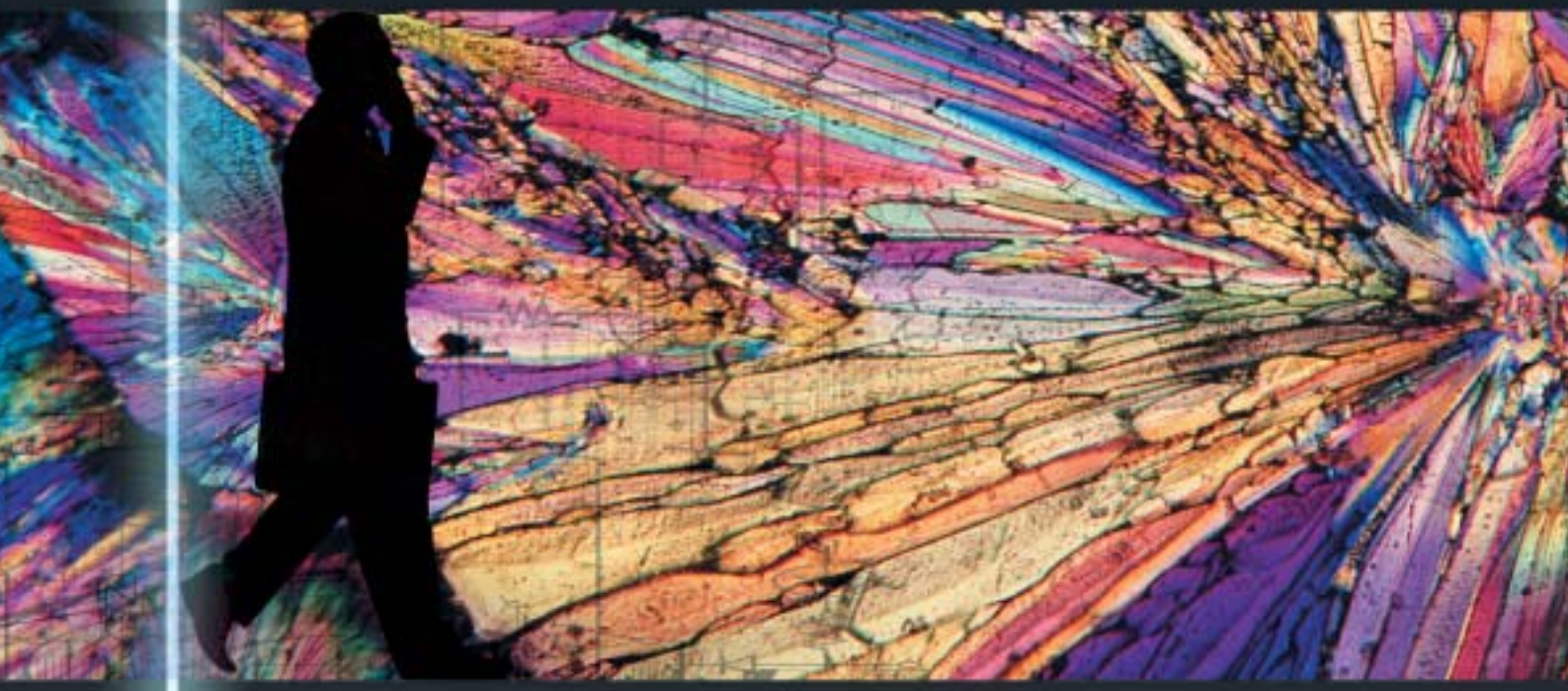



# Systems and Components for Spectroscopy

Optical Spectroscopy Division

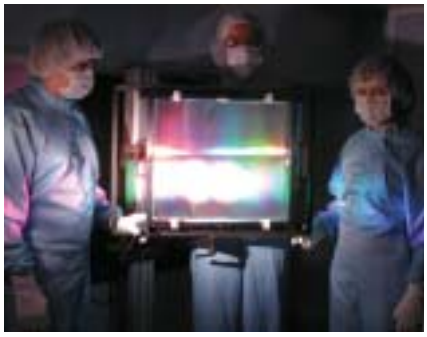
JOBIN YVON HORIBA

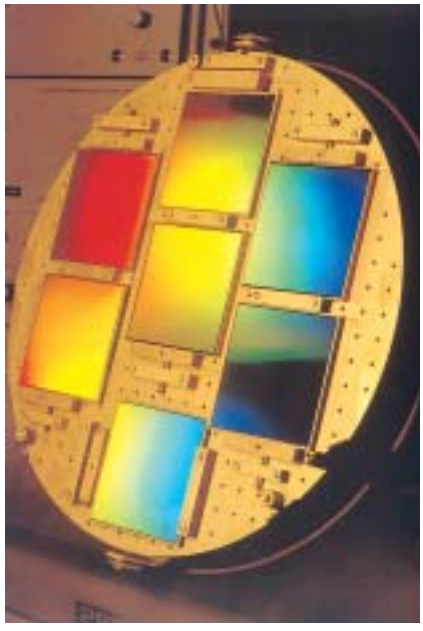
Explore the future

HORIBA GROUP

EMISSION • FLUORESCENCE • FORENSICS • GRATINGS & OEM • OPTICAL SPECTROSCOPY • RAMAN • THIN FILM

# The Optical Spectroscopy Division





Founded in 1819, Jobin Yvon (JY) has defined the leading edge of the Optics of Spectroscopy.

Our pattern of leadership in optics has been hallmarked by the continuing development of both Classically Ruled and Holo-graphic Grating Technology. This led to the introduction in 1967 of the Aberration Corrected Holographic Grating and subsequently Ion Etched, Blazed Concave and Plane Holographic Gratings.

JY gratings are found in both high volume OEM instruments and cutting edge scientific applications such as synchrotrons, rocket and space flight missions, astronomy, ultra-high speed lasers, ultra-high energy lasers, spectrophotometers, bioanalyzers, HPLC detectors, color monitors, emission spectrometers, and many other instruments that measure light spectroscopically.

For over 40 years, JY has taken a leading position in the design, development and manufactur of master and replica diffraction gratings.

The Optical Spectroscopy Division of JY Horiba specializes in plug and play components for spectroscopy. We offer a number of spectrometers, detectors and optical accessories all designed to work together as a complete system. Now you can create a system to perform your experiment, not design your experiment around your equipment. We supply the tools, you supply the sample and the imagination…

As Specialists in Spectroscopy, we at JY can take an in depth look into your application and help you to develop a spectroscopy solution from a fresh perspective.

# Spectroscopic Useful Information

## Grating Efficiency

The working range of a grating can be globally given by the general relation:

$2/3\ \lambda < \lambda < 2\lambda$

Where $\lambda$ is the grating blaze

## Defining a Bandpass or a Resolution

• With a Monochromator as an illuminator

The bandpass is defined as the width of the spectrum passed by a monochromator when illuminated by a light source with a continuous spectrum. The bandpass is calculated as the product of the optical dispersion of the monochromator and the entrance slit aperture. Reducing the slit width will decrease the bandpass until a limiting bandpass, referred to as the resolution of the instrument, is reached. The resolution is usually obtained at the diffraction limit, using less than 20 µm slit width. It corresponds to the FWHM (Full Width at Half Maximum height).

*Example:*

For a TRIAX 320 linear dispersion:

D = 2.64 nm/mm

- Measured with 100 µm slits

BP = 2.64 x 0.1= 0.264 nm

- Measured with 10 µm slits this resolution is given in the monochromator specifications.

R = 0.06 nm

## Nanometer Conversion Formulas

• Energy

$$E_{[eV]} \times \lambda_{[nm]} = C^{te} = 1230$$

$$\Delta E_{[eV]} = \left( \frac{1}{\lambda_{[nm]}} - \frac{1}{[\lambda+\Delta\lambda]_{[nm]}} \right) \times 1230$$

$$\Delta\lambda_{[nm]} = \left( \frac{1}{E_{[eV]}} - \frac{1}{[E+\Delta E]_{[eV]}} \right) \times 1230$$

*Example:*

E = 1.6 eV

$\Delta E$ = 0.01 eV

$\lambda$ = 768.75 nm

$\Delta\lambda$ = 4.77 nm

## F/value, Numerical Aperture Relation

| f/value | f/2 | f/3 | f/5 | f/7 | f/10 | f/15 |
|---|---|---|---|---|---|---|
| Ω (degrees) | 14.48 | 9.6 | 5.7 | 4.0 | 2.9 | 1.9 |
| NA | 0.25 | 0.16 | 0.10 | 0.07 | 0.05 | 0.03 |

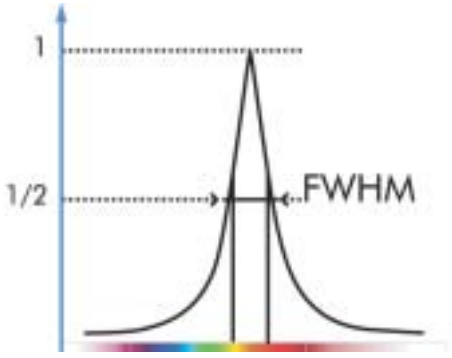
• With a Spectrograph

The bandpass is defined as the length of spectrum accessible in the flat field.
The theoretical resolution on a multichannel detector corresponds to the dispersion of the spectrograph over 3 pixels.

*Example:*

For a Triax 550 (1200 gr/mm grating)
with a 2048 x 512 pixels CCD (13.5 x 13.5 µm 3 pixel)

- D = 1.55 nm/mm
- BP = 1.55 x (2048 x 0.0135) = 42.8 nm
- R = 1.55 x (3 x 0.0135) = 0.06 nm




*The FWHM is measured using an atomic emission line such as Hg, Zn, …*

• Energy, $cm^{-1}$ (wavenumbers)

$$\upsilon_{[cm^{-1}]} \times \lambda_{[nm]} = C^{te} = 10^7$$

$$\Delta\upsilon_{[cm^{-1}]} = \left( \frac{1}{\lambda_{[nm]}} - \frac{1}{[\lambda+\Delta\lambda]_{[nm]}} \right) \times 10^7$$

$$\Delta\lambda_{[nm]} = \left( \frac{1}{\upsilon_{[cm^{-1}]}} - \frac{1}{[\upsilon+\Delta\upsilon]_{[cm^{-1}]}} \right) \times 10^7$$

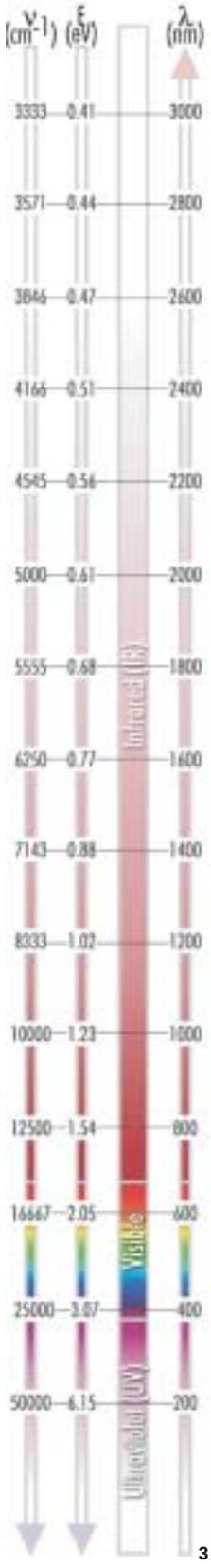
*Example:*

$\upsilon$ = 50000 $cm^{-1}$

$\Delta\upsilon$ = 20 $cm^{-1}$

$\lambda$ = 200 nm

$\Delta\lambda$ = 0.08 nm



# Choosing the Right Instrument for Your Application

**Monochromator:** An optical instrument used to isolate a narrow bandwidth of optical radiation using a diffraction grating as the dispersive element. It can be manually tuned or motorized in order to scan a range of wavelengths.
**Spectrograph:** presents a range of wavelengths at the exit focal plane for detection by a multichannel detector. The latest generation of JY spectrographs can have two exits. Both exits can be equipped with a slit or with a multichannel flange so that the same instrument can serve as a spectrograph as well as a scanning monochromator.
**Imaging Spectrograph:** has special corrective optics that maintain a better image quality and resolution along the length of the slit (perpendicular to the wavelength dispersion axis) as well as along the dispersion axis in the focal plane.

## You should consider several factors when choosing...

### A Monochromator or a Spectrograph

- Resolution
- Imaging capability
- Bandpass
- Flux (aperture)
- Spectral range

### A Detector

- Spectral range
- Detector area
- Signal to noise ratio
- Dynamic range - what levels of light need to be analyzed
- Speed of data acquisition
- Time resolution of process or event
- Single channel or array
- Triggering

| | Applications | | Transmission / Reflectance / Absorbance | Illuminator / Filter | Fluorescence | Emission Plasma | Luminescence / Photoluminescence | Raman | Cathodoluminescence | LIBS* / Pulsed Plasma | LIPS* / LIF* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Small Monochromators Spectrographs** | H10 | *M* | •••• | •••• | •• | - | •• | - | - | - | •• |
| | H20 | *M* | •••• | •••• | •• | •• | •• | - | - | - | •• |
| | CP140 | *SI* | •• | - | •• | •••• | •• | - | •••• | •• | •• |
| | CP200 | *SI* | •• | - | •• | •••• | •• | - | •••• | •• | •• |
| | MicroHR | *MSI* | •••• | •••• | •••• | •••• | •••• | •• | •••• | •••• | •••• |
| **Triax Series** | 180 / 190 | *MSI* | •• | •• | •••• | •••• | •• | - | •••• | •••• | •• |
| | 320 / 322 | *MSI* | •••• | •• | •••• | •••• | •••• | •••• | •• | •••• | •••• |
| | 550 / 552 | *MSI* | •••• | - | •• | •••• | •••• | •••• | •• | •••• | •• |
| **Classical Monochromators Spectrographs** | 500M | *MS* | •• | - | •• | •••• | •••• | •••• | - | •• | •• |
| | FHR640 | *MS* | •• | - | - | •••• | •••• | •••• | - | •• | •• |
| | 750Mi | *MSI* | •• | - | - | •••• | •••• | •••• | - | •• | •• |
| | FHR1000 | *MS* | •• | - | - | •••• | •••• | •••• | - | •• | •• |
| | 1000M | *MS* | •• | - | - | •••• | •••• | •••• | - | •• | •• |
| | 1250M | *MS* | - | - | - | •• | •• | •••• | - | - | - |
| | Gemini | *M* | •••• | •••• | •••• | - | - | •• | - | - | - |

M : Monochromator
S : Spectrograph
I : Imaging

*LIBS : Laser-Induced Breakdown Spectroscopy
LIPS : Laser-Induced Plasma Spectroscopy
LIF : Laser-Induced Fluorescence

•••• Recommended
•• Suitable
- Not recommended

# Choosing the Right Instrument for Your Application

**Single Channel Detector:** **A PMT, DSS or MCT detector must be installed behind the exit slit of a monochromator. Single channel detectors measure a single point of the spectrum. The entire spectrum must be scanned across the slit and a measurement is taken at each point.**

**Multichannel Detector:** **A CCD, InGaAs array or ICCD can detect multiple wavelengths simultaneously. Multichannel detectors must be placed at the exit port of a spectrograph.**

| Applications | | Transmission / Reflectance / Absorbance | Fluorescence | Emission Plasma | Luminescence / Photoluminescence | Raman | Cathodoluminescence | LIBS* / Pulsed Plasma | LIPS* / LIF* |
|---|---|---|---|---|---|---|---|---|---|
| CCD Detector – Front Illuminated | STE | •••• | •••• | •••• | •••• | •••• | •••• | •• | •• |
| | $LN_2$ | - | •••• | •••• | •••• | •••• | •••• | •• | •• |
| CCD Detector – Back Illuminated | STE | - | •• | •••• | •• | •• | - | - | - |
| | $LN_2$ | - | •• | •••• | •• | •• | - | - | - |
| CCD Detector – Deep Depleted | STE | - | •• | •• | •••• | •• | - | - | - |
| | $LN_2$ | - | •• | •• | •••• | •••• | - | - | - |
| CCD Detector – Open Electrode | STE | •••• | •••• | •••• | •••• | •••• | •••• | •• | •• |
| | $LN_2$ | - | •••• | •••• | •••• | •••• | •••• | •• | •• |
| ICCD Detector | | - | - | - | - | •••• | - | •••• | •••• |
| IGA Detector | STE | •••• | •• | •• | •••• | •••• | - | - | •• |
| | $LN_2$ | - | •• | •• | •••• | •••• | - | - | •• |

M : Monochromator
S : Spectrograph
I : Imaging

*LIBS : Laser-Induced Breakdown Spectroscopy
LIPS : Laser-Induced Plasma Spectroscopy
LIF : Laser-Induced Fluorescence

•••• Recommended
•• Suitable
- Not recommended

| Accessories | Small Monochromators / Spectrographs | | | Triax Series | Classical Monochromators / Spectrographs | | |
|---|---|---|---|---|---|---|---|
| | H10 / H20 | CP140 / CP200 | MicroHR | | FHR | M Series | Gemini |
| Light Source | •••• | - | •••• | •••• | •••• | •••• | •••• |
| Fiber Optic Adapter | •••• | •••• | •••• | •••• | •••• | •••• | •••• |
| DSS / PMT Detectors | •••• | - | •••• | •••• | •••• | •••• | •••• |
| CCD/ICCD/IGA Array Detectors | - | •••• | •••• | •••• | •••• | •••• | - |
| Filter Wheel | •• | •• | •••• | •••• | •••• | •••• | •••• |
| Chopper / Lock-in | •••• | - | •••• | •••• | •••• | •••• | •••• |
| SampleMax | •••• | •• | •••• | •••• | •• | •• | •••• |

•••• Recommended •• Suitable - Not recommended

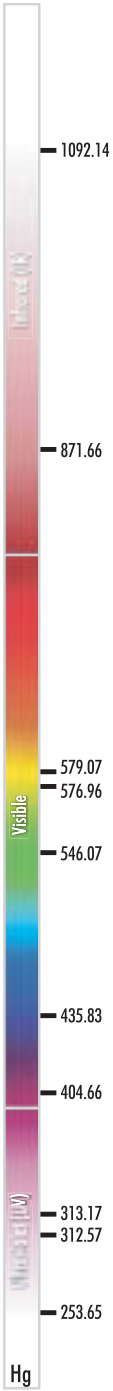
# The Light Sources

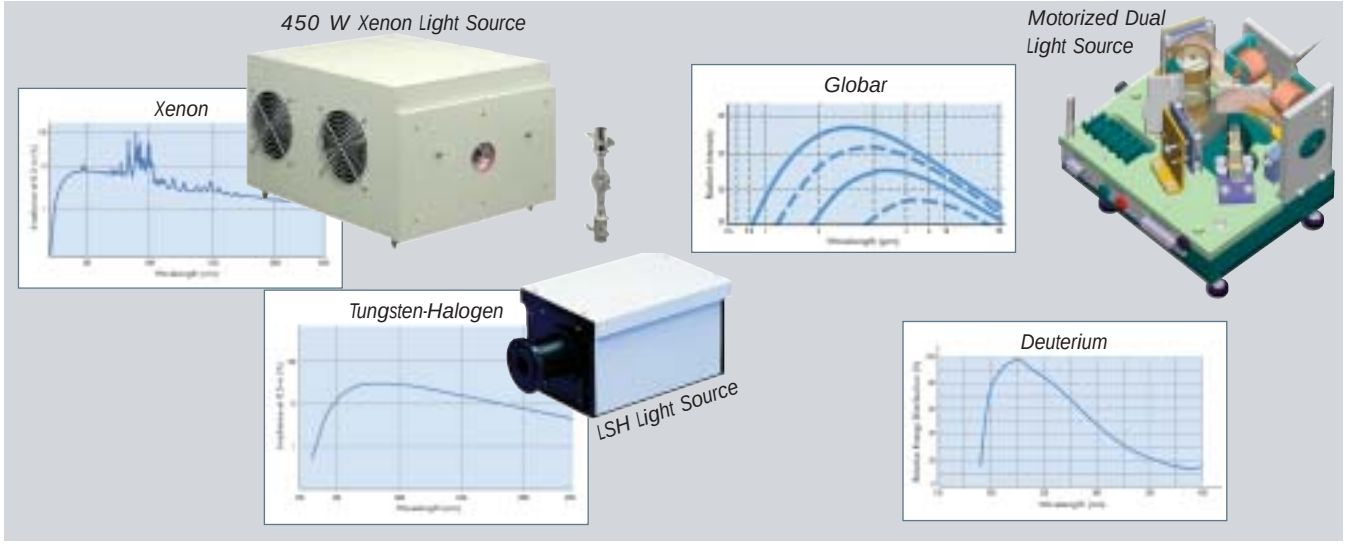
**JY offers a variety of light sources covering the spectral region from 120 nm to 20 µm, to accommodate a wide range of applications. Mirror based to avoid chromatic aberrations, these F/4 aperture optimized sources can be mounted directly to our monochromators or used by themselves. Offered in single or dual housings, our light sources are compatible with multiple accessories such as filter wheels, choppers and fiber adapters.**

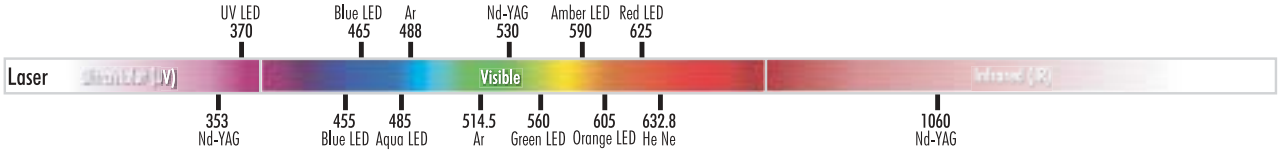
**Each type of application requires the careful choice of a light source. For example, a filament light source, such as Tungsten or Globar is usually less powerful than a discharged light source (such as Xenon), although it offers a more stable emission. Light uniformity of the focused point can affect measurements. Applications using fibers require a light source with a small, uniform spot size.**

**Our specialists can help you in choosing the best dedicated light source for your experiment.**

| Single Source | Power (W) | Spectral Range (nm) | Emission Spectrum | Size of Focus Point (mm) | Notes |
|---|---|---|---|---|---|
| **Tungsten-Halogen** | 100<br>250 | 380-2000<br>350-2500 | Continuous | ▮ 9.5 x 6.2<br>▮ 11.7 x 5.5 | Filament. More stable than Xenon lamps |
| **Deuterium** | 30 | 200-400 | Continuous | ■ 4 x 4 | Dedicated UV lamp generating higher throughput than Xenon lamps. Flat spectral shape in UV range |
| **Far UV Deuterium** | 200 | 120-400 | Continuous | ● 1 | |
| **Xenon** | 75<br>450 | 200-2400<br>180-2400 | Continuous & Lines > 600 nm | ■ 4 x 4<br>■ 18 x 18 | Available as ozone free but low spectral limit reduced to 250 nm. Spot light source |
| **Globar** **Stick Ceramic** | 75 | 1000-20000 | Continuous | ▮ 26.8 x 356<br>▮ 12 x 40 | Relatively uniform emissivity over this range |
| **Dual Source** | | | | | |
| **Tungsten-Xenon** | 75<br>100 | 200-2500 | Continuous & Lines > 600 nm | Same as Single Source | Manual / Motorized |
| **Tungsten-Deuterium** | 75<br>100 | 200-2500 | Continuous | Same as Single Source | Manual / Motorized |
| **Spectral Calibration Lamp** | | | | | |
| **Mercury** | | 200-1000 | Lines | Same as Single Source | Has distinct emission lines nominally between 200-600 nm Generally used as a wavelength calibration source |



# Small Monochromators / Spectrographs

## Higher Throughput, Fewer Optical Components

Ask for our specific documentation on small Spectrographs / Monochromators

**The small focal length of JY's compact monochromators and spectrographs makes them ideal for high dispersion applications when resolution is not the target. Our H-Series monochromators are mostly used as filters, illuminators or low resolution analyzers - applications include fluorescence, transmission and absorption. Our CP-Series of spectrographs are specially designed to be equipped with array detectors, allowing a large spectral range to be displayed in a single acquisition - applications include low resolution plasma analysis, process analysis and Cathodoluminescence. Our new MicroHR combines the versatility of the H and CP-Series spectrometers with a unique monochromator / spectrograph interchangeable configuration.**

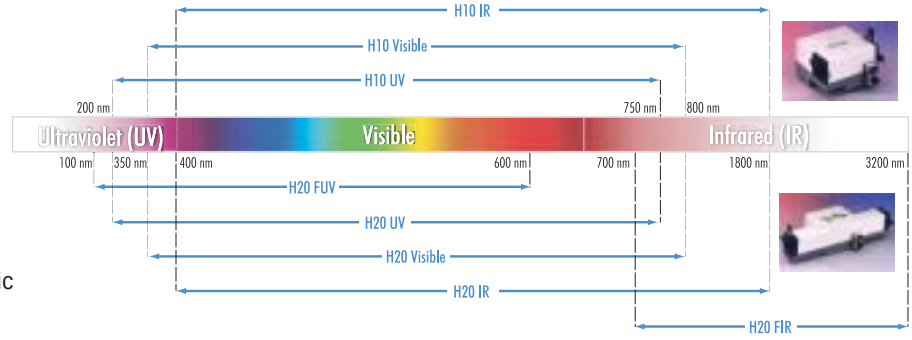
### MicroHR Monochromator / Spectrograph

- Imaging Spectrograph and Monochromator
- Interchangeable grating with more than 50 JY grating choices
- Unique design for no re-entrant light and low stray light
- Manual slit and drive
- Works in all positions
- Various accessories such as C-mount adapter, integrated shutter and imaging flange

*MicroHR Monochromator / Spectrograph*

### H10 / H20 Monochromators

- Compact and robust
- Low cost
- Fully manual (optional motorized drive)
- Patented Aberration corrected concave holographic diffraction grating
- Limited numbers of optics for High Throughput



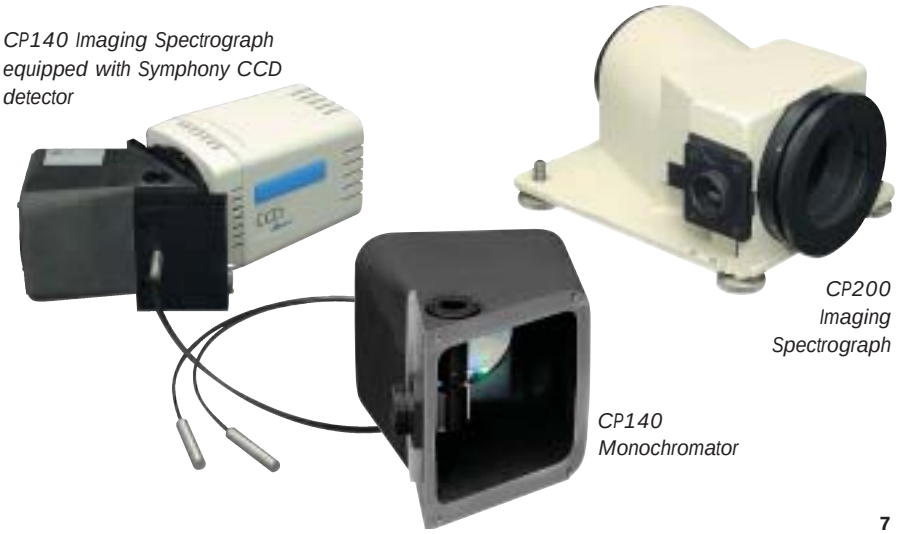

| Model | Focal (mm) | Aperture | Dispersion* (nm / mm) | Resolution** (nm) |
|---|---|---|---|---|
| **H10** | 100 | f / 3.5 | 8 - 16 | 1 |
| **H20** | 200 | f / 4.2 | 4 - 16 | 0.5 |
| **MicroHR** | 145 | f / 3.8 | 5.25 | 0.35 |

* Depending on the grating - **At 500 with 0.01 slit, 1200 gr / mm grating

### CP140 / CP200 Spectrographs: For Fixed Analysis

- Imaging Cased Spectrograph with fixed grating
- 2D corrected 25 mm x 8 mm focal plane
- Very high throughput
- Perfect for multiple fiber inputs and array detectors up to 25 mm
- Different models available:
  - spectral range from 190 nm to 2500 nm (grating dependent)
  - dispersion from 16.7 nm / mm to 70.9 nm / mm
  - Resolution from 1 nm to 7 nm

*CP140 Imaging Spectrograph equipped with Symphony CCD detector*



*CP200 Imaging Spectrograph*

*CP140 Monochromator*

# The Triax Series

## On Axis Triple Grating Turret

Ask for our specific documentation on Triax Series

**The TRIAX series uses special corrective optics to maintain an excellent image quality, resolution and throughput along the length of the slit as well as along the dispersion axis in the exit focal plane. Thus, a point source on the entrance slit is re-imaged as a point for every occurrence of its wavelength in the focal plane. This makes TRIAX spectrographs ideal for a wide range of high resolution, multichannel spectroscopic applications.**

- Very high throughput
- Low stray light and re-entrant light
- Exceptional image quality
- Dual field on 322 and 552 version
- New drive for the best repeatability

*TRIAX 322 for dual arrays*

Rediffracted light in a commercial CT spectrograph

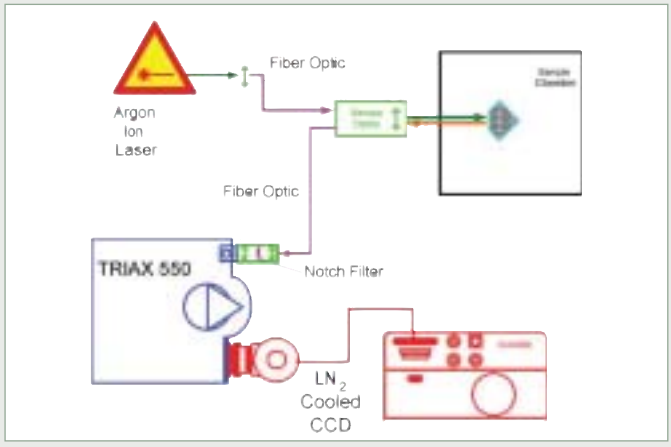
Triax 180 has no rediffraction

Exceptional image quality: image of line fiber acquired with TRIAX (right) and other commercial spectrograph (left)

| Model | Focal (mm) | Aperture | Dispersion* (nm / mm) | Resolution** (nm) |
|---|---|---|---|---|
| 180/190 | 190 | f/3.9 | 3.6 | 0.3 |
| 320/322 | 320 | f/4.1 | 2.64 | 0.06 |
| 550/552 | 550 | f/6.4 | 1.55 | 0.025 |

*Depending on the grating - **At 500 nm with 0.01 mm slit, 1200 gr/mm grating

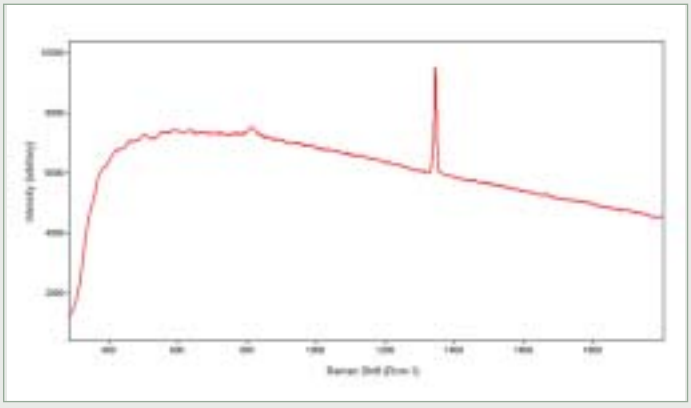
## Application: Quality Assurance of Diamond Films




Due to their unique physical properties, diamond films find applications in protective coatings, cutting tools and thermal and electronic devices. Most diamond films are grown by chemical vapor deposition, aiming for a high content of diamond and very little graphite. Raman spectroscopy can be used for diagnostic testing to determine the quality of diamond films. Raman offers a quick, sensitive, non-destructive, and non-contact method to qualitatively test the resulting films.

The presence of diamond band was observed with the low-cost Raman system. This and similar systems are suitable for characterization and quality assurance of diamond films. For more demanding research measurements closer to the excitation line, the JY Raman Division focuses on dedicated, fully-characterized Raman systems based on single, double and triple monochromator configurations. These systems allow analyses within 10 $cm^{-1}$ from the Rayleigh excitation line with ultra-low stray light rejection.

*Diamond Raman Sample Excited at 514 nm*



# Gemini, FHR and M-Series

## Long Focal Length Spectrometers

Ask for our specific documentation on our large spectrometers

**When extremely low stray light levels are required, such as in Raman, fluorescence excitation or when ultra high resolution is needed for emission structure analysis, our large monochromators and spectrographs are the solution for your application.**

### Gemini 180: Ideal for Low Stray Light Applications and Illumination

- Double additive Czerny-Turner with dual torroidal mirrors
- Stray light: $10^{-9}$ at 8 nm from 632.8 nm
- Single drive to move both gratings
- Optical design optimized for high throughput
- Fully automated
- Interchangeable grating

*Gemini 180: dual stage monochromator for the best stray light rejection*

### FHR: For High Resolution and Ultra Fast Acquisition

*FHR 1000: the fastest 1 meter spectrograph*

JY 2004

Our lastest JY OSD product development, the FHR series combines high resolution, precision and high speed. When equipped with an array detector, the FHR is the ideal tool for researchers who need accuracy and immediate results.

- Two focal lengths available: 640 mm or 1000 mm
- Speed: faster than 300 nm / sec with 1200 gr / mm grating
- Fully automated (drive and slit)
- 110 mm x 110 mm single grating or 80 mm x 110 mm dual grating turret for high throughput

| Model | Focal (m) | Aperture | Dispersion* (nm / mm) | Resolution** (nm) |
|---|---|---|---|---|
| 500M | 0.50 | f / 4[1]<br>f / 6.9[2] | 1.60 | 0.02 |
| FHR 640 | 0.64 | f / 5.4[1] | 1.20 | 0.016 |
| 750M | 0.75 | f / 6[1]<br>f / 10.4[2] | 1.10 | 0.01 |
| 750S/I | 0.75 | f / 6[1]<br>f / 10.4[2] | 1.10 | 0.015 |
| 1000M | 1.00 | f / 8[1]<br>f / 13.9[2] | 0.80 | 0.008 |
| FHR1000 | 1.00 | f / 9[1] | 0.80 | 0.008 |
| 1250M | 1.25 | f / 9[3]<br>f / 11[1] | 0.65 | 0.006 |

**1** with 110 mm x 110 mm grating - **2** with 64 mm x 64 mm grating
**3** with 120 mm x 140 mm grating

*Depending on the grating
**At 500 nm with 0.01 mm slit, 1200 gr / mm grating

### M Series: The Ultimate Performance Spectrometers

The M-series is a proven family of research grade spectrometers. Individually, each spectrometer in this family delivers higher resolution and offers a degree of system automation and versatility not found in any comparable focal length spectrometer.

*750S Spectrograph*

# Symphony CCD Detectors

## Orchestrate your Experiment with the New Symphony CCD Line

Ask for our specific documentation on our CCD detectors

**The Symphony CCD detector line offers a unique combination of outstanding sensitivity, high speed, low noise, ruggedness and durability, all in compact and economical packages. These array detectors have totally revolutionized spectroscopic detection with the ultimate performance in a wide range of spectroscopic applications.**

- Specially designed of spectroscopy
- Low read out noise
- Cooling options:
  - $LN_2$: 72 hours of hold time with extremely low noise
  - STE: better than 70 °C (with air only)
- All type available in a variety of formats with pixel sizes from 13.5 µm to 26 µm

**Front Illuminated detectors** are the standard for spectroscopy. They are the best choice for applications such as Raman and photoluminescence ($LN_2$ cooled detectors), or Transmission / Reflection measurements in the 400 nm - 900 nm spectral range (TE cooled detectors).

**Open Electrode detectors** are becoming more and more popular. They offer an attractive solution for Emission, Transmission and Reflection or other applications where the dynamic range is not a limiting factor.

**Back Illuminated detectors** have a dramatically increased quantum efficiency (approaching that of 90 %), compared to other detector types. Ideally used for extremely low signal detections, such as very weak Raman scattering or Emission analysis of low concentration plasmas, they are limited in their use by the etaloning effect.

**Deep Depleted detectors** are optimized for increased NIR response. Mainly used in the $LN_2$ cooled version, these devices offer a detection solution in NIR spectral range when back illuminated detectors are inefficient as a result of the etaloning effect.

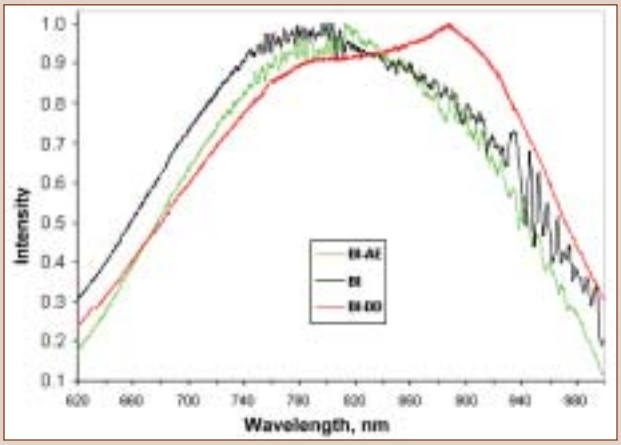
**Front Illuminated**
- Standard
  - UV-Visible
  - Visible
- Open Electrode
- Deep Depleted

**Back Illuminated**
- Standard
  - UV-Visible
  - Visible
- Deep Depleted


*Symphony $LN_2$ and TE heads*

## Application: Etalonning Effect

Back illuminated CCDs, illuminated from the rear, allow incident photons to interact directly with the photosensitive silicon substrate without having to penetrate an electrode layer. This design results in increased sensitivity and quantum efficiency (QE). However, in the near infrared (NIR) region of the spectrum, back illuminated CCDs experience reflections between their front and back surfaces. This adverse side effect, referred to as etaloning, leads to fringes of constructive and destructive interference which distort a spectrum. Although the effects of etaloning cannot be completely suppressed, they can be greatly reduced depending on the CCD type. JY offers several CCD detector options to combat the effects of etaloning, allowing for optimal results in NIR applications.




*Example of etaloning effects with different Back Illuminated CCD chips*

# Symphony CCD Detectors

## The CCD Chips Dedicated to Your Applications

Ask for our specific documentation on our CCD detectors

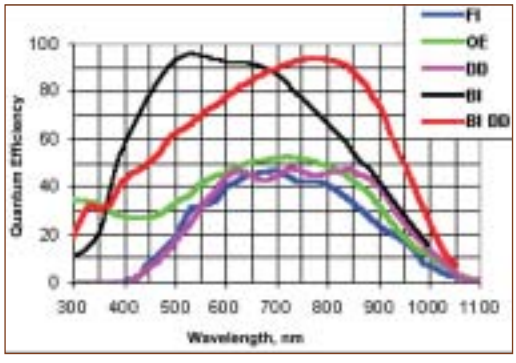
**All detectors in this family use high quality, full-frame, scientific-grade CCD sensors from various major chip manufacturers. JY works very closely with these manufacturers to specify and design these chips in order to make them ideally suited for spectroscopic and scientific applications.**

In general, the optimum choice of a CCD detector will depend upon:
- The wavelength range of interest
- The anticipated signal or light levels
- The required spectral coverage and resolution.

These parameters in turn will determine the type of chip (best quantum efficiency, QE), the type of detector cooling, the overall active sensor area and the individual pixel size. In addition to these operating parameters, other important experimental factors include the required dynamic range of the measurements and the desired speed of data acquisition.

| Architecture | Front Illuminated | | | | Back Illuminated | | |
|---|---|---|---|---|---|---|---|
| Chip | UV - Vis | | Open Electrode | Deep Depleted | UV - Vis | | Deep Depleted |
| **Chip format** | 1024x128<br>1024x256 | 2048x512 | 1024x512 | 1024x512 | 1024x128<br>1024x256 | 2048x512 | 1024x256 |
| **Pixel size, µm** | 26 | 13.5 | 26 | 26 | 26 | 13.5 | 26 |
| **Readout Noise (e-rms)(Typ)** | 3.5<br>20 | 2<br>20 | 4<br>20 | 4<br>20 | 5<br>20 | 3<br>20 | 4<br>20 |
| **Dark current** | 0.3*<br>0.002** | 0.3*<br>0.001** | 0.5*<br>0.002** | 1*<br>2** | 0.3*<br>0.0024** | 0.3*<br>0.002** | 2*<br>2** |

* e / pixel / hour - ** e / pixel / second




Quantum efficiency (QE) is defined as the ratio of induced current to incident flux (often measured in electrons per photon). The basic signal element is a photoelectron. The QE depends on the wavelength of light (i.e. the energy of the impinging photon), the material type, shape, and other physical parameters such as thickness and reflectivity of the surface.


## Symphony CCD Controllers

Symphony - Solo-Fast: "For arrays" (included in our Symphony Array package)

- Minimized system noise
- 16 Bit ADC with 20 kHz to 1 MHz readout rates
- Fast TCP / IP interface with 100 % data integrity ensures against data transmission errors
- User programmable Input and Output Triggering
- Compatible with all Symphony heads (automatic recognition)
- Operational with *SynerJY*® software
- Built-in self diagnostics

# The iCCD

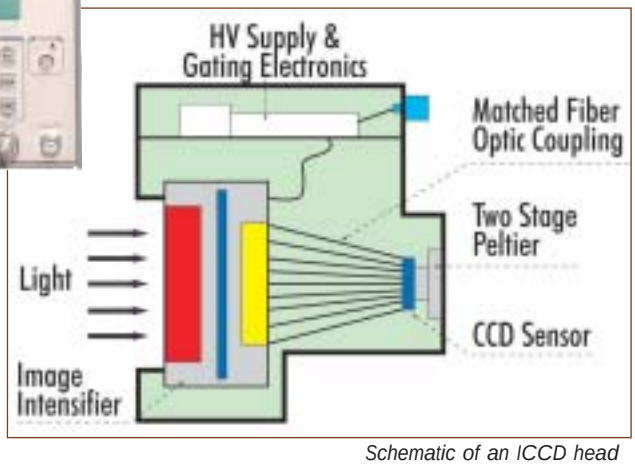
## A High Speed ICCD Detector for Time Resolved Measurements

Ask for our specific documentation on our CCD detectors

**Time domain measurements have become increasingly important in many materials and spectroscopic applications. JY has been very active in time resolved measurements and our Intensified Charge Couple Device (ICCD) system is an ideal choice for time gated spectral applications from nanoseconds to seconds in the UV/VIS/NIR regions.**

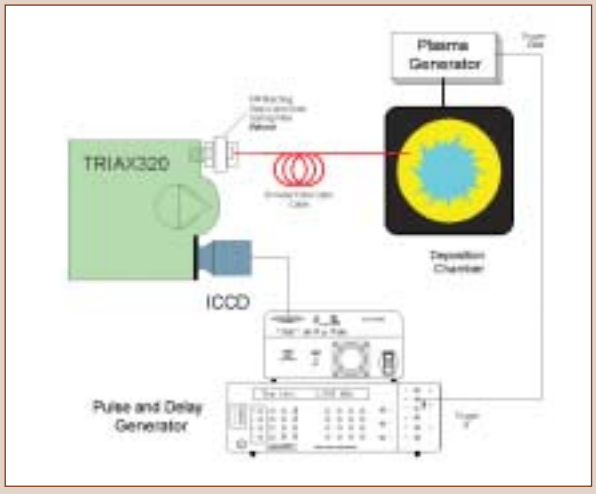
- Ideal for time domain measurement
- Nanosecond scale acquisition
- Full trigger capability
- UV-visible range
- Extremely low dark current
- Very stable trigger and pulse generator
- S20 or S25 available photocathode
- Pulse counting capability
- Stand alone pulse generator

Our ICCD with its ICCD Pulser




*Schematic of an ICCD head*

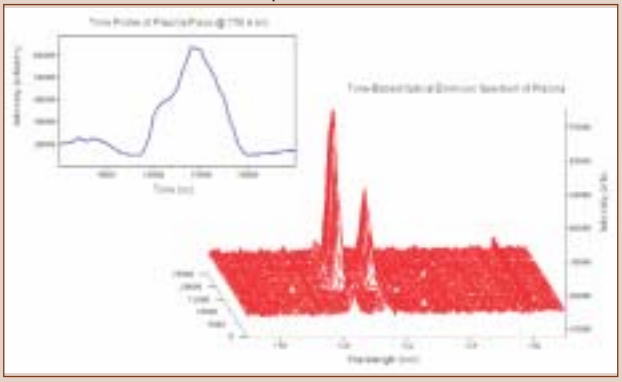
## Application: Plasma Monitoring




A JY spectroscopy system is used for the analysis and optimization of pulsed plasmas to provide a higher quality deposition as well as a steady-state Optical Emission Spectrum measurement.

Improvements in Sputtering Deposition systems have led to the use of pulsed plasmas. It is believed that pulsing the plasma causes a temporary increase in electron temperature and that as pulsing frequency increases higher plasma potentials result. Higher plasma potentials cause higher energy ion bombardment of films and thus greater surface mobility of atoms and more thermodynamically favorable film growth. For the systematic study the effects of frequency and duty cycle on pulsed plasmas for sputtering systems, a spectroscopy system including a JY Intensified CCD detector was designed to study the effects of pulsing parameters on the optical emission spectra.

*Plasma sample taken with ICCD*



# The Symphony IGA

## NIR Sensitivity with Ultra Low Noise

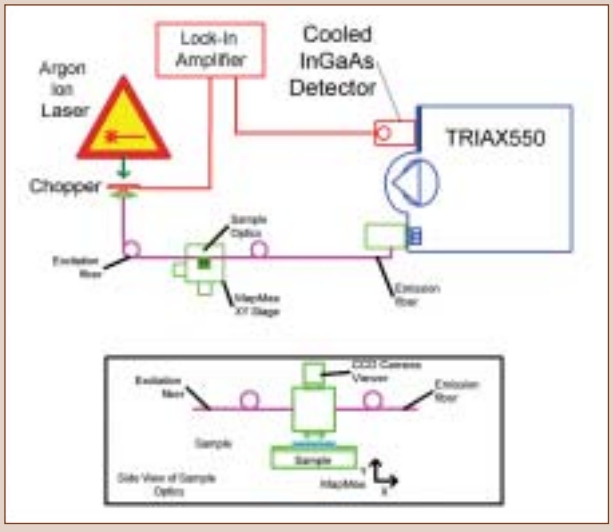
Ask for our specific documentation on our IGA detectors

**As the semiconductor and telecommunications industries continue to become more sophisticated, there is an increasing interest in the NIR region of the spectrum for characterization of optical fibers, light sources, semiconductors and other related materials. In order to cover such applications, JY has developed the Symphony InGaAs linear array family, which consists of very low noise detectors optimized for spectroscopic measurements.**

- Array detector for 0.8 µm to 1.65 µm
- Highest NIR sensitivity with ultra low noise
- Large choice of pixel formats (512 or 1024 pixels)
- 25 µm or 50 µm pixel widths
- High performance TE or $LN_2$ cooling options
- Two acquisition modes:
  - Hi S (High Sensitivity)
  - Hi D (High Dynamic Range)
- Ideal for:
  - NIR Raman Spectroscopy
  - Photoluminescence
  - Plasma diagnostics
  - Emission spectroscopy
  - NIR characterization of laser diodes and optical filters
  - Fiber optic transmission measurements in the telecommunications industries


Incredible NIR Sensitivity

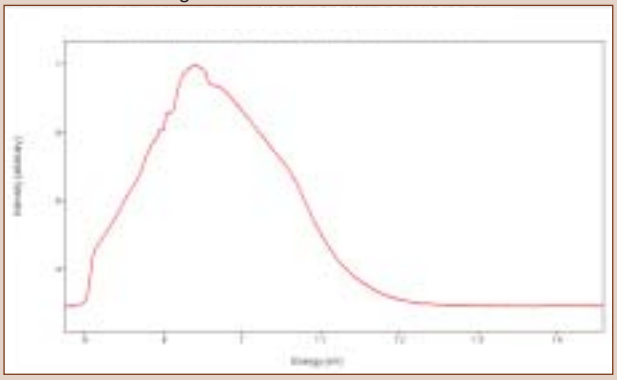
## Application: Photoluminescence of Semiconductors




A complete, nearly turn-key system for photoluminescence measurements from JY is shown to produce spectra with high signal-to-noise ratio, for diagnostic testing of semiconductors and other materials. A JY photoluminescence system provides a comprehensive solution for characterization of semiconductor materials.

Photoluminescence (PL) spectroscopy is a powerful optical method used for characterizing materials. It can be used to find impurities and defects in silicon and group III-V element semiconductors, and to determine semiconductor band gaps. A material absorbs light, creating an electron hole pair; an electron from the valence band jumps to the conduction band leaving a hole. The photon emitted upon recombination corresponds to the energy difference between the valence and conduction bands, and is hence lower in energy than the excitation photon.

*Photoluminescence spectrum of a doped GaAs sample obtained using a $LN_2$ cooled InGaAs detector*



# Single Channel Detectors

## When Sensitivity is the Issue From 200 nm to Beyond 20 µm

Ask for our specific documentation on our single channel detectors

**Solid State Detectors (DSS) are opto-electronic devices used to convert incident photons to electronic signals. Available with wavelength ranges from 200 nm to beyond 20 µm, solid state detectors offer a combined sensitivity, dependability, cost and efficiency not available in other devices. Photomultiplier tube (PMT) detectors typically offer much higher sensitivity than solid state detectors and operate effectively in the 180 nm to 1.0 µm spectral range. PMT detectors also require high voltage power supplies.**

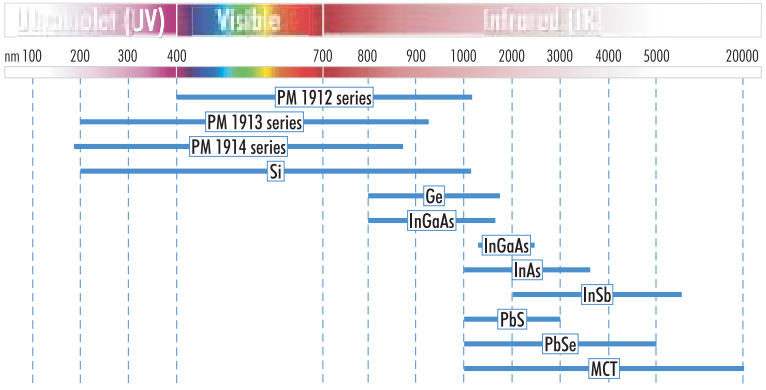
- Large choice of single channel detectors
- Available from 200 mm to 20 µm spectral range
- Optimized interface for JY Spectrometers
- Room temperature, thermo electric, $LN_2$ cooled
- Photon counting PMT choice

## Specifications of DSS Detectors

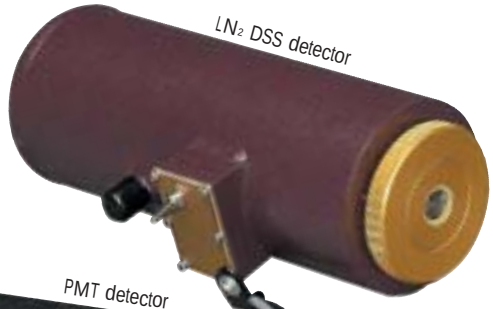
| | Range (µm) | NEP | Active Area (mm) | Cooling |
|---|---|---|---|---|
| **Si*** | 0.2-1.1 | $1.5x10^{-14}$ | ø10 | RT |
| | 0.2-1.1 | $1x10^{-14}$ | ø2.5 | RT-TE |
| **Ge**** | 0.8-1.8 | $4.5x10^{-13}$ | ø2 | RT |
| | 0.8-1.75 | $5x10^{-13}$ | ø2 | TE |
| **InGaAs*** | 0.8-1.7 | $5x10^{-14}$ | ø2 | RT |
| | 0.8-1.65 | $1.5x10^{-14}$ | ø2 | TE |
| | 0.8-1.5 | $1x10^{-15}$ | ø2 | $LN_2$ |
| | 1.2-2.5 | $5x10^{-13}$ | ø1 | TE |
| | 1.2-2.3 | $5x10^{-13}$ | ø1 | $LN_2$ |
| **InAs***** | 1.0-3.5 | $2x10^{-10}$ | ø2 | RT |
| | 1.0-3.4 | $1x10^{-11}$ | ø2 | TE |
| **InSb***** | 2.0-5.5 | $1x10^{-12}$ | ø2 | $LN_2$ |
| **PbS**** | 1.0-2.8 | $2x10^{-12}$ | 2x2 | RT |
| | 1.0-2.8 | $3x10^{-13}$ | 2x2 | TE |
| **PbSe***** | 1.0-4.5 | $5x10^{-10}$ | 2x2 | RT |
| | 1.0-4.5 | $2x10^{-11}$ | 2x2 | TE |
| **MCT**** | 1.0-5.0 | $1x10^{-11}$ | 2x2 | TE |
| | 1.0-10.0 | $2x10^{-8}$ | 2x2 | TE |
| | 1.0-14.0 | $5x10^{-12}$ | 2x2 | $LN_2$ |
| | 1.0-20.0 | $2x10^{-11}$ | 1x1 | $LN_2$ |
| **Two color** | Please contact JY | | | |

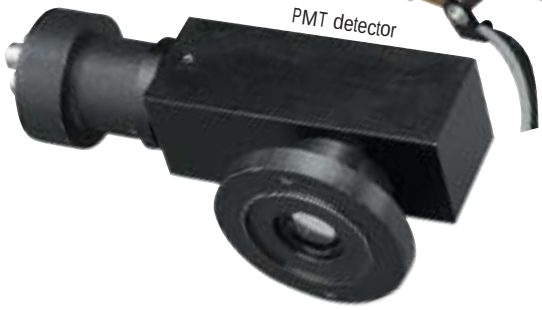
**Lock-in not required* ***lock-in suggested* ****Lock-in required*

## Type of Single Channel Detectors Available








## SpectrAcq2: For PMT or solid state detectors


*SpectrAcq2 single acquisition controller*

- Compact spectral data acquisition system for spectroscopy
- Data acquisition from one channel
- 16 bit resolution and accuracy
- Configurable for current or voltage signal inputs
- Optional photon counting module
- Analog output for controlling PMT high voltage: 0 V to +5 V

# Software

## Spectroscopic Tools Developed by Spectroscopists

Ask for our specific documentation on our software

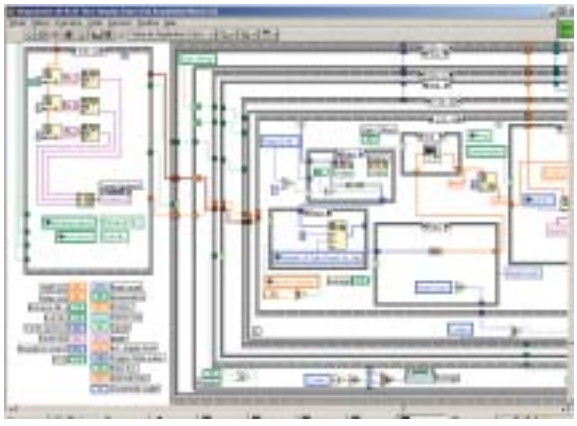
**SynerJY® is a sophisticated, fully integrated spectroscopic software package for data acquisition and analysis. It is designed specifically for data acquisition from JY spectroscopy systems. The software provides complete control of all aspects of JY's imaging and high-resolution spectrometers, scientific grade CCD and InGaAs systems, single channel detectors and data acquisition electronics, and full line of automated accessories. Using the well known Origin environment for data treatments and viewing, SynerJY® is an indispensable tool for your application.**

### SynerJY®

- Easy to use integrated software
- Controls JY spectroscopy accessories:
  - Spectrometers
  - Arrays (CCD, InGaAs…)
  - PMTs and solid state detectors
  - Lock-in amplifiers (contact JY for compatibility)
  - Filter wheels
  - Symphony, Spectracq2, Datascan2 electronics compatible
- Simultaneous multichannel and single channel data acquisition
- Powerful data processing (Origin Pro based)
- Data presentation (Origin Pro based)
- Data import and export
- Computer requirements:
  Windows® XP or 2000, 128 MB RAM, CD ROM drive, 200 MB disk space.

**SynerJY®**: *Area selection*

***SynerJY®**: Data Preview mode*



*Runtime: Setup Diagram*

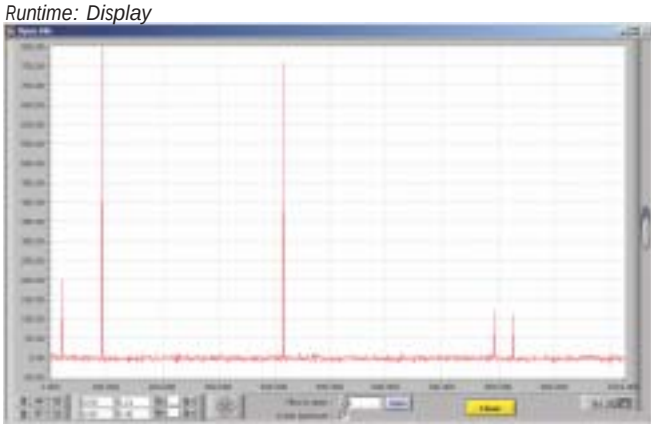
### LabView® Possibilities

The Virtual Instrument (V.I.) drivers offered by JY, allow end users to develop their own software using our devices. Based on these V.I.s, JY can also supply runtime for a full turn key system built on your specifications.

- Controls all JY Optical Spectroscopy Division products
- Dedicated Runtimes for specific applications (LabView® software not needed: contact us for more information)
- Customized development

*Runtime: Device Configuration*

*Runtime: Display*



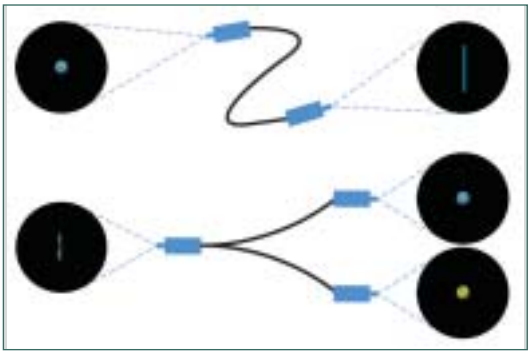
# Fibers

## Easy to Install, no Alignment Issues

**When light emission is not accessible with classical mirror or lens assembly, or when multiple reflections are not desired, and if loss of collected signal is not an issue, fibers can be an alternative to complicated optical alignment. Designed as a single fibers, bundles with multiple arm capabilities, or as compact optical probes, fibers offer a real solution for lighting, multi-tracking spectroscopy, fluorescence, Raman or plasma analysis. With expertise in this field, JY offers a complete line of fibers and fiber accessories designed to maximize system performance.**

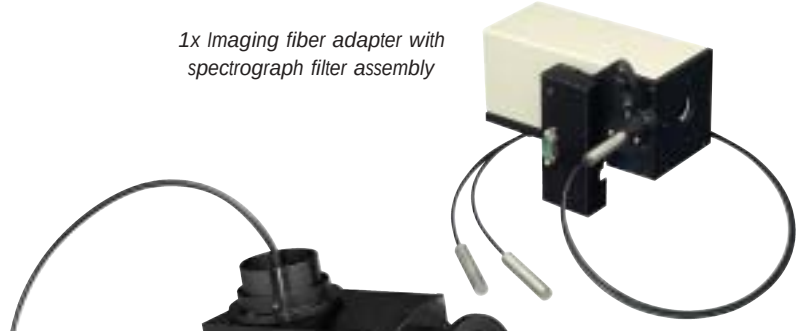
### Optical Fibers

- Extremely flexible to use, ideal for modular spectroscopy
- Transmission range optimized from 200 µm to 6 µm
- Multiple connector types: SMA, Ferrule 10 mm, FC / PC
- Standard length: 1 m or 3 m
- Round to line bundle optimized for collected light into a spectrometer
- Multi-leg configuration for multi-tracking experiments or probe
- Customized fiber configuration for specific applications



*Example of fiber optics bundles*

*1x Imaging fiber adapter with spectrograph filter assembly*



*Fibered 1427B mirror based adapter for lighting*

*2x fiber adapter*

### Optical Fiber Adapters for Monochromators and Spectrographs

As the numerical apertures (NA) of a fiber does not necessarily match the aperture of the spectrometer, JY offers a full range of fiber adapters.

- For spectrographs / spectrometers / monochromators at entrances:
  - direct adaptor (optic free)
  - lens based, adapting the NA for short spectral range
  - mirror based: imaging adapter specially designed for multi-tracking solutions (magnification x1) light collecting adapter
- For monochromators at exit:
  - elliptical mirror based system (1427B) collecting light from the whole hight of the exit slits focusing the flux on one point (magnification 1 / 6)

### Fiber Adapters for Samples

Our fiber adapters are optimized for lighting or signal collection from samples.

- Collimating beam up to 25 mm
- 5 to 25 mm Spot Analysis
- SMA, Ferrule 10 mm, FC / PC connector compatible.

*Example of a lens based fiber adapter for lighting*

# Accessories

## We Supply the Tools, You Supply the Sample...

Ask for our specific documentation on our accessories

**If you do not have the time and space to design and adapt your own experimental accessories, trust in our spectroscopic knowledge and choose a JY solution.**
**We offer all of the necessary spectroscopic accessories that you need for building an experiment. Based on our modular spectroscopy concept, our accessories such as sample compartments, cryostat adapters, microscopes, X-Z stages, automatic or manual filter wheels and optical choppers can be easily assembled together making a device targeted to your application.**

### Sample Compartment

- Lens or mirror based
- Solid or liquid sample holders
- X-Z 2 stages
- Interchangeable optics for operation in the visible, UV and IR spectral regions
- Ideal for reflectance, transmission, absorption, emission, photoluminescence, Raman and fluorescence measurements
- Wide range of accessories such as polarizer, variable, slits and filters

*SampleMax: a flexible sample compartment*

*5 position filter wheel*

### Filter Wheel and Filters

- Manual or automatic filter wheels are compatible with JY spectrometers and accessories
- 1" or 1 / 2" cut off filters
- Automatic filter slide for fiber adapters

### Application: Transmission / Absorption / Reflectance

Example of a simple instrument for Transmission or Absorption measurements built with a TRIAX and the following accessories: LSH light source, 6 position filter wheel, SampleMax sample compartment, DSS single detector, SpectrAcq2 acquisition controller and *SynerJY*® software.

*TRIAX based transmission system*

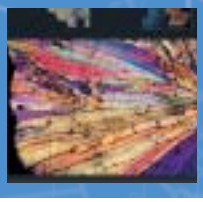
### Motorized XY Stage

Ideal for Macro or Micro spectroscopy applications requiring data acquisition from several locations of sample or mappings.

- 2 axes translational crossed stage
- Precise linear motion (100 µm)
- High repeatability and accuracy with extremely low back lash
- Fully automated, equipped with an IEEE-488 or RS232
- LabView® V.I.s drivers available

*MapMax XY stage*

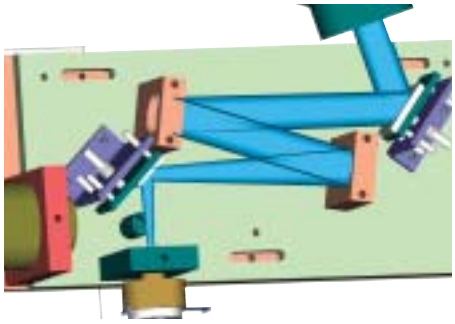
LabView® is registered trademark of National Instrument



# Customized System

## Dedicated Answer to Your Needs

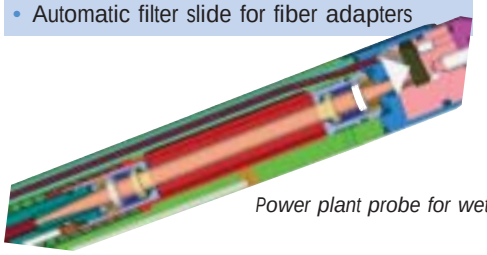
**JY has acquired a vast experience in providing turnkey systems. We offer complete spectroscopic solutions in designing and manufacturing equipment and products for Research and Industry.**



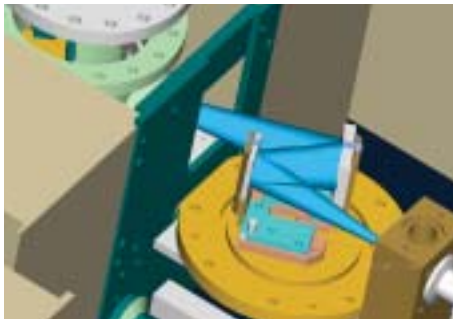
*Focusing optical head on evaporator for one meter focal length spectrograph.*

### Our Experience

- Optical design
- Mechanical design
- Software development
- 1" or 1 / 2" cut off filters
- Automatic filter slide for fiber adapters



*Power plant probe for wetness measurement*



*FUV excitation on fluorescence application*

## Current systems :

The custom systems described bellow are applications currently offered by JY. We can also provide turnkey adapted system based on customer requests and specifications. Our team of experts will work with you to design a custom solution for any spectroscopic application.

### • Photoluminescence

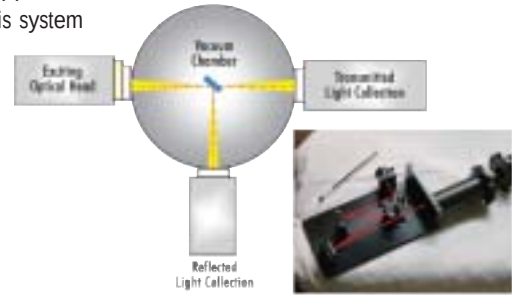
This PL system includes an excitation light source, a detector and a cryostat attached to a high resolution 1000M spectrometer. All components are software controlled.

### • Detector Response Analysis

This device measures the absolute response of detector. A light source (Xenon 450W) is coupled to a single or a double filtered monochromator. Monochromatic light is then diffused in an integrating sphere and is analyzed in a real time by a calibrated reference detector and a test detector. The calculated ratio of these measurements gives the response of the detector.

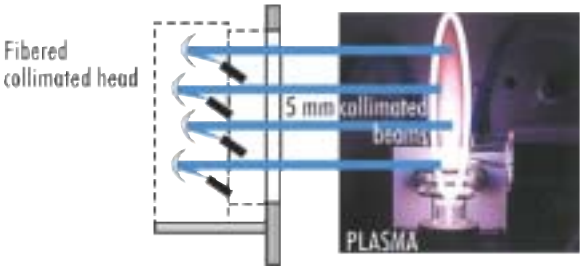

### • Transmission and Reflection Characterization

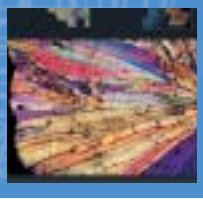
Used in coating process or post process (in vacuum or in ambient conditions), these two optical heads produce a collimated or focusing beam on a sample (such as an evaporator) installed in the chamber. Sample transmission and reflection are simultaneously measured using a spectrometer equipped with a CCD detector. Real time measurement capability makes this system ideal for end point detection.




### • Plasma Spectroscopic Analysis

This setup has been developed for Spatial Plasma analysis. Five to ten mirrors collect a 5 mm collimated beam oriented to different plasma areas. The signals are analyzed through a fibered spectrograph. As result, this system gives the location of the species present in the plasma.





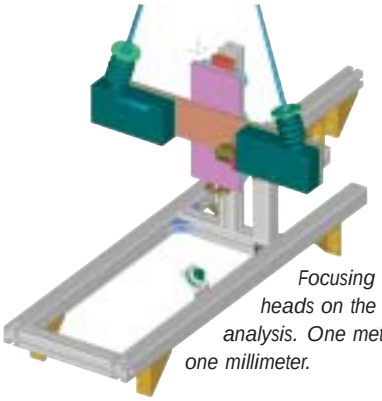
# Customized Accessories

## Dedicated Accessories Optimized with Your Set Up

### • Light Focusing & Collection Modules

*Achromatic one meter viewfinder on solar illuminator*

Chromatic aberration free optical heads for signal collection or sample illumination are supplied with collimating or focusing optics.



*Focusing and collecting achromatic heads on the same arm for reflectance analysis. One meter focal distance - Spot size one millimeter.*

### • Sample Compartment

JY designs sample compartments for "extreme" characterization, offering solutions when the nature or size of samples and environmental conditions (vacuum, gas, purge, temperature, illumination…) are a real challenge.

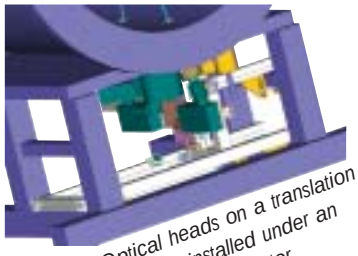
*Thermostat with toxic gas flow cell for fluorescence characterization*

*Sample holder, in vacuum chamber, allowing transmission and reflection analysis at variable angles.*

### • Mechanical Integration

We integrate standard devices such as cryostats, spheres, lasers, detectors, microscopes and fibers.

Our spectroscopy systems can be integrated to your existing device with respect to its mechanical set-up.



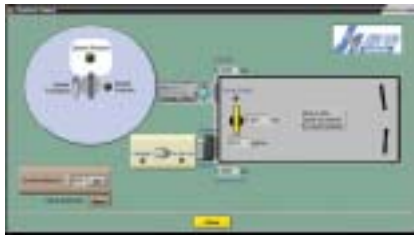
*Optical heads on a translation stage installed under an evaporator*

*Laser-cryostat integration for photoluminescence applications.*

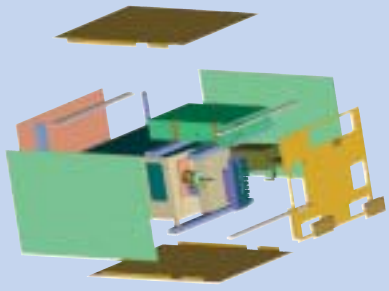
### • Dedicated Software with an easy-to-read diagram

Showing easy reading diagram control and setup, our Runtime software based on Labview®, simplifies your data acquisition. Key functions automate your process and are able to monitor other Labview® compatible devices. Each screen is customized according to your need.

*Display tailored to the customer experiment*



## Engagement in European Research Project



JOBIN YVON is involved as a partner in the Megajoule project.

For this project, we designed a spectral analyzer for a 1ω and 3ω laser line. This device, using a customized fibered spectrograph, simultaneously analyzes the bandpass stability of twenty-two check points located along the laser path. Integrated in a single box, this device can be serviced in less than thirty minutes.

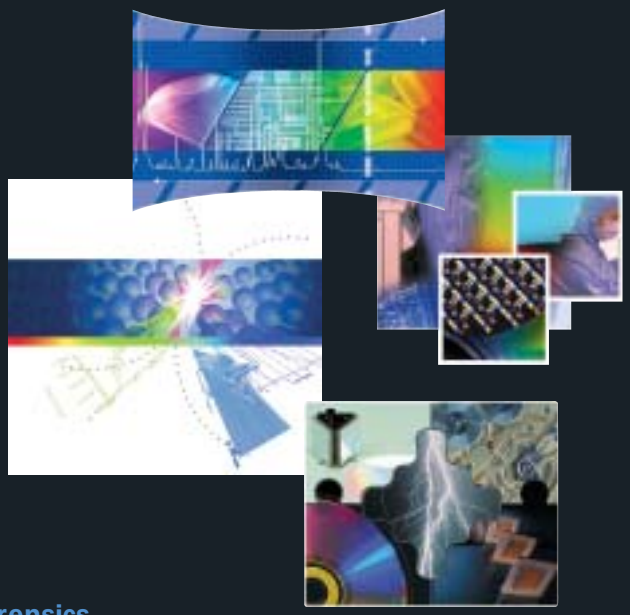
# Let's explore the light together

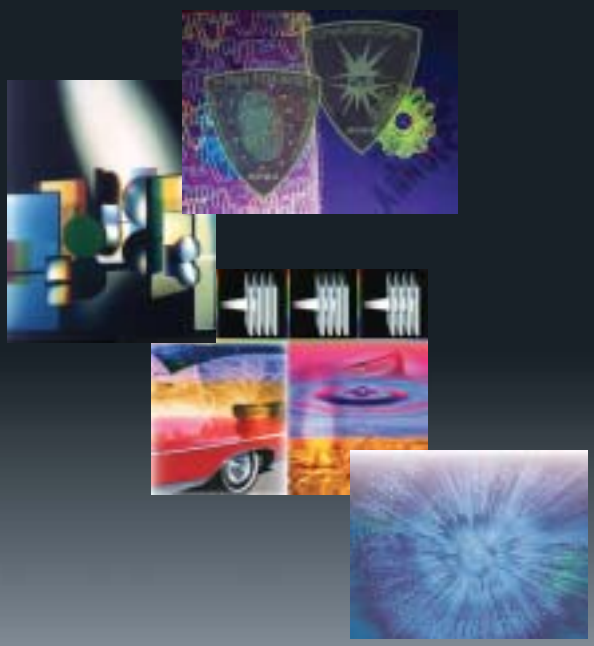
## Raman
- Laboratory, research and process instruments from UV to NIR
- Unique combination microRaman-microFTIR

## Thin Film
Thin Film Characterization
- Ellipsometry and Reflectometry from DUV to NIR
- Real Time Process Control by OES and Imaging Interferometry

## Fluorescence
- Compact and Modular Spectrofluorometers
- Steady-state and Fluorescence Lifetime acquisition
- Full range of Accessories

## Optical Spectroscopy
- Monochromators and Imaging Spectrographs
- CCD and IR Detector Arrays
- Light Sources and other accessories
- Custom application-oriented solutions





## Forensics
- Forensics Light Sources
- Fingerprint Imaging Systems UV-Visible
- AFIS-APIS - Automated Fingerprint & Palmprint Identification Systems
- Laboratory and Crime Scene Supplies
- Surveillance and Security Equipment

## Gratings - OEM - VUV
- Holographic and blazed holographic gratings for research and OEM applications
- OEM monochromators and spectrograph modules
- VUV special gratings and spectrometers
- Synchrotron beamline monochromators

## Emission
- Atomic Spectroscopy by ICP-OES / Glow Discharge / Spark
- Elemental Analyzers by C / S, O / N and H Analysis
- Sulfur in oils analyzers

## Particle Size Analysis
- Laser scattering PSDA
- Dynamic light scattering PSDA



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