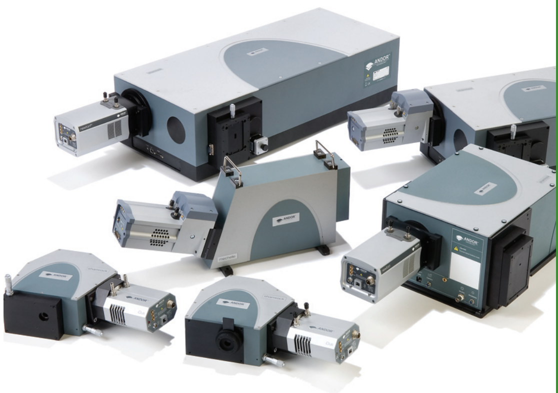
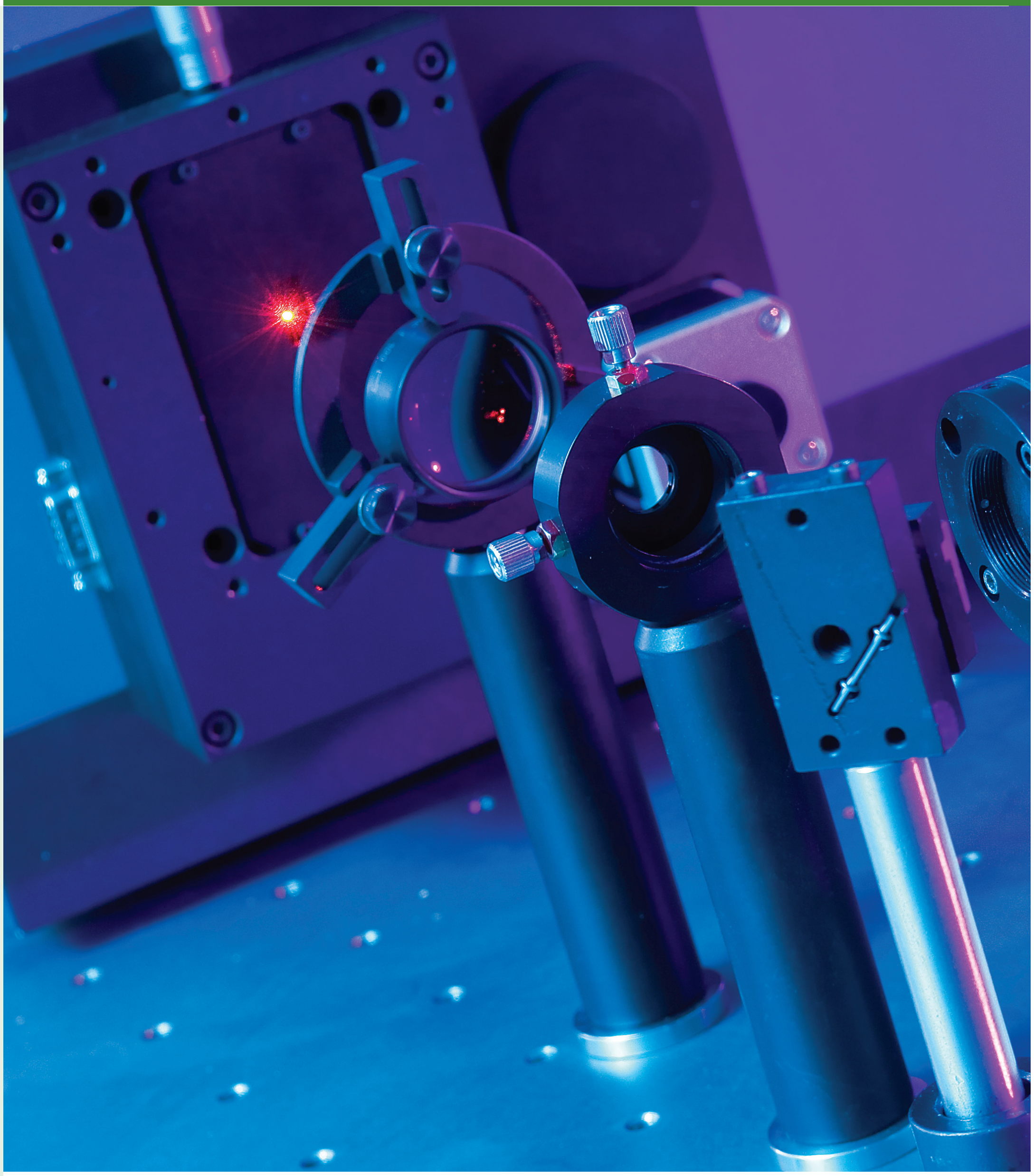


high sensitivity spectrocopy detection solutions

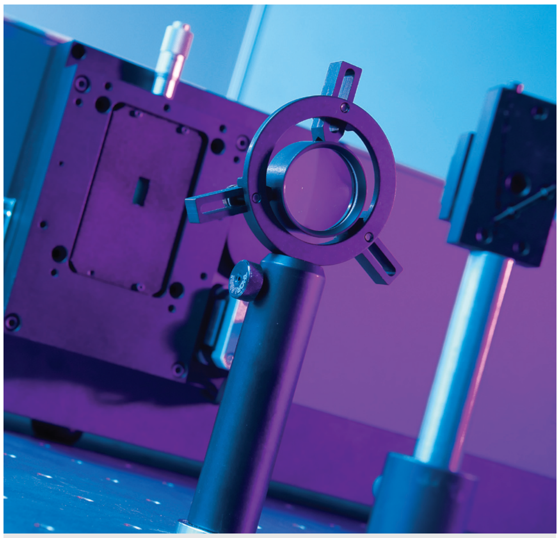
spectroscopy



ANDOR™ TECHNOLOGY

www.andor.com

discover new ways of seeing™



Mission Statement

Andor Technology's mission is to become the Global Leader in pioneering and manufacturing High Performance Light Measuring Systems. That doesn't only include some of the world's most advanced and versatile CCD, and ICCD detectors, or pushing the boundaries of working in low light by pioneering EMCCD technology, or even the development of UltraVac™, the industry's most reliable hermetic vacuum seal for CCD detectors. In addition, we aim to become the leading supplier of OEM and Analytical Instrumentation systems and solutions which require high performance light measurement.

"To become the Global Leader in Pioneering & Manufacturing High Performance Light Measuring Solutions "

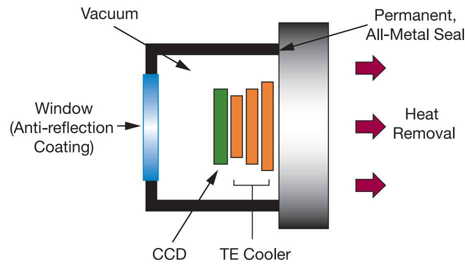
Andor has manufactured and sold thousands of spectroscopy detectors over the last twenty years. These detectors are used in dozens of spectroscopy applications, which have helped scientists all over the world discover new ways of seeing. Our experience has enabled us to bring together the latest developments in sensors, electronics, optics, vacuum technology and software to deliver world-class detector systems for spectroscopy and scientific imaging.

spectroscopy expertise:

UltraVac™ Sealed Vacuum Technology

The ability to operate the detector at very low temperatures is essential in achieving the highest sensitivity of the detector system. To cool the sensor it must be operated in a vacuum. To efficiently cool it, the sensor should be the coldest component in the camera. However, this means if the sensor is not housed in a very good vacuum it becomes the surface of choice for condensates such as moisture and hydrocarbons which degrade it and damage its performance, particularly its quantum efficiency. To ensure the highest performance from our detectors, Andor has developed our proprietary UltraVac™ sealed Vacuum Technology providing the highest vacuum possible and offering a guaranteed permanent seal.

Andor's innovative UltraVac™ vacuum seal design allows for the requirement of only one window in front of the sensor, enabling maximum photon throughput.



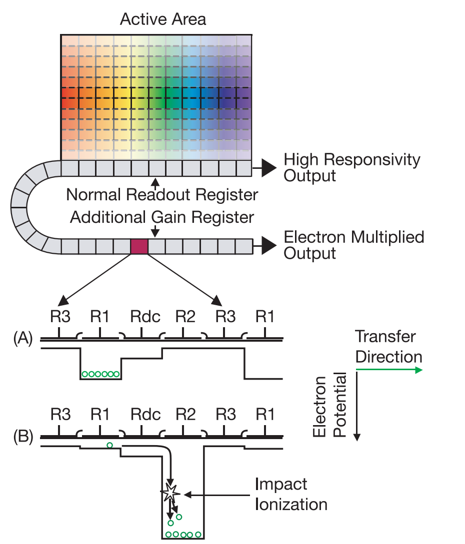
UltraVac™ metal hermetic vacuum sealing technology

This design is suited to high-end CCD cameras used in photon-starved spectroscopic applications.

Our cameras are produced in our production facility in Belfast, Northern Ireland. The Class 10,000 clean room where we build our permanent vacuum systems admits fewer than 10,000 particles of less than 0.5µm dimension per cubic meter. This environment is essential for constructing permanent vacuum systems.

Electron Multiplying CCD (EMCCD) Sensors

What is EMCCD? Electron Multiplying CCD (EMCCD) technology, sometimes known as 'on-chip multiplication' employs an image sensor capable of detecting single photon events without an image intensifier and using a unique electron multiplying structure built into the chip. First pioneered by Andor in 2001 for the introduction of our ultra-sensitive camera iXon, EMCCD's are manufactured utilizing standard CCD fabrication techniques. The unique feature of the EMCCD is an electron multiplying structure that is inserted between the end of the shift register and the output amplifier and is referred to as the gain register. This gain register is similar to the shift register except that the R2 phase of this section is replaced with two electrodes, the first held at a fixed potential and the second clocked with a much higher voltage amplitude than is necessary for charge transfer alone. The design of these electrodes and the relatively large voltage difference between them, results in an intense electric field that is sufficiently high for the transferring electrons to undergo Impact Ionization, generating new electrons, i.e. multiplication or gain. Readout noise is effectively eliminated allowing the detection of very weak spectra, even at fast readout speeds.



Schematic of an EM sensor showing the position of the gain register. (A) and (B) depict the process of impact ionization in the gain register, leading to gain multiplication before the signal is read out at the amplifier.

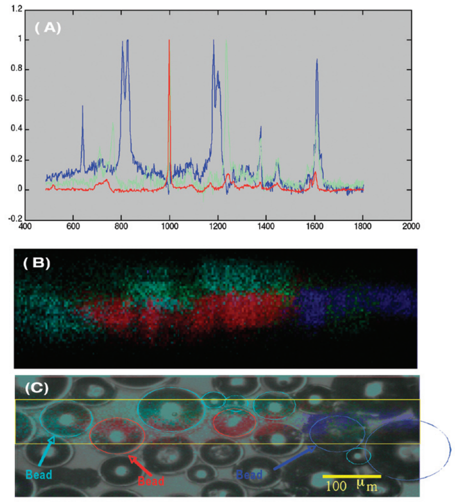
In 2005, Andor launched the Newton^{EM}, the industry's best-in-class spectroscopic camera and the first on the market to utilize Electron Multiplying CCD technology. The world's most sensitive UV to NIR spectroscopic detector ever, the Newton^{EM} enables charge from each pixel to be multiplied on the sensor before readout, providing single photon sensitivity with both multi-MHz readout and USB 2.0 connectivity.

spectroscopy applications:

Rapid Particle Scanning and Detection using Raman Micro-spectroscopy and Imaging

Low-light micro-spectroscopy and imaging Raman experiments were conducted to evaluate the effectiveness of EM technology on different types of polystyrene beads using an Andor Newton[EM].
The effect of EM gain was compared over a range of exposure times, and it was found that the signal varies linearly with the exposure time over all ranges of the gain. In comparison to the operating system in the conventional CCD mode, operating the camera with EM Gain resulted in a 50X increase in signal intensity and 50X reduction in spectral acquisition time and identification of the different types of beads. It was also seen that, despite a 100X reduction in laser power, the spectra obtained in the EM Mode are equivalent to those obtained in the conventional CCD mode.

These features provide a powerful advantage for the Raman process industry where scanning and particle identification is the most time consuming process. Overall, it has been seen that EMCCD technology when compared to conventional CCD technology can be used to dramatically reduce acquisition time, increase signal intensities and acquire data at reduced laser powers.



(A) shows the spectra as obtained from the three types of polystyrene beads. (B) shows the positioning of the beads as identified by the analysis of results. The results of particle identification match well with the actual positioning of the beads as shown in (C). The experiment was performed with an EM gain of 250, with 1s exposure. Conventional CCDs normally take 50x more time to obtain similar spectra.

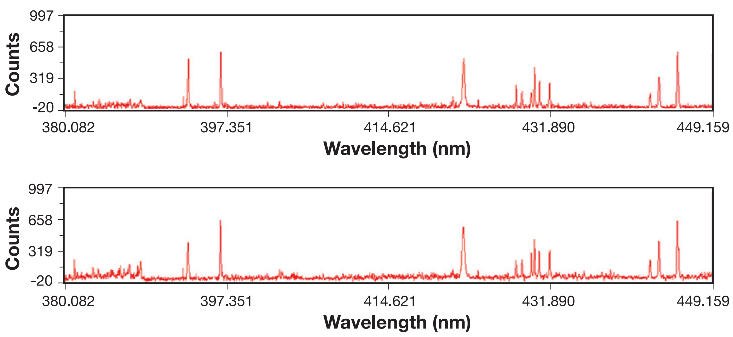
Analysis of Wood Samples from a Crime Scene using LIBS

The Laboratory of Tree-Ring Science (LTRS) in the Department of Geography, University of Arizona, received 14 logs with burnt and unburnt portions from the Criminal Investigation Section office of the Sheriff in Collin County, Texas. LTRS was asked to determine if the logs from the crime scene could have originated from the same tree or from the same location as logs found with the suspect. Through a LIBS technique using an Andor iStar ICCD and Mechelle ME-5000 spectrograph, they were able to produce a chemical "fingerprint" of wood based on heavy metals and other trace elements.

It was subsequently shown that this chemical fingerprint was consistent for all the wood samples that were tested; burnt parts of the logs showed identical spectra as did all of the unburnt parts. Statistical analysis of the data sets showed a very strong correlation between all 14 logs which helped in connecting the suspect to the crime, strongly suggesting that:

1) The wood logs come from the same type of tree species.

2) The logs likely came from the same tree or from a group of trees growing in the same area. The results were shown to be 99.999% accurate and supported a successful conviction in this case.

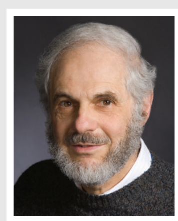


Depicts comparison of the unburnt portions of two of the fourteen logs found at the crime scene.

Courtesy of Dr. Madhavi Martin,Ph.D, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN.

Applications

- Absorption/Transmission/Reflection
- Combustion Studies
- Differential Optical Absorption Spectroscopy (DOAS)
- Elemental Analysis
- Environmental Analysis
- Laser Induced Breakdown Spectroscopy (LIBS)
- Laser Ablation
- Laser Induced Detection And Ranging (LIDAR)
- Laser Induced Fluorescence (LIF)
- Laser Induced Plasma Spectroscopy (LIPS)
- Planar LIF (PLIF)
- Plasma Studies
- Pulsed Laser Deposition
- Raman Spectroscopy
- Single Photon Spectroscopy
- Spectro-radiometry
- Time Resolved Fluorescence (TRF)
- Time Resolved Resonance Raman Spectroscopy
- Time Resolved Transient Absorption



Professor Michael Morris
Professor of Chemistry
University of Michigan

"In our lab the Andor Newton[EM] EMCCD has enabled millisecond Raman spectroscopy and hyperspectral Raman imaging in times as short as a minute or two. And the 1600 x 400 format is just right for spectroscopy."

Newton^{EM} ultimate sensitivity & flexibility

Features & Benefits

- Exclusive EMCCD sensors
- Single photon sensitivity capability
- Up to 1500 spectra/second
- USB 2.0 connectivity with 2.5MHz readout
- TE Cooling to -100˚C
- UltraVac™ - metal hermetic vacuum sealing
- Up to 95% QE
- Available in a range of sensor formats

Applications

- Fluorescence and Luminescence Spectroscopy
- UV/VIS/NIR Raman Spectroscopy
- Rapid Particle Scanning and Detection
- Transient (Pump-Probe) Spectroscopy
- Atomic Emission Spectroscopy
- Fast Reactions

Newton^{EM}	Model No.	Pixel Size (μ)	Sensor Option
	DU-970N (EMCCD)	16 x 16	BV, UVB, FI, UV
	DU-971N (EMCCD)	16 x 16	BV, UVB, FI, UVB
	DU-920N	26 x 26	BV, BU, BU2, BRD
	DU-940N	13.5 x 13.5	BV, UVB, BU, BU2, FI, UV

iDus price performance CCD technology

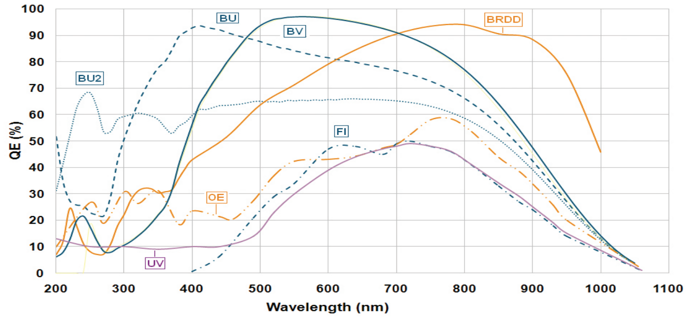
Features & Benefits

- Ultra-low noise
- USB 2.0 connectivity
- TE Cooling to -100˚C
- UltraVac™ - metal hermetic vacuum sealing
- Up to 95% QE
- Available in a range of sensor formats
- InGaAs arrays for 1.7 and 2.2 micron range

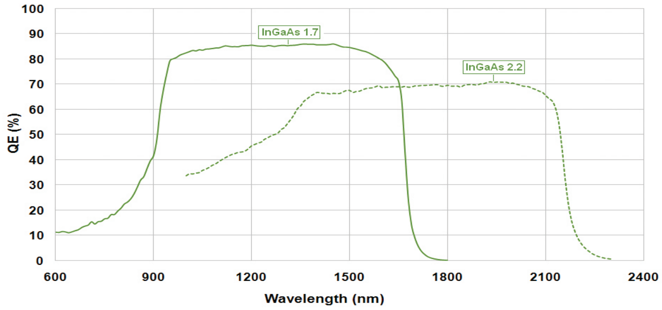
Applications

- Fluorescence and Luminescence Spectroscopy
- NIR Spectroscopy (InGaAs sensors)
- UV/VIS/NIR Raman Spectroscopy
- Absorption / Transmittance / Reflection
- Atomic Emission Spectroscopy

iDus	Model No.	Pixel Size (μ)	Sensor Option
	DV-401A	26 x 26	BV, FI, UV
	DU-401A	26 x 26	BRD
	DV-420A	26 x 26	BV, OE, FI, UV
	DU-490A (InGaAs)	25 x 500	1.7, 2.2
	DU-491A (InGaAs)	25 x 500	1.7, 2.2
	DU-492A (InGaAs)	50 x 500	1.7, 2.2



(A)



(B)

Spectroscopy (A) and InGaAs (B) CCD QE curves

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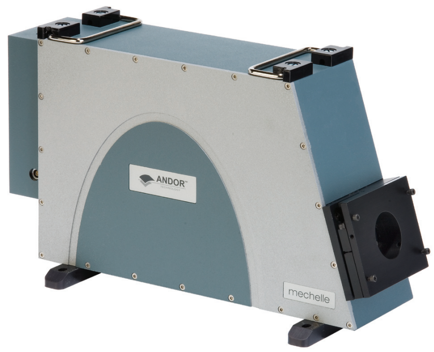
Mechelle ME-5000 high bandpass Echelle spectrograph



Features & Benefits

- Simultaneous acquisition of 200-950nm wavelength range
- No moving parts
- Compact and robust design
- F/7 highest throughput in industry
- Patented dual prism ensures lowest crosstalk
- Resolution better than 0.04nm FWHM at 200nm
- Auto-Temperature Correction
- Ideal for Lab and Field Environments

Applications

- Laser Induced Breakdown Spectroscopy (LIBS)
- Laser Induced Plasma Spectroscopy (LIPS)
- Raman Spectroscopy
- Spectro-radiometry
- Environmental Analysis
- Elemental Analysis

iStar the best ICCD in the world

Features & Benefits

- Simultaneous acquisition of 200-950nm wavelength range
- No moving parts
- Compact and robust design
- F/7 highest throughput in industry
- Patented dual prism ensures lowest crosstalk
- Resolution better than 0.04nm FWHM at 200nm
- Auto-Temperature Correction
- Ideal for Lab and Field Environments

Applications

- Laser Induced Breakdown Spectroscopy (LIBS)
- Laser Induced Plasma Spectroscopy (LIPS)
- Raman Spectroscopy
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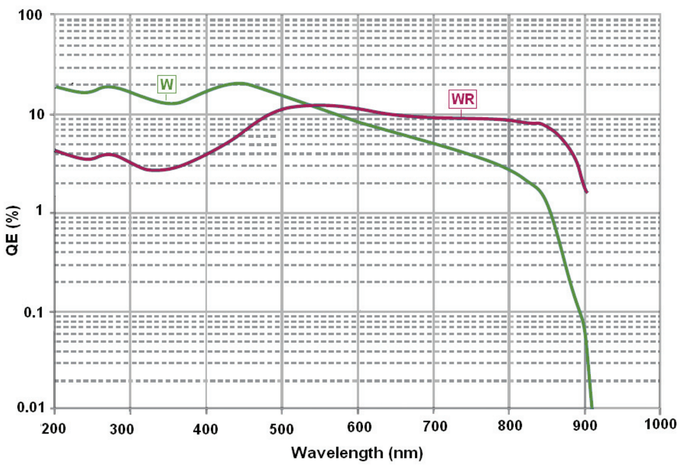
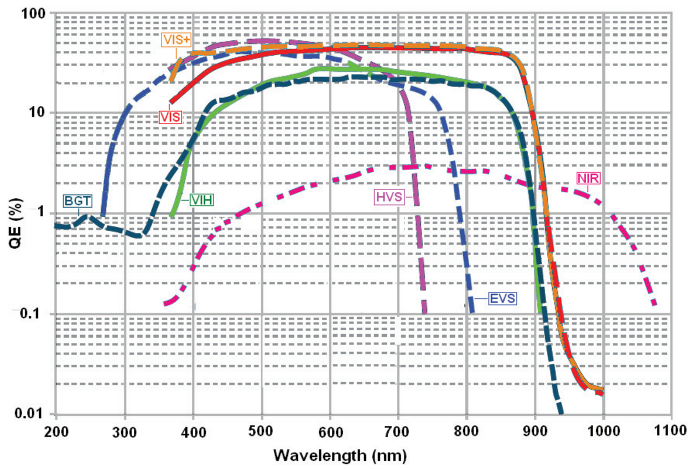


Gen II QE curves



Gen III QE curves

discover new ways of seeing™

Shamrock SR-303i fully automated imaging spectrograph

Features & Benefits

- 303mm focal length imaging control
- Pre-aligned and pre-calibrated system
- High throughput optics
- Interchangeable triple grating turret
- USB 2.0 interface
- Interactive software provides direct and responsive control
- Provides fully integrated solution with Andor detectors

Applications

- Raman Spectroscopy
- Combustion Studies
- Differential Optical Absorption Spectroscopy (DOAS)
- Laser Induced Breakdown Spectroscopy (LIBS)
- Laser Induced Fluorescence (LIF)
- Single Photon Spectroscopy
- Time Resolved Resonance

Shamrock SR-163 price performance spectrograph

Features & Benefits

- Patented 163mm focal length optical design
- Provides better resolution with higher throughput
- Interchangeable gratings and slits
- Manual micrometer wavelength adjustment
- Robust, compact and accurate
- Wide range of input accessories
- Imaging and non-imaging models available

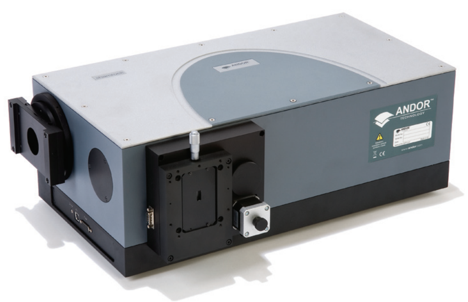
Applications

- Absorption/Transmission/Reflection
- Fluorescence and Luminescence
- Light Source Characterization
- Combustion Studies
- Laser Induced Breakdown Spectroscopy (LIBS)

Spectrograph Specifications	ME-5000	SR-163
Optical Design	Echelle	Czerny-Turner
Operating Wavelength Range	200-975nm (single shot)	UV thru Far IR
Grating	Single Fixed Echelle Grating	Interchangeable Single Grating
Focal Length (mm)	195	163
Aperture Ratio (F#)	F/7	F/3.6
Resolution	CSR = 5000*	0.17nm†
Wavelength Accuracy (nm)	<±0.05	± 0.25†
Stray Light (measured at 20nm from 633nm laser line)	$1.5x10^{-4}$	$2x10^{-4}$
Reciprocal Dispersion (nm/mm)	/213.2	4.76†
Size (mm [inch] LxWxH)	250[9.8] x 102[4.0] x 222[8.7]	210[8.3] x 216[8.5] x 96[3.8]
Weight (kg [lb])	10[22]	3.9[8.6]

* CSR (Constant Spectral Resolution)= l/FWHM. Hence Resolution = 0.04nm @ 200nm. The FWHM corresponds to 3 pixel width. † = measured with 1200 l/mm grating, 10µ slit @435.8, 13.5µ pixel

Shamrock SR-500/750 ultimate resolution solution



Features & Benefits

- Pre-aligned detector/spectrograph solution
- Direct and responsive software interactivity
- Triple grating turret
- USB interface or RS232
- Wide range of accessories available
- Provides fully integrated solution with Andor detectors

Applications

- Absorption/Transmission/Reflection
- Fluorescence and Luminescence
- Raman
- Light Source Characterization
- Combustion Studies
- Laser Induced Breakdown Spectroscopy (LIBS)

3rd Party Spectroscopy Solutions

offers second exit port scanning capabilities

Specim ImSpector

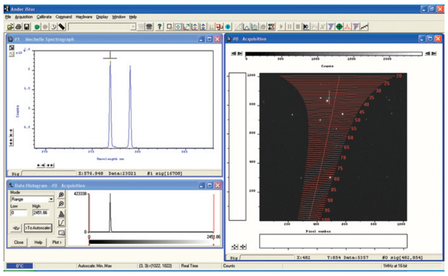
- Wavelength ranges coverage 380 - 1000nm
- High spectral resolution
- Long spatial image width
- Input through C-mount objective lens or multi-channel fiber optics
- Optional shutter

Headwall Raman Explorer

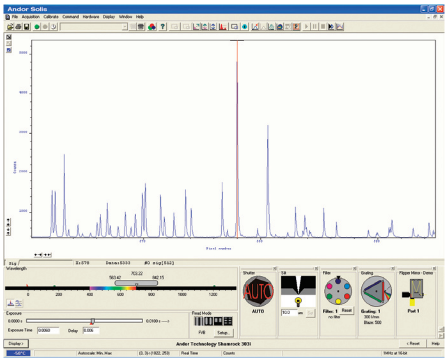
- Superior spectral resolution for Raman applications
- F/2.4 aperture for optical throughput and high signal-to-noise
- Multi-spectrum capability for simultaneous measurement of extended wavelength ranges
- Small form factor and rugged design for OEM applications

	SR-303i	SR-500	SR-750
	Czerny-Turner	Czerny-Turner	Czerny-Turner
	UV thru Far IR		
	Interchangeable Triple Grating	Triple Grating Turret	Triple Grating Turret
	303	500	750
	F/4	F/6.5	F/9.8
	0.1nm†	0.05nm†	0.03nm†
	± 0.2†	±0.2	±0.2
	1.5x10^{-4}	1.5.10^{-4}	1.5.10^{-4}
	2.6†	1.7	1.1
	394[15.5] x 238[9.4] x 208[8.2]	550[21.7] x 288[11.3] x 207[8.1]	800[31.5] x 338[13.3] x 214[8.4]
	20[44.1]	25[55.1]	35[77.2]

Solis (s) optimized spectroscopy software



Solis (s) software with Mechelle software interface



Solis (s) software with Shamrock SR-303i interface

Features & Benefits

For spectroscopy applications, the Andor Solis (s) is the appropriate software platform. It has been specifically tailored to enable the user to quickly configure their acquisition, capture the data display and process results in a user-friendly manner. The user can also control Andor's motorized spectrographs in a direct and responsive manner.

- Full spectrograph and camera control within the same package
- Easy and accurate wavelength calibration routines
- Flexible data display – view your data in 2D, 3D, stacked & overlayed
- Data export options – SIF, GRAMS, ASCII XY, FITS
- Easy automation of your experiment with additional commands added to the Andor Basic programming language
- User defined background and data colors allow the user to optimize the screen under low light or low contrast monitors
- Automatic spectral line identification against NIST library

accessories

configured for maximum system versatility

Shamrock SR-163 accessories

Selection of accessories include:

- Wide range of mounting flanges, slit assemblies, diffraction gratings, mechanical shutters, optical fibers/bundles, optical filters, calibration sources
- Radiometry and colorimetry add-on modules
- Software Development Kits (SDK)
- Input/Output triggering boxes
- Water recirculator/cooler

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ANDOR™ TECHNOLOGY

OHSAS 18001:1999 ISO 14001:2004 ISO 9001:2000 INVESTOR IN PEOPLE

SB-01/09