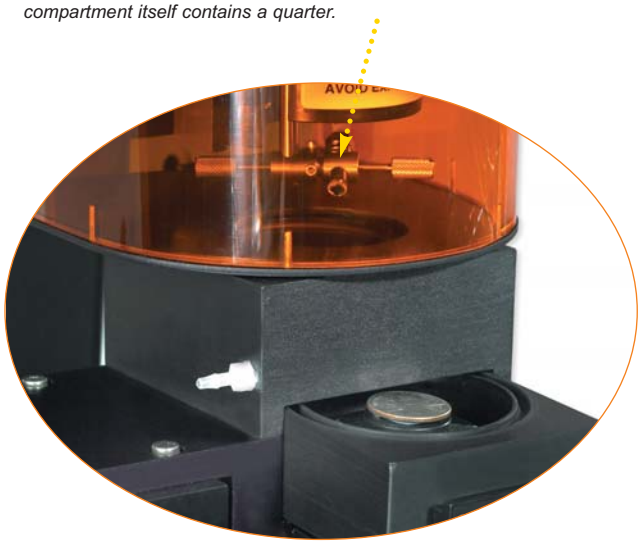
Software with Spectral Library

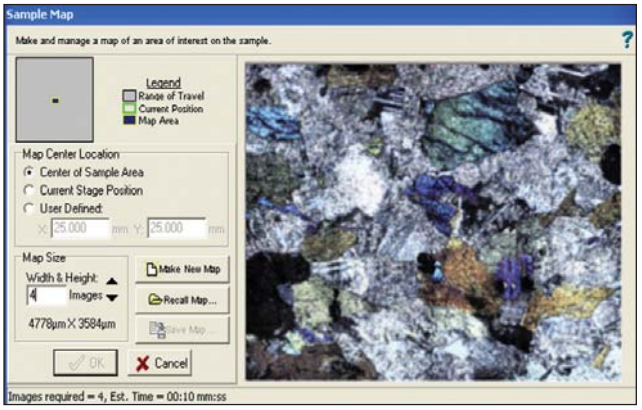
The LIBS-ELITE comes with intuitive operating software and a library of elemental emission lines, which enables automatic identification of all elements present in a sample. The software includes controls for ablation mode, laser repetition rate, laser power, sample spot size selection, X-Y positioning, sample viewing, sample mapping, gas routing, spectrometer system triggering and automating sampling processes.

Sold Exclusively by New Wave Research

For pricing on the LIBS-ELITE systems, contact New Wave Research at lasers@new-wave.com or 800-566-1743. Also, visit www.new-wave.com for more product information.

The LIBS-ELITE works with the Ocean Optics LIBS2500-7 Spectrometer System (see page 48) to provide full spectral analysis from 200-980 nm, with optical resolution of 0.1 nm and sensitivity to parts-per-billion. Below is a magnification of the sampling area where the ablation plume is produced behind an orange Class 1 shield. The sample compartment itself contains a quarter.





View an exact spot of the sample before, during and after the ablation process. The LIBS-ELITE provides real-time, high-resolution qualitative analysis of trace elements in diverse materials such as metals, biological tissues, soils, optics, semiconductors, gems and other geological, biological and environmental specimens.

Raman Selection Guide

Raman System Selection Guide

Raman spectroscopy is quickly becoming one of the preferred chemical identification techniques in many application areas. Raman is advantageous because it is:

- Non-invasive: Sample through glass and plastic
- Non-destructive: Sample can be reused
- Fast: Typical measurement times 5-30 seconds

Raman spectroscopy provides rapid and reliable non-destructive chemical analysis of aqueous solutions, powders, tablets, gels and surfaces. A basic setup consists of a monochromatic source, typically a laser, which interacts with the sample. The scattered radiation is then collected by a spectrometer. We offer several options for using Raman as a measurement tool:

QE65000 Modular Raman System, pages 52-53

The QE65000 Scientific-grade Spectrometer was designed for low-light level applications such as Raman spectroscopy. You have several grating and entrance aperture sizes from which to choose to optimize a system for your specific application. In addition, we have lasers and Raman probes to complete your own modular Raman setup.

Turnkey Raman Systems, page 54

We offer several Raman turnkey sensing systems from our partner, Raman Systems, Inc. Their high-performance systems are designed specifically for quick material identification and verification in almost any setting. The RSL-Plus is for field deployment and fast incident response, while the R-3000 is a self contained semi-portable system for lab or field use.

MMS-Raman, page 55

Centice Corporation offers their Multimodal Multiplex Spectroscopy Raman System to provide high performance chemical analysis for a fraction of the cost of research-grade systems. Due to its high sensitivity and great resolution, the MMS-Raman is an ideal system for substance verification and accurate concentration analysis, as well as for analysis of very low-concentration samples.

Raman System Selection Guide

Specification	QE65000	R-3000	R-3000-HR & R-3000 QE	RSL-Plus	MMS-RAMAN
Optical resolution	6-18 cm^{-1}; Grating and slit dependent	10 cm^{-1}	6 cm^{-1}; 8 cm^{-1}	12 cm^{-1}	4 cm^{-1}
Excitation wavelength	785 nm or 532 nm	785 nm or 532 nm	785 nm or 532 nm	785 nm	785 nm
Spectral range	Several options from 150 cm^{-1} to 7500 cm^{-1}; Grating & laser dependent	200-2700 cm^{-1} (785 nm); 200-4000 cm^{-1} (532 nm)	200-2700 cm^{-1} (785 nm); 200-4000 cm^{-1} (532 nm)	200-2700 cm^{-1} (785 nm)	220-2000 cm^{-1}
Detector	Hamamatsu	Sony/Toshiba/ Hamamatsu	Sony/Toshiba/ Hamamatsu	Sony/Toshiba/ Hamamatsu	Hamamatsu
Detector type	Back Thinned	Linear CCD/ Back Thinned	Linear CCD/ Back Thinned	Linear CCD/ Back Thinned	Back Thinned
Pixels	1044 x 64	2048 or 1024 x 58	2048 or 1024 x 58	2048 or 1024 x 58	512 x 122

Raman Application Areas

Raman spectroscopy is useful for analyzing molecules without a permanent dipole moment, which does not show up on an IR spectrum. Raman spectroscopy is used to determine bond lengths in non-polar molecules. It is useful for determining the identity of organic and inorganic species in solution, as the Raman transitions for these species are more characteristic than for IR, where the transitions are much more affected by the other species present in the solution. Raman can be used to analyze solid, liquid and gaseous sample components even through glass and plastic containers.

- Art: Pigments, inks, substrates, resins
- Biology: in vivo studies, surface studies, SERS
- Catalysts: NO decomposition, kinetics of hydrogenation reactions
- Corrosion: corrosion kinetic studies, bronze, aluminum
- Forensics: drugs, explosives, pigments, powders, tablets, gels and surfaces, chemicals
- Materials: diamond films, semiconductors, nanotubes, asbestos, materials ID
- Pharmaceuticals: in situ crystal growth monitoring, kinetics, active ingredients, polymorphs differentiation
- Polymers: polymerization monitoring, plasticizer studies, density mapping of films
- Process: online monitoring, quality control, research
- Other: gemology, geology, chemical and petrochemical processes, water-quality analysis

Modular Raman Measurement Tools

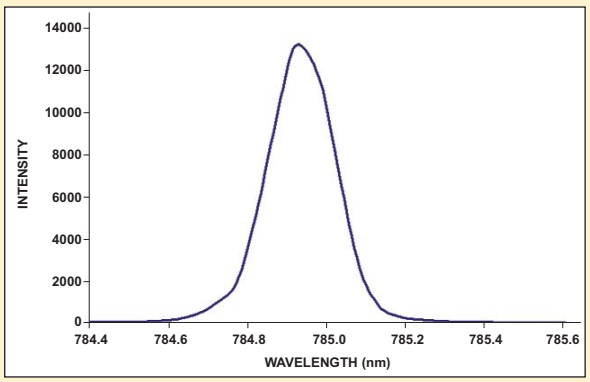
785 nm Excitation Laser for Raman

The LASER-785 is a 500-milliwatt, continuous-wave laser specifically developed for Raman spectroscopy. The high-power excitation source has an integrated laser driver, a thermoelectric cooler, a TEC controller and a TTL modulation port for controlling the input up to 100 kHz. The LASER-785 has a narrow spectral line width of only 0.2 nm (see spectrum below). Its compact and rugged design and its hermetically sealed laser component make it optimal for various industrial and medical applications.

LASER-785: $6,499

Specifications			
Dimensions:	110 mm x 89 mm x 53 mm	Laser life:	10,000 hours
Weight:	600 grams	Power consumption:	3.0 A @ 5 VDC
Noise:	<0.5% RMS	Power output (CW):	>500 mW
Output fiber:	100 µm @ 0.22 NA	Peak wavelengths:	785 +/- 0.3 nm
Warm-up:	15 minutes	Spectral line width:	0.2 nm (typical)
Temperature:	-10 °C to 40 °C	Rise time:	<500 msec
Stability:	<3% peak-to-peak in 8 hours	Control:	TTL modulation -- 0 to 100 kHz
Humidity:	5-95% non-condensing	Connector:	SMA 905

HR4000 Spectrum of LASER-785



Fiber Optic Probes for Raman Applications

We offer several fiber optic probes for Raman spectroscopy from our corporate partner InPhotonics. Each probe provides complete optical filtering of the Rayleigh line and high signal collection in a compact, rugged probe design. Several probe models are available for laboratory, industrial and environmental applications.

The probes listed below are available for several excitation wavelengths. Please contact Ocean Optics for details.

RPB Laboratory Probe

Item	Description	Probe Size (in mm)	Fiber Length	Price
RIP-RPB	Laboratory probe for use with lasers up to 3 nm from specified operating wavelength; has 7.5-mm focal length	114 x 38 x 12.7	1.5 meter	$2,750
RIP-RPS	Stainless-steel focused probe for lab and field use; has 5-mm focal length (7.5 mm or 10 mm also available)	12.7 OD x 101 length	5 meters	$4,950
RIP-RP2	Stainless-steel immersion probe is immersible up to 200 °C and has adjustable working distance	15.87 OD x 203 length	5 meters	$6,745
RIP-RPR-H	Hastelloy C immersion probe with gold gasket for use in process control applications up to 200 °C and 1500 psi; comes with sapphire window and has adjustable working distance	15.87 OD x 330 length	5 meters	$9,200
RIP-RPR-S	Stainless-steel immersion probe with elastomeric O-ring seal for use in process control applications up to 200 °C and 1500 psi; comes with sapphire window and has adjustable working distance	15.87 OD x 330 length	5 meters	$8,200
RIP-RPP	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	9.52 OD x 300 length	5 meters	$10,200
RIP-PA-SH	Sample holder, with inserts for round vials, square cuvettes, and cups	not applicable	not applicable	$850

Modular Raman Measurement Tools

QE65000 Scientific-grade Spectrometer for Raman

New Scientific-grade Spectrometer

The QE65000 Spectrometer is a unique combination of detector and optical bench technologies that provides users with high spectral response and high optical resolution in one package.

Demanding Low Light-level Applications

The QE65000 was designed for low-light level applications such as Raman spectroscopy. The detector is TE-cooled, resulting in virtually no dark noise, which allows you to set the integration time of the spectrometer (analogous to a camera's shutter speed) at up to 15 minutes with little spectral distortion.

Quantum Efficiency to 90%

With its scientific-grade detector, the QE65000 achieves up to 90% quantum efficiency (defined as how efficiently a photon is converted to a photoelectron). With this "2D" detector in the QE65000, we bin a vertical row of 64 pixels, which increases the signal-to-noise ratio to 1200:1. (See page 26 for detailed QE65000 specifications.)

Increased System Sensitivity

QE65000 system sensitivity is improved because the 2D detector allows us to take advantage of the height of the entrance slit. In our spectrometers, you regulate the light entering the bench according to the slit's width. Most of our other spectrometers use linear detectors; in those spectrometers, slit height doesn't matter because linear detectors cannot efficiently collect the light from the entire height of the slit. But with the 2D detector in the QE65000, we can better take advantage of this additional light.

NIST-traceable Raman Standards

The STAN-RAM785 and STAN-RAM532 are NIST-certified standards for determining the absolute spectral intensity of your Raman system. They consist of an optical glass that emits a broadband luminescence spectrum when excited with a laser. (Select the STAN-RAM785 when using a 785 nm laser as your excitation source; select the STAN-RAM532 when using a 532 nm laser.) The shape of this luminescence spectrum is expressed by a polynomial equation that relates the relative spectral intensity to the wavenumber from the excitation wavelength. Determining the absolute spectral intensity of your Raman system is essential for those performing peak-to-peak height analysis and those collecting a spectral library.

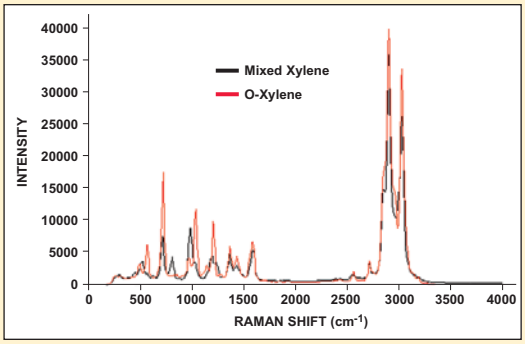
QE65000:	$9,999
STAN-RAM532:	$1,015
STAN-RAM785:	$1,015

Examples of QE65000 Configurations for Raman

Sample Config.	Spectral Range	Excitation Source	Grating p. 28	Slit p. 27	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}

Above, the QE65000 is configured for use with a LASER-785 and an RIP-RPB probe (see facing page for details). At left is the STAN-RAM785 for determining the absolute spectral intensity of your Raman system.

Comparing Xylenes Using Raman

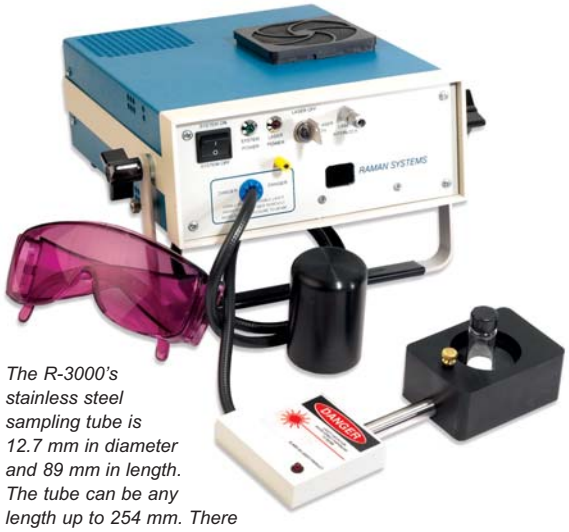


We used the QE65000 Sample Configuration #3 (described in the table at lower left), and an InPhotonics probe to acquire Raman spectra of xylene samples.

Specifications

Dimensions:	182 mm x 110 mm x 47 mm; 1.05 kg
Detector:	Hamamatsu back-thinned CCD (page 28)
Pixels:	1024 x 58 (1044 x 64 total pixels)
Signal-to-noise ratio:	1000:1 (at full signal)
Dark noise:	2.5 RMS counts
Optical bench design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input and 101.6 mm output
Entrance aperture:	5, 10, 25, 50, 100, or 200 µm wide slits (page 27)
Gratings:	14 gratings UV through Shortwave NIR (page 28)
Integration time:	8 milliseconds to 15 minutes
Dynamic range:	7.5 x 10^9 (system); 25000:1 for one acquisition
Fiber optic connector:	SMA 905 to 0.22 numerical aperture fiber
Power consumption:	3 A @ 5 VDC with TE cooling
Data transfer speed	Full spectrum to memory every 8 ms with USB 2.0
Inputs/Outputs	10 onboard digital user-programmable GPIOs
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port
Temperature limits:	0 °C to 50 °C
Temperature range:	13 °C maximum range between high and low
Set point:	Software controlled
Lowest set point:	40 °C below ambient, to -15 °C
Stability:	±0.1 °C of set temperature in <2 minutes

Raman Measurement Systems



The R-3000's stainless steel sampling tube is 12.7 mm in diameter and 89 mm in length. The tube can be any length up to 254 mm. There are two focusing caps: one for direct contact with a sample; the other for use with a sample container.

Specifications	
Lasers:	Solid-state 785 nm or 532 nm diode
Raman shift range:	~200-2700 cm^{-1}
Resolution:	~10 cm^{-1} to ~6 cm^{-1}
Detector:	Linear CCD array; option of cooled detector
Stability:	1 cm^{-1} wavelength, 4% output stability
Power output:	125 mW and 250 mW; software-controlled
Sampling via:	Fiber optic probe for solutions, solids, gels
Remote sampling:	Up to 200 meters using optical fibers
PC interface:	USB
Data storage:	SPC or ASCII format
Calibration:	One-touch calibration
Laser safety:	Class 3b laser requires use of safety eyewear
Tolerances:	Up to 1500 psi and up to 200 ºC for tube and caps
Temperature limit:	Up to 80 ºC for probe head and fiber

Great Resolution & Stability in a Versatile Package

Raman Systems' R-3000-series of Raman instruments are fully integrated analyzers for real-time qualitative and quantitative analysis of solutions, powders, tablets, gels and surface media from ~200-2700 cm^{-1}. The systems include high-performance lasers that provide excellent resolution and achieve better than 1 cm^{-1} wavelength stability and 4% output stability. The R-3000s are used in pharmaceutical monitoring, petrochemical process control, drug and explosives detection, and water-quality analysis.

Fully Integrated System with New Software

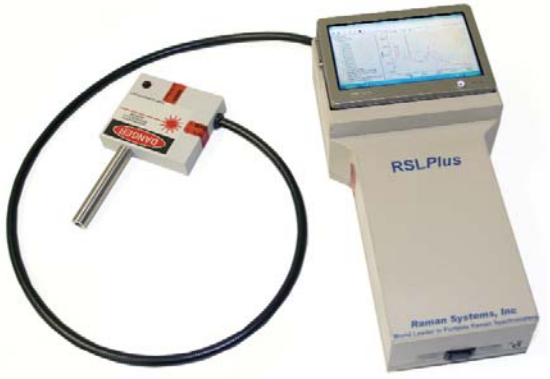
The R-3000 systems come with a 785 nm or 532 nm solid-state diode laser; a software-controlled laser shutter; a fiber optic spectrometer with optional TE cooling; a multi-purpose fiber optic probe for solutions, solids and powders; focusing and calibration caps; a sample holder; operating software; and safety goggles. In addition, the R-3000 systems have new software features that include fingerprinting and quantification capabilities, and a multiple-spectrum display function.

Versatile Sampling Optics Add Value

The sample tubes and probe "caps" that come with the R-3000 systems provide easy transferability between samples in transparent containers and in immersion applications. The probe head is coupled to the spectrometer and laser via two 1-meter fibers (200 μm and 100 μm in diameter).

R-3000-785: $14,950
R-3000-532: $18,300
R-3000-HR-532: $19,950
R-3000-QE-532: $23,450
R-3000-QE-785: $21,950

RSL-Plus Handheld Raman System



Specifications	
Dimensions:	305 mm x 52 mm x 76 mm
Weight:	1.72 kg
Raman shift range:	~200-2700 cm^{-1}
Resolution:	~12 cm^{-1}
Laser:	Solid-state 785 nm diode
Output power:	500 mW
Detection via:	Linear CCD-array detector spectrometer
Sampling via:	Shuttered probe for solutions, solids, gels, etc.
Remote sampling:	Up to 200 meters using optical fibers
Battery:	2-hour rechargeable battery
Computer:	Embedded PC with spectral-matching software
Calibration:	Self-calibration and automated validation
Compliance:	Compliant with 21CFR Part 11

Small Footprint

The RSL-Plus Handheld Raman Spectrometer is a 12" x 6" system for performing low-resolution Raman spectroscopy for on-site materials analysis. Although a high-resolution Raman spectrum provides detailed information about the vibrational fine structure of sample molecules, most routine applications need only ~15 cm^{-1} resolution for quantitative or qualitative analysis. As a result, a system such as the RSL-Plus can be assembled using less expensive optics and lasers -- without sacrificing the power of Raman analysis.

Compact Spectral Matching System

The RSL-Plus consists of an embedded computer with spectral matching software for quality control, verification and validation routines. The system includes a spectrometer, a 785 nm diode laser, a fiber optic probe, and a 2-hour rechargeable battery.

FDA Compliance

The operating software of the RSL-Plus is compliant with the Food and Drug Administration's 21CFR Part 11, and includes features such as audit logging, database creation, spectral matching, and automatic detection of data tampering.

RSL-PLUS: $25,000

MMS-Raman Spectrometer

Next-generation Raman Spectroscopy

We've teamed with Centice Corporation to offer next-generation Raman spectroscopy that combines the simplicity of dispersive instruments with the multiplex advantage of a transform spectrometer. The MMS-Raman Spectrometer uses Centice's patent-pending Multimodal Multiplex Spectroscopy to provide high-performance Raman analysis for a fraction of the cost of research-grade systems. The MMS-Raman Spectrometer offers a unique combination of resolving power, spectral range and flexibility, making it an ideal system for the routine analysis of many types of liquids and solids.

How Multimodal Multiplex Spectroscopy Works

Dispersive, fixed-grating spectrometer designs typically use a slit or a fiber as the input into the spectrometer. These apertures restrict the amount of light that can reach the detector. In these designs, there is an inherent tradeoff between resolution and light throughput. While spectral resolution increases as slit width decreases, a narrow input slit limits the light throughput and, likewise, measurement sensitivity. In the MMS-Raman Spectrometer, a wide-area coded aperture takes the place of a traditional slit entrance that allows 10-1000x greater light throughput -- and then applies precise algorithms to extract a high resolution spectrum from the collected light. There is much more light collected, without sacrificing resolution. Multimodal Multiplex Spectroscopy instruments are ideal for measuring weak, scattering and diffuse samples because the spectrometer can collect and process far more light through its wide-area aperture, without affecting spectral resolution.

Key Applications

Key applications include material inspection, identification of unknown materials, and quantitative analysis of both intermediates and final products in the chemical and pharmaceutical industries. Typical samples include powders, liquids and polymers. All experimental and parameter set-up options are computer-controlled for increased ease of use, reliability and speed.

Integrated Sample Holder

The MMS-Raman Spectrometer has a sample holder with cover for operation in full ambient light without affecting performance. The spectrometer's removable sample compartment is integrated into the optical path, avoiding inefficiencies associated with remote compartments. Sample positioning is rapid and precise using the external z-axis alignment control knob. The sample compartment is especially useful for measuring measure weak, scattering and diffuse sources with the highest possible sensitivity. The sample holder supports up to 10-mm cuvettes and test tubes.

MMS-Raman Delivers Great Sensitivity & Resolution

The MMS-Raman spectrometer samples up to 1,000 optical channels simultaneously through the large coded aperture. A mathematical transformation algorithm precisely reconstructs the spectrum with a 4x signal-to-noise improvement as compared with a slit-based system equipped with identical source, grating and detector components, and 70-80x greater than with a fiber input of equivalent resolution.

MMS-RAMAN: $19,995

Specifications	
SYSTEM	
Wavelength range:	220 cm^{-1} to 2000 cm^{-1}
Spectral resolution:	~4 cm^{-1}
Grating:	Transmissive
Stray light:	<0.1%
Integration time:	50 ms to 100 seconds
A/D resolution:	16-bit
APERTURE AND DETECTOR	
MMS aperture size:	0.58 mm x 2.3 mm
Detector array size:	512 x 122 pixels
Number of active pixels:	62,464
Pixel size:	24 µm x 24 µm
Well depth:	~300,000 electrons
Quantum efficiency:	85% at 250 nm
Dark noise:	300 e^-/pixel/sec @ 0° C
Readout noise:	2 RMS counts, 8 RMS electrons
Gain:	4.7
Detector temperature:	To -20 °C below ambient
LASER	
Excitation wavelength:	785 nm
Laser power:	70 mW at sample
SAMPLE CHAMBER	
Cuvettes:	Square, up to 10 mm
Test tubes:	Up to 17 mm
COMPUTER	
Interface:	USB 2.0
Operating systems:	Windows XP (with SP2)
RAM requirements:	12 MB

LED Measurement Tools

When coupled with the optimum sampling accessories, the USB4000 Spectrometer is a highly accurate spectroradiometer for measuring the color, relative power and absolute spectral intensity of LEDs.

Miniature Fiber Optic Spectrometer

A USB4000 Spectrometer optimized for LED measurements is configured with a 350-1000 nm wavelength range, a 25 µm entrance aperture and an L4 Collection Lens to increase light efficiency. With this configuration, optical resolution is ~1.33 nm (FWHM).

LED Power Supply: Secures, Powers & Drives LED

The LED-PS Power Supply provides three useful functions: securing the LED in place, powering the LED, and displaying the LED's drive current. Use the adjustable drive current feature to increase or decrease an LED's current up to 50 mA. We offer a standard LED-PS and a NIST-traceable version.

Integrating Sphere: 360° Energy Collection

The LED is powered by the LED-PS and is inserted into the 9.5-mm diameter port of the FOIS-1 Fiber Optic Integrating Sphere, which has a 360° field of view. The P400-2-VIS-NIR Optical Fiber collects the light from the FOIS-1 and funnels it to the USB4000 Spectrometer.

Light Source: Radiometric Reference Source

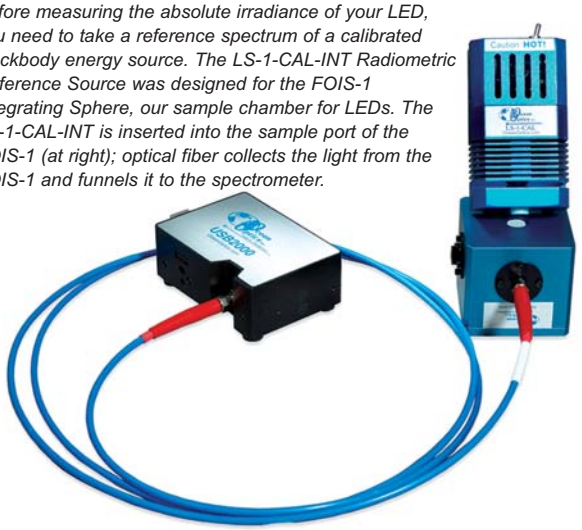
The LS-1-CAL-INT is a NIST-traceable light source designed specifically to calibrate the spectral response of a spectroradiometric system that uses the FOIS-1 as the sampling device. It provides known absolute intensity values at several wavelengths. The LS-1 is used as a reference for relative power measurements.

Spectral & Color Measurement

Our software provides absolute spectral intensities for LEDs, and calculates L*a*b*, XYZ, xyz, u'v'w', hue, RGB, chroma, saturation and more. See page 81 for details.

Spectrometer Specifications	
Detector:	Toshiba TCD1304AP linear CCD array (page 17)
Detector range:	200-1100 nm
Pixels:	3648 pixels, size of 8 µm x 200 µm
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm
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 slit or fiber (page 15)
Grating options:	14 gratings, UV through Shortwave NIR (page 16)
Fiber optic connector:	SMA 905 to 0.22 numerical aperture fiber
Wavelength range:	Grating dependent
Optical resolution:	~0.3-10.0 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)
Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition
Integration time:	3.8 milliseconds to 10 seconds
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Power consumption:	250 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 5 ms with USB 2.0 port, 18 ms with USB 1.1 port
Inputs/Outputs:	Yes, 8 onboard digital user-programmable GPIOs
Operating systems:	Windows 98/Me/2000/XP, Mac OSX and Linux with USB port; Any 32-bit Windows OS with serial port

Before measuring the absolute irradiance of your LED, you need to take a reference spectrum of a calibrated blackbody energy source. The LS-1-CAL-INT Radiometric Reference Source was designed for the FOIS-1 Integrating Sphere, our sample chamber for LEDs. The LS-1-CAL-INT is inserted into the sample port of the FOIS-1 (at right); optical fiber collects the light from the FOIS-1 and funnels it to the spectrometer.



After taking a reference and a dark spectrum, insert an LED into the LED-PS Power Supply, which holds and powers the LED, displays the LED drive current, and allows you to adjust the current. The LED-PS is placed over the FOIS-1, so that the LED is inserted into the sample port of the FOIS-1.

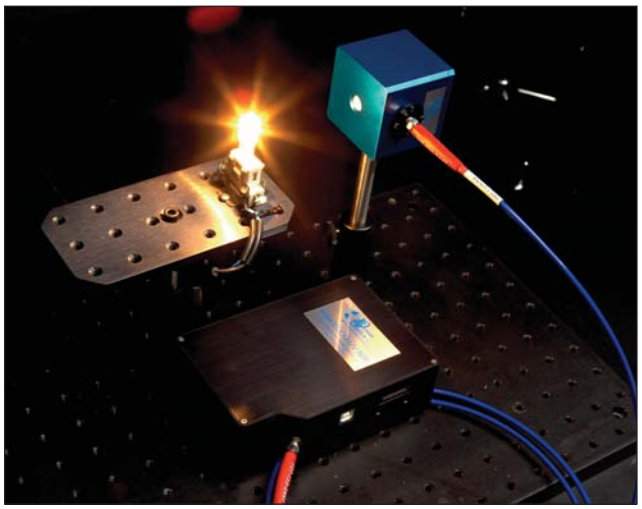
In this setup, the LED-PS is on top of the FOIS-1 Integrating Sphere. A P400-2-VIS-NIR Optical Fiber collects the light energy from the FOIS-1 and sends it to the spectrometer. Our software reports the absolute spectral intensities for the LED as well as color values, photopic data and more.

Item	Description	Page	Price
USB4000	Spectrometer ($2,199) with 25 µm slit ($150), L4 Lens ($150), and DET4-350-1000 with OFLV-350-1000 filter ($150)	14	$2,649
LS-1-CAL-INT	Radiometrically calibrated LS-1	133	$749
FOIS-1	Fiber Optic Integrating Sphere	105	$499
LED-PS-NIST	NIST-traceable LED power supply	104	$749
SpectraSuite	Software for Color and Irradiance	81	$199
P400-2-VIS-NIR	Optical fiber for connecting FOIS-1 to USB4000	144	$120
P200-2-VIS-NIR	Optical fiber for connecting LS-1-CAL-INT to USB4000	144	$100

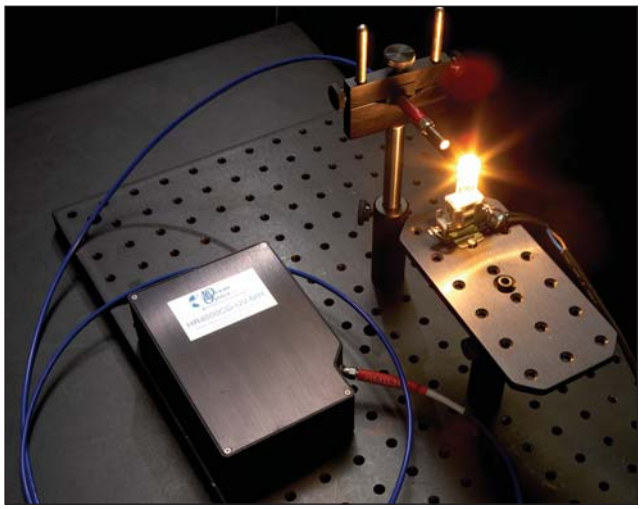
Spectroradiometric Tools

Spectrometer for Light Analysis

Our spectrometers and accessories can be configured easily into spectroradiometric systems for measuring the absolute or relative irradiance of radiant sources such as flat panel displays, CRTs, incandescent lamps and the sun. The HR2000+ and HR4000 Spectrometers are designed for laser analysis (pages 20-21), while the USB4000 (page 14) and the HR4000CG (page 35) are good general-purpose choices. Working with our Applications Scientists to select and configure the right spectrometer for your spectroradiometric system is the first step. Once the spectroradiometer is configured, it's time to select from several sampling options to complete your system.



The FOIS-1 Integrating Sphere collects light from 360° field of view.



The CC-3-UV (attached to a fiber) collects light from 180° field of view.

Fiber Optic Integrating Sphere

The FOIS-1 (at right) is used to collect light from a 360° field of view and funnel it to a spectrometer via an optical fiber for measuring the spectral properties of emission sources. Light enters the sphere via a 9.5-mm diameter port and an optical fiber -- oriented at 90° to the sample port -- collects the light. For details, see page 105.

FOIS-1: $499

The FOIS-1.

Cosine Correctors

Our Cosine Correctors collect radiation with a 180° field of view. When used in a fiber coupled to a spectrometer, they measure light intensity at the surface of the probe. See page 104 for more.

CC-3-DA: $299
CC-3-UV: $129

CC-3-DA (above left) directly attaches to a spectrometer while the CC-3-UV screws onto an optical fiber.

NIST-traceable Calibration Standards

Our NIST-traceable Calibration Standards provide you with known absolute intensity values at the sources' fiber optic sample ports. These sources are strictly for calibrating the absolute spectral response of your system before measuring the absolute irradiance of radiant sources. For all your options, see pages 132-133.

LS-1-CAL: $749
DH2000-CAL: $3,302

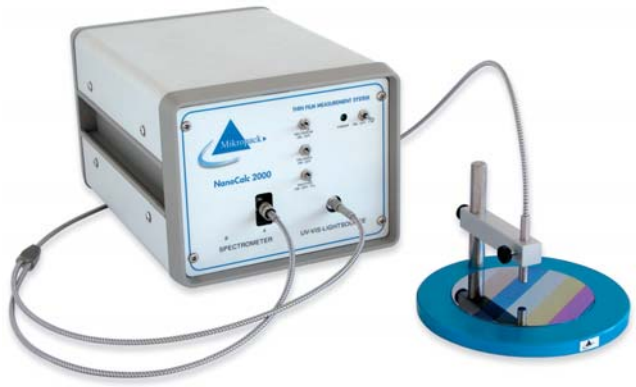
The LS-1-CAL.

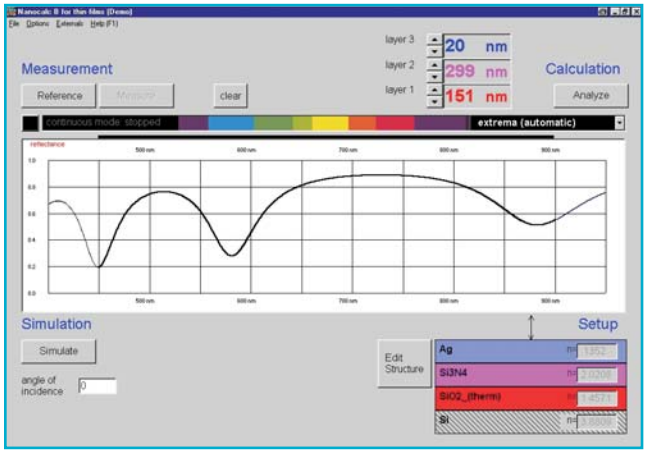
SpectraSuite Spectroscopy Operating Software

SpectraSuite Spectroscopy Operating Software is 32-bit acquisition and display software for performing a number of functions in measuring the absolute spectral intensity of emission sources. For more on the software, see pages 80-81.

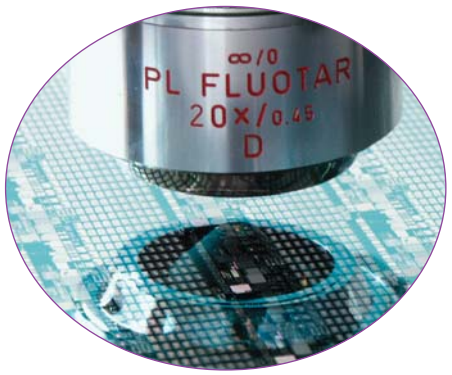
SpectraSuite: $199

NanoCalc Thin Film Analysis System





NanoCalc Software displays a sample interference spectrum, predicted spectra and up to four layers.



Analyze Layers from 10 nm in Thickness

The optical properties of thin films arise from reflection and interference. The NanoCalc Thin Film Reflectometry System allows you to analyze the thickness of optical layers from 10 nm to ~250 µm. You can observe a single thickness with a resolution of 0.1 nm. Depending on your software choice, you can analyze single-layer or multilayer films in less than one second and can measure the thickness and removal rates of semiconductor process films or anti-scratch coatings, hard coatings and anti-reflection coatings.

Theory of Operation

The two most common ways to measure thin film characteristics are spectral reflectance/transmission and ellipsometry. NanoCalc utilizes the reflectance method and measures the amount of light reflected from a thin film over a range of wavelengths, with the incident light normal to the sample surface.

Search by *n* and *k*

As many as four layers can be specified in a film stack. The various films and substrate materials can be metallic, dielectric, amorphous or crystalline semiconductors. The NanoCalc Software includes a large library of *n* and *k* values for the most common materials. You can edit and add to this library. Also, you can define material types by equation or dispersion formulas.

Applications

NanoCalc Thin Film Reflectometry Systems are ideal for in situ, on-line thickness measurements and removal rate applications, and can be used to measure the thickness of oxides, SiNx, photoresist and other semiconductor process films. NanoCalc Systems measure anti-reflection coatings, anti-scratch coatings and rough layers on substrates such as steel, aluminum, brass, copper, ceramics and plastics.

Item	Wavelength Range	Thickness	Light Source Included
NC-UV-VIS-NIR	250-1100 nm	10 nm-70 µm	Deuterium and Tungsten Halogen
NC-UV-VIS	250-850 nm	10 nm-20 µm	Deuterium and Tungsten Halogen
NC-VIS-NIR	400-1100 nm	50 nm-100 µm (optional 1 µm-250 µm)	Tungsten Halogen
NC-VIS	400-850 nm	50 nm-20 µm	Tungsten Halogen
NC-NIR	650-1100 nm	70 nm-70 µm	Tungsten Halogen
NC-NIR-HR	700-978 nm	1 µm-250 µm	Tungsten Halogen
NC-512-NIR	900-1700 nm	50 nm-200 µm	High-power Tungsten Halogen

Specifications			
Angle of incidence:	90°	On-line possibilities:	Yes
Number of layers:	4 or fewer	Mechanical tolerance (height):	With new reference or collimation (74-UV)
Reference measurement needed:	Yes (bare substrate)	Mechanical tolerance (angle):	Yes, with new reference
Transparent materials:	Yes	Microspot option:	Yes, with microscope
Transmission mode:	Yes	Vision option:	Yes, with microscope
Rough materials:	Yes	Mapping option:	6" and 12" XYZ mapping tables
Measurement speed:	100 milliseconds to 1 second	Vacuum possibilities:	Yes

SpecEl Ellipsometer System

Full Spectral Range in Easy-to-use System

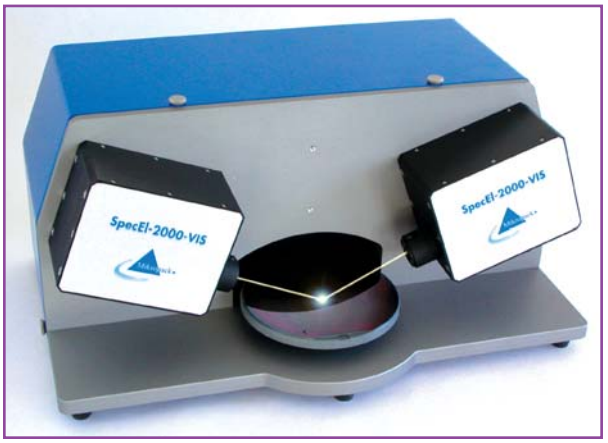
Measure refractive index, absorbance and thickness of substrates with the touch of a button! The SpecEl-2000-VIS Ellipsometer from Mikropack measures polarized light reflected from the surface of a substrate to determine the thickness and refractive index of the material as a function of wavelength. The SpecEl is controlled via a PC.

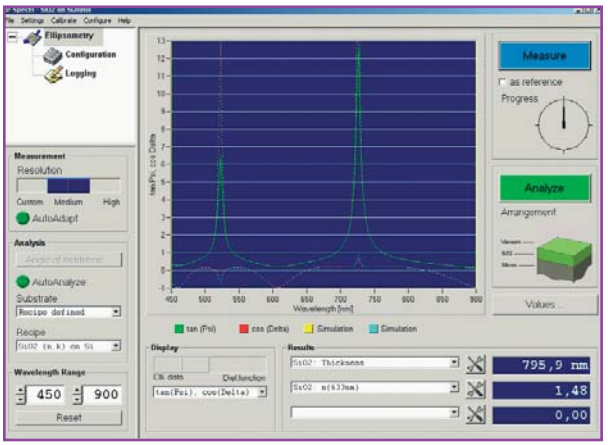
All-in-one Accurate System

The SpecEl houses an integrated light source, a spectrometer and two polarizers fixed to 70°. It also includes a PC with a 32-bit Windows operating system. The SpecEl can detect a single layer as thin as 0.1 nm and up to 5 µm thick. In addition, it can provide refractive indices to 0.005° over lambda.

SpecEl Software and "Recipe" Files

In SpecEl Software, you can configure and save experiment method files for one-step analysis. After creating a "recipe," you can select the recipe to execute the experiment.





This screen from the SpecEl Software demonstrates the Psi and Delta values you can calculate for thickness, refractive index and absorbance.

Specifications	
Wavelength range:	450-900 nm
Optical resolution:	4.0 nm FWHM
Accuracy:	0.1 nm thickness; 0.005% refractive index
Angle of incidence:	70°
Film thickness:	from 0.1 to 8000 nm for single transparent film
Spot size:	2 mm x 4 mm (standard) or 200 µm x 400 µm (optional)
Sampling time:	5-15 seconds (minimum)
Kinetic logging:	5 seconds
Mechanical tolerance:	Height ± 1 mm, angle ± 1.0°
Number of layers:	Up to 32 layers
Reference:	Not applicable

PlasCalc Plasma Monitoring & Control

Real-time, Full-spectral Plasma Monitoring

PlasCalc-UV-NIR measures plasma emission from 200-1100 nm in only three milliseconds. The PlasCalc benefits from advanced process control systems and sophisticated algorithms for data acquisition.

Recipe Editor

The Recipe Editor tool allows you to easily and rapidly configure, build and save experiment methods. It is easy to build robust recipes for the most difficult plasma processes such as measuring film deposition, monitoring plasma etching, examining surface cleaning, analyzing plasma chamber health control, and monitoring abnormal pollution or discharge phenomena.

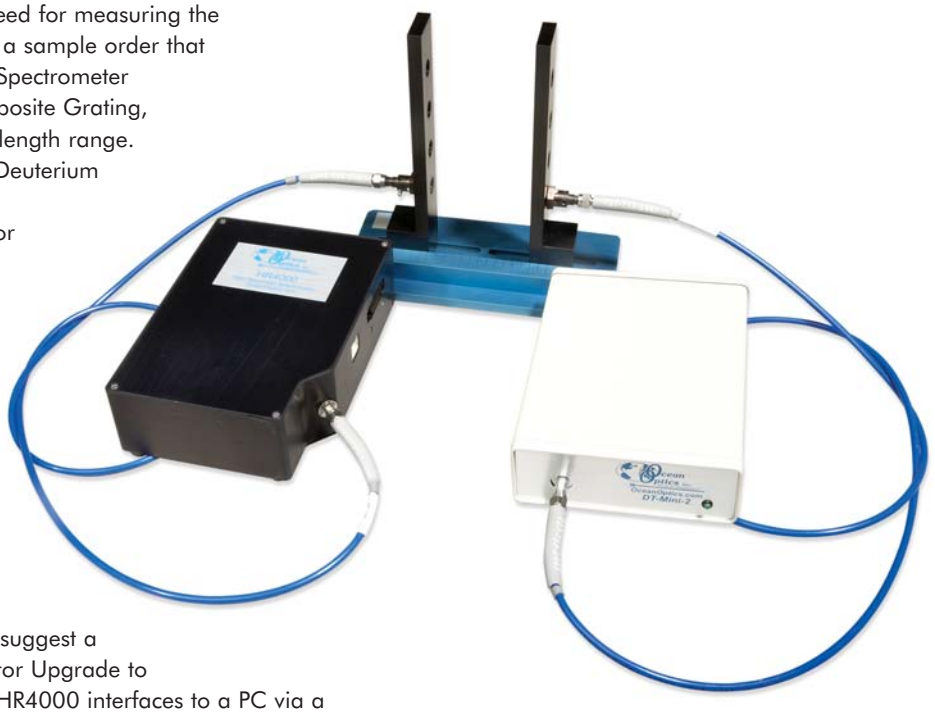
Multiple Tools for Easy Plasma Diagnosis

The Integrated Formula Editor provides easy access to a full range of mathematical and algorithmic functions. An Emission Wavelength Library provides species identification, while the Wavelength Editor allows you to optimize signal-to-noise. A dual-window interface shows the actual spectrum and all process control information.

Specifications	
Spectral range:	200-1100 nm
Optical resolution:	1.0 nm FWHM
D/A-converter:	14 bit
Digital inputs/outputs:	8 x TTL digital inputs/outputs
Analog output:	4 x [0-10V]
Interface:	USB 1.1
Power consumption:	12 VDC @ 1.25 A
Power requirements:	90-240 VAC 50/60 Hz
Dimensions:	257 mm x 152 mm x 263 mm
Weight:	5 kg

Transmission of Optics Tools

We offer all of the components you need for measuring the transmission of optics. Listed below is a sample order that specifies an HR4000 High-resolution Spectrometer configured with our novel HC-1 Composite Grating, which provides a 200-1050 nm wavelength range. In addition, we suggest a DT-MINI-2 Deuterium Tungsten Halogen Source, plus fibers, collimating lenses and a lens fixture for sampling.



HR4000 with 200-1050 nm Wavelength Range

The HR4000 configuration we recommend for this application includes a new 3648-element CCD-array detector, the proprietary HC-1 Composite Grating and an order-sorting filter to provide a 200-1050 nm wavelength range (best efficiency) and optical resolution better than 1.0 nm (FWHM). We also suggest a 25 µm entrance slit and a UV2 Detector Upgrade to enhance performance in the UV. The HR4000 interfaces to a PC via a USB 2.0 port.

Broad Spectral Range Light Source

The DT-MINI-2 Deuterium Tungsten Halogen Light Source combines the continuous spectrum of a deuterium UV light source and a tungsten halogen VIS-NIR light source in a single optical path. The combined-spectrum source produces stable spectral output from ~200-2000 nm in a compact package.

Holder for a Variety of Samples

The 74-ACH Adjustable Collimating Lens Holder consists of adjustable bars with several threaded holes for collimating lenses. The bars can be set to accept samples up to ~100 mm thick, making the 74-ACH a convenient option for transmission measurements of large samples.

Collimating Lenses

The 74-UV Collimating Lenses screw into the threaded holes of the 74-ACH to collimate light. The lenses have an inner barrel threaded for attaching to optical fibers. When focused for collimation, beam divergence is 2° or less. The inner barrel can slide relative to the lens fixture to adjust the focus.

Optical Fiber

Our fiber assemblies can act as both illumination and read fibers. The two 600 µm diameter optical fibers recommended are one meter in length and connect easily from the collimating lenses installed in the 74-ACH to the HR4000 Spectrometer and the light source.

Spectrometer Specifications	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
Power consumption:	450 mA @ 5 VDC
Detector:	3648-element linear CCD array (page 24)
Wavelength range:	200-1100 nm, 200-1050 best efficiency
Optical resolution:	~1.0 nm FWHM
Grating:	HC-1, 300 lines per mm grating (page 23)
Entrance aperture:	25 µm wide slit (page 22)
Order-sorting filters:	Installed OFLV-200-1100 (page 24)
Focal length:	f/4, 101 mm
Dynamic range:	2 x 10^8 (system); 2000:1 for a single acquisition
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Data transfer rate:	Full spectrum into memory every 4 ms with USB 2.0; 18 ms with USB 1.1
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; any 32-bit Windows operating system when using the serial port
Inputs/Outputs:	10 digital user-programmable GPIOs*
Analog channels:	One 13-bit analog input and one 9-bit analog output

** Programming the GPIOs requires SpectraSuite, OmniDriver or another one of our device drivers. See pages 80-82 for details.*

Quantity	Item	Description	Page	Price
1	HR4000	HR4000 ($3,999) with HC-1 Composite Grating ($600); 25 µm slit ($150); DET4-200-1100 Detector with OFLV Order-sorting Filter and UV4 Detector Upgrade ($400)	21	$5,149
1	DT-MINI-2	Miniature Deuterium Tungsten Halogen Light Source	125	$1,499
1	74-ACH	Adjustable Collimating Lens Holder	89	$299
2	74-UV	Collimating Lens	88	$318
2	P600-1-SR	600 µm diameter optical fiber in 1-meter length	144	$238
			TOTAL:	**$7,503**

Spectrometer Accessories

Spectral Hyper Adapter for Picometer Resolution

Get even higher spectral resolution from your spectrometer with the SHA-1 Spectral Hyper Adapter from Ocean Optics partner Spectral Applied Research. The SHA-1 Spectral Hyper Adapter further improves the optical resolution of the already high-performance HR4000. Increased resolution is achieved by plugging the SHA-1 into a setup between the sampling device and the HR4000. The SHA-1 plugs directly into the HR4000's 30-pin connector and connects to the HR4000's optical bench via the included 50-µm optical fiber. Commands are transmitted via the USB port and data acquisition is synchronized with the HR4000. The table below gives examples of the improvement in optical resolution the SHA-1 provides for certain HR4000 configurations.

SHA-1: $5,000

Examples of Resolution Improvements

Slit	Grating	Starting Wavelength	Wavelength Range	Resolution no SHA-1	Resolution with SHA-1
5 µm	H11 (1800 mm^{-1})	700 nm	700-791 nm	0.05 nm	0.004-0.006 nm or 4.0-6.0 pm
5 µm	H12 (2400 mm^{-1})	550 nm	550-615 nm	0.035 nm	0.003-0.004 nm or 3.0-4.0 pm

Specifications	
Dimensions:	40.6 mm x 68.6 mm x 68.6 mm
Wavelength range:	550-900 nm
Fiber size:	50 µm diameter optical fiber
Integration time:	2 seconds (minimum)
Optical resolution:	7x-10x improvement; see table at left for examples
Optical throughput:	10-25%, specify throughput required

Breakout Box

For easier access to a variety of functions found in the HR4000, specify the HR4-BREAKOUT, a passive module that separates the signals from its 30-pin port to an array of standard connectors and headers. The Breakout Box allows multiple interfaces to a spectrometer, such as:

- 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 of 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 Spectrometers Plug-and-Play Spectrometers (page 14)
- HR4000 High-resolution Spectrometers (page 21).
- HR2000+ High-speed, High-resolution Spectrometer (page 20)
- QE65000 Scientific-grade Spectrometer (page 26)

HR4-BREAKOUT: $199
USB-CBL-PS: $25

The Breakout Box includes a 30-pin HR4000-CBL-BB Ribbon Cable that connects the Box to the spectrometer.

This enlarged photo of the Breakout Box shows the connectors available. Below is an example of a setup with the HR4000 and Breakout Box.

Cables, Adapters, Power Supplies & More

Enclosures & Cases for Spectrometers & Accessories

Item	Description	Price
BOX-DESKTOP	Desktop Box Enclosure, 3U x 42HP, up to 7 slots	$825
BOX-DUAL	Dual Box Enclosure, 153 x 105 x 66 mm	$350
BOX-DUAL-CE	Dual Box Enclosure, 153 x 105 x 66 mm, CE Approved	$450
BOX-RACK	Rack Mount Box Enclosure, 3U x 84HP, up to 14 slots	$900
BOX-SINGLE	Single Box Enclosure, 143 x 104 x 40 mm	$350
BOX-SINGLE-CE	Single Box Enclosure, 143 x 104 x 40 mm, CE Approved	$550
SPEC-CADDY	Rugged, water-tight case for spectrometers and accessories	$150

SPEC-CADDY

Adapters and Cables

Item	Description	Price
USB-CBL-1	Cable connects from USB port on USB-enabled Spectrometers to USB port on computer; included with purchase of USB-enabled Spectrometers	$25
USB-ADP-PC	Cable and adapter block to connect from serial port on spectrometer to serial port on computer; comes with USB-CBL-PS power supply	$75
USB-ADP-PC-E	European version of the USB-ADP-PC	$50
USB-CBL-PS	5 VDC Power Supply for spectrometers in serial mode	$25
USB-ADP-DT2	Adapter for directly attaching the USB-DT Light Source to the USB4000	$75
USB-ADP-PX2	Adapter block and cable to connect PX-2 Pulsed Xenon Lamp (page 127), DT-MINI (page 125) or LS-450 Blue LED (page 130) to the USB4000	$50
HR4-CBL-DB15	HR4000 DB15 Accessory cable	$25
CBL-PX-2	Cable for connecting PX-2 to S2000 Spectrometer	$25
CBL-SER	Serial Cable, 9-pin	$25

USB-CBL-PS Power Supply

Power Supplies*

Item	Description	Price
WT-12V	Regulated 12 VDC Power Supply (1.5A, 110/220 VAC)	$25
WT-12V-R-E	Regulated 12 VDC Power Supply (2.5 A, 220 V)	$100
WT-12V-E	12 VDC Power Supply (800 mA, 220 V)	$20
USB-BP	Lithium Ion Battery Pack has two lithium ion cells; provides 8 hours of power to a USB2000 or USB4000 Spectrometer; comes with charger; charges in 3 hours with the included charger; delivers 2 amp-hours at 5 volts	$499

** Each Ocean Optics Sales, Service & Support location sells power supplies that best serves its region.*

USB-ADP-DT2

USB-ADP-PX2

Device Control

Item	Description	Price
ACC-CON-US4	Accessory connector for external triggering for USB4000 Spectrometers	Free
ACC-CON-US2	Accessory connector for external triggering for USB2000 Spectrometers	Free
HR4-BREAKOUT	A passive module that allows control of a variety of spectrometer functions such as external triggering, GPIOs and light sources; includes USB4-CBL-BB Ribbon Cable to interface to the spectrometer (see page 61 for details)	$199
FIRMWARE-FLG	Gating Firmware Upgrade for USB2000s	$250
PX-2-FIRMWARE	USB2000 or USB4000 programmed for use with PX-2	Free
USB2000-O2CODE	Stand-alone Oxygen Firmware for USB2000	$499
USB-AOUT	4-20 mA Analog Output Module for USB2000 and USB4000 Spectrometers	$499

USB-BP

ACC-CON-US2

Extended Warranty and Annual Service Packages

Item	Description	Price
ASP	Extends the standard warranty from 1 year to 2 years. Price is per spectrometer channel.	$250
ASP-ES	A 1-year warranty package available to customers whose original warranty has expired. Price is per spectrometer channel.	$300
ASP-NIR	Extends the standard warranty on NIR Spectrometers from 1 year to 2 years.	$1,000
ASP-QE	Extends the standard warranty on QE Spectrometers from 1 year to 2 years.	$750
ASP-R	1-year renewal option for holders of expiring ASPs; price is per channel.	$250
ASP-R-E	2-year renewal option for holders of expiring ASPs; price is per channel.	$350

HR4-BREAKOUT