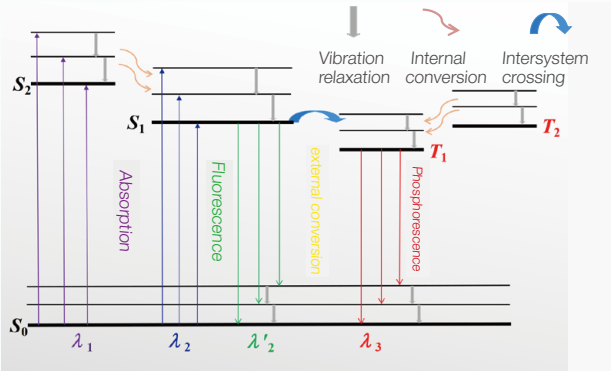
Zolix

OmniFluo900 series

Fluorescence Spectrometer

www.zolix.com.cn

The Mechanism of Fluorescence



Fluorescence describes a phenomenon where a molecular system absorbs then emits light. In absorption, the energy of the photon absorbed excites the molecule from its ground state to one of the excited states. Molecules in the excited states will jump back to the ground state and emit light, releasing the stored energy to emitted photons.

The dependence of the fluorescence intensity on excitation wavelength is called excitation spectroscopy; similarly, the wavelength dependence of the emitted fluorescence is called emission spectroscopy. Both can help to understand the energy level structure of a molecule.

Usually there will be some energy loss due to non-radiation relaxation procedures, thus the emitted photons have less energy than the absorbed ones — or the wavelength of the emitted light is longer than that of the excitation source. This is the called Stokes shift.

Once excited, a molecule will return its ground state in a short time. The time for how long a molecule is expected to stay at the excited state is called fluorescence lifetime.

Steady State Fluorescence

Steady state fluorescence spectra are when molecules, excited by a constant source of light, emit fluorescence, and the intensity of emitted light, are recorded as a function of wavelength.

Steady state measurements include:

Emission Spectrum: when the excitation wavelength is fixed and the emission wavelength is scanned to get a plot of intensity vs. Emission wavelength;

Excitation Spectrum: when the emission wavelength is fixed and the excitation wavelength is scanned to get a plot of intensity vs. Excitation wavelength;

Synchronous Scan: both excitation and emission wavelengths are scanned synchronously with a pre-set offset;

Excitation- Emission Mapping(EEM): To measure a series of emission scans with different excitation wavelengths in a selected range, making a 3-D mapping.

Fluorescence Lifetime

Fluorescence lifetime is the intensity of the fluorescence of a sample monitored as a function of time after excitation by a pulsed light. It can be obtained in a number of ways, depending on the required sensitivity and time regions. Zolix Instruments reaches the highest sensitivity by time-correlated single photon counter with lifetime range from 500ps to 10s.

Fluorescence Spectrometer
OmniFluo900 series

The OmniFluo900 series is a high performance, versatile, modular fluorescence spectrometer for the research applications in material science, physics, chemistry, life science and agricultural science.

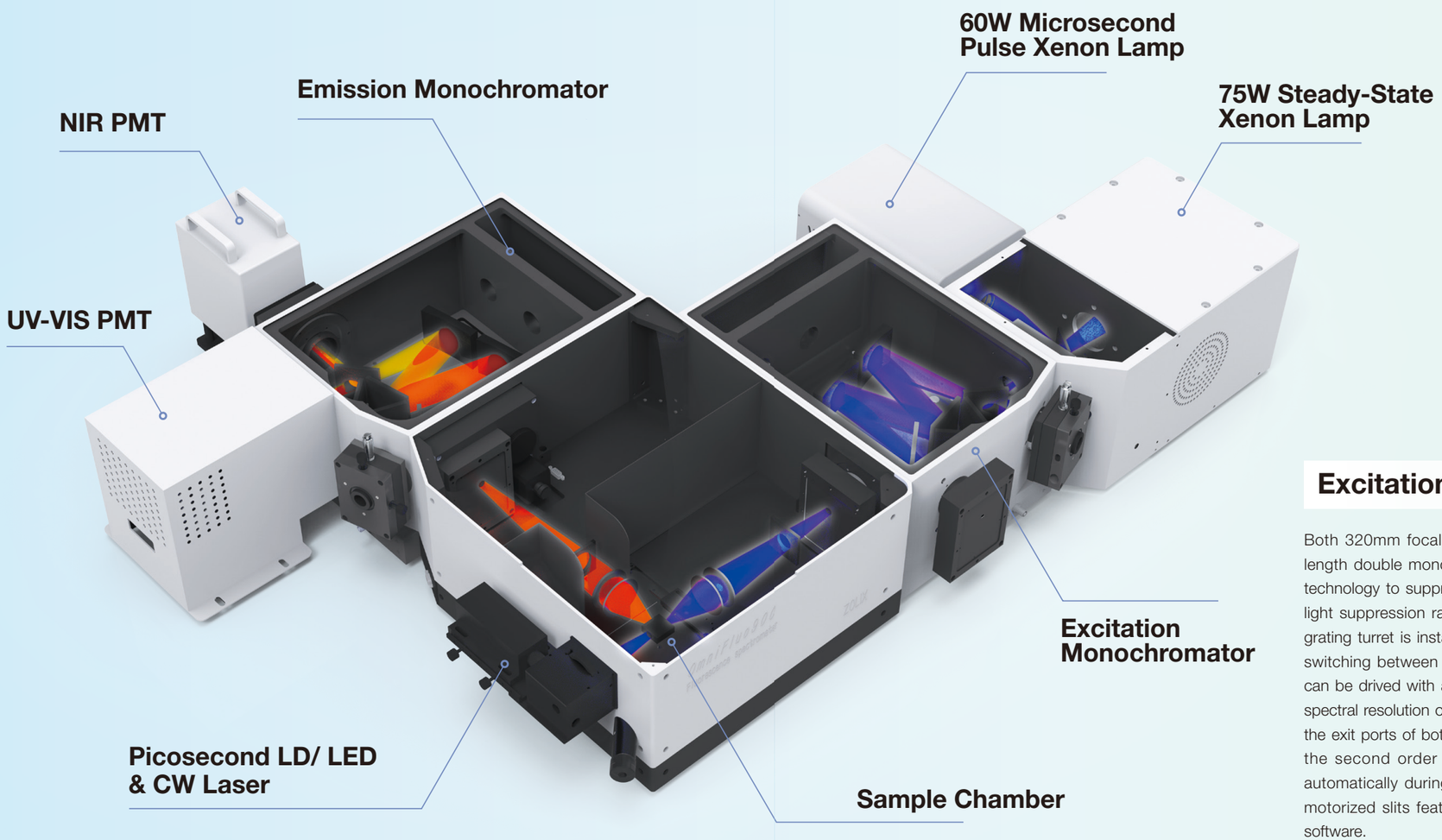
This system provides both steady state and lifetime measurement. It can be configured for spectral measurements from the ultraviolet to the infrared range and for lifetime measurements from hundreds of picoseconds to seconds.

The instrument features extraordinary sensitivity and exceptional stray light suppression that is very important for weak fluorescence detection. The S/N ratio of the water Raman scattering signal —— the index commonly used to represent the sensitivity of a fluorescence spectrometer —— can reach 10,500: 1. Microscopy and cryostat are optional to achieve high spatial resolution and temperature dependent measurement.

Main Features

- Modular design for maximum flexibility and extendability;
- The water Raman S/N ratio larger than 10,500: 1;
- Large spectral coverage from the UV to MIR (200nm ~ 5500nm);
- Excellent stray light rejection;
- Multi light sources/ detectors available; Optional double-monochromator configuration;
- Intuitive software for steady state and time resolved measurements with lifetime fitting function.

Spectrometer Configuration



Detector

The standard detector for UV-VIS range is a single photon counting photo multiplying tube (PMT) with TE cooling down to -10 ℃ , covering 185 - 900nm wavelength range.

Infrared PMTs and analogue detectors can be selected to extend the spectral range up to 5500nm.

Excitation Light Source

The standard excitation light source for steady-state spectroscopy is a 75W xenon lamp that emits continuous radiation from 200nm to 1800nm. The light is focused into the monochromator with a high-reflectivity off-axis elliptical mirror, ensuring excellent focusing angle at the entrance slit to achieve the best collection efficiency. The xenon lamp is controlled by a stable power supply to ensure the stability of the light source.

Excitation / Emission Monochromator

Both 320mm focal length single monochromator and 2×180mm focal length double monochromator are optional and adopt image correction technology to suppress astigmatism to the greatest extent, and the stray light suppression ratio is 10^{-5} (10^{-9} for double monochromators). A triple grating turret is installed to each monochromator, capable of holding and switching between 3 gratings for different wavelength range. The turret can be drived with a minimum step size of 0.005nm, ensuring the 0.1nm spectral resolution of the system. Six-position filter wheels are equipped at the exit ports of both the excitation and emission arm. Filters to suppress the second order diffraction from an monochromator are switched automatically during wavelength scanning. The monochromators equip motorized slits feature 0.01-3mm continuous adjustment controlled by software.

Single Photon Counter

Single photon counting is the most sensitive light acquisition technique in fluorescence spectroscopy. Each Omnifluo900 series fluorescence spectrometer is equipped with a single photon counter for steady-state fluorescence spectrosopy and fluorescence lifetime measurements from hundreds of picoseconds to seconds.

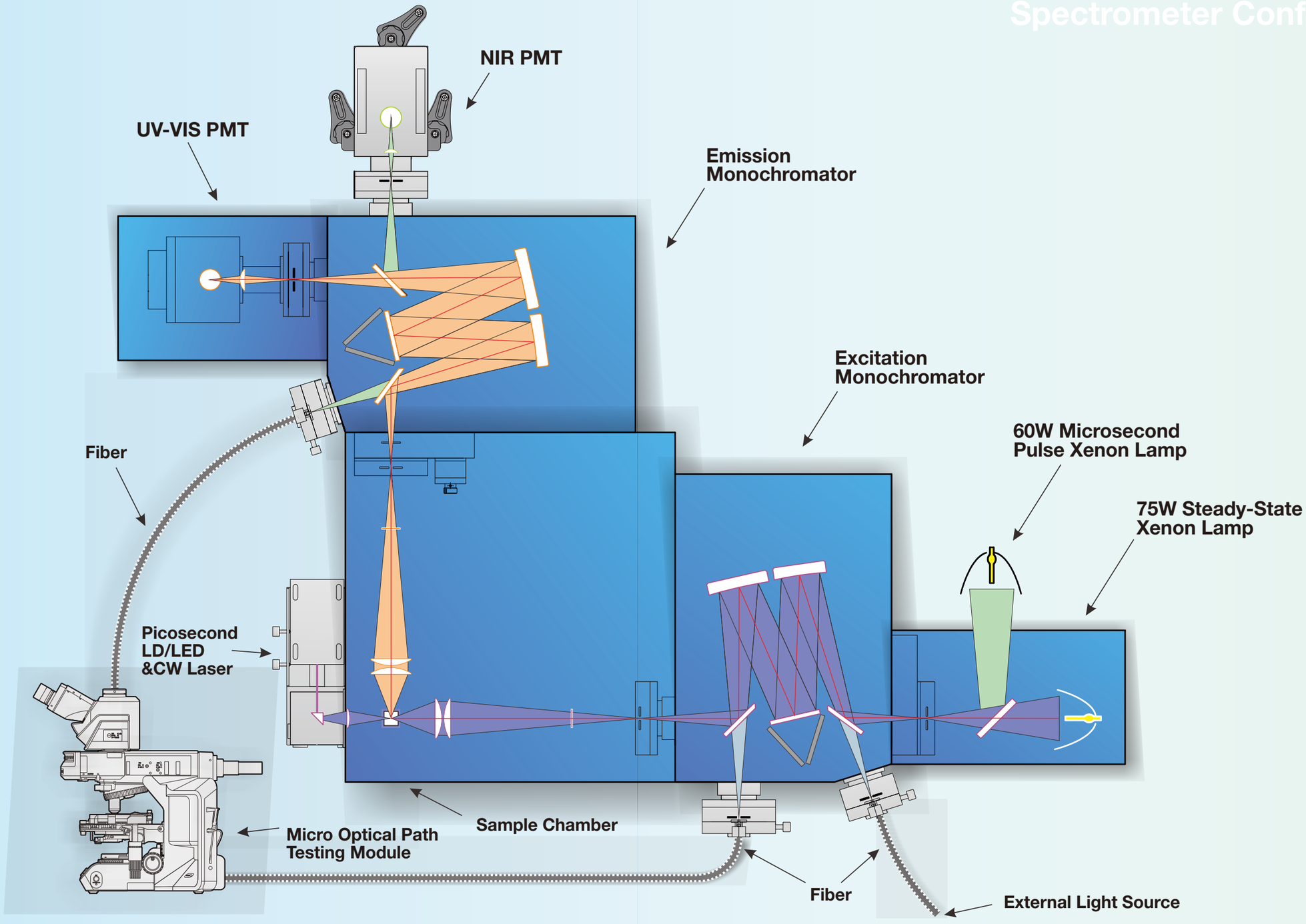
Sample Chamber

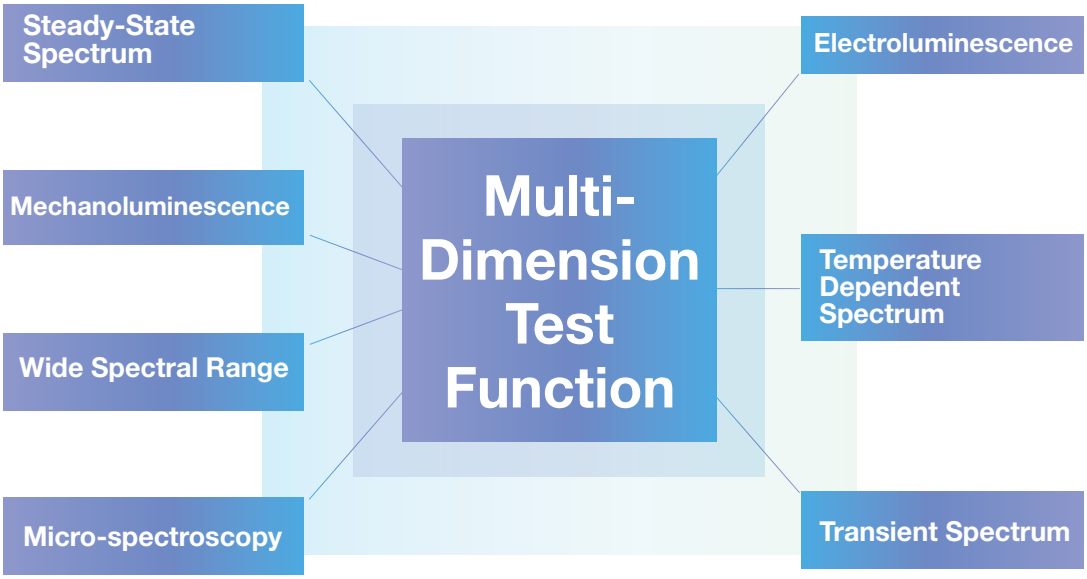
At the heart of a Omnifluo900 is a large sample chamber that features a dedicated design for best results. Large-aperture fused silica lenses are used for high efficiency of excitation and collection fluorescence. A filter holder in the emission arm can accommodate 50mm×50mm or 25mm×25mm filters, allowing the user to use low-pass, high-pass or band-pass filters for special purpose.

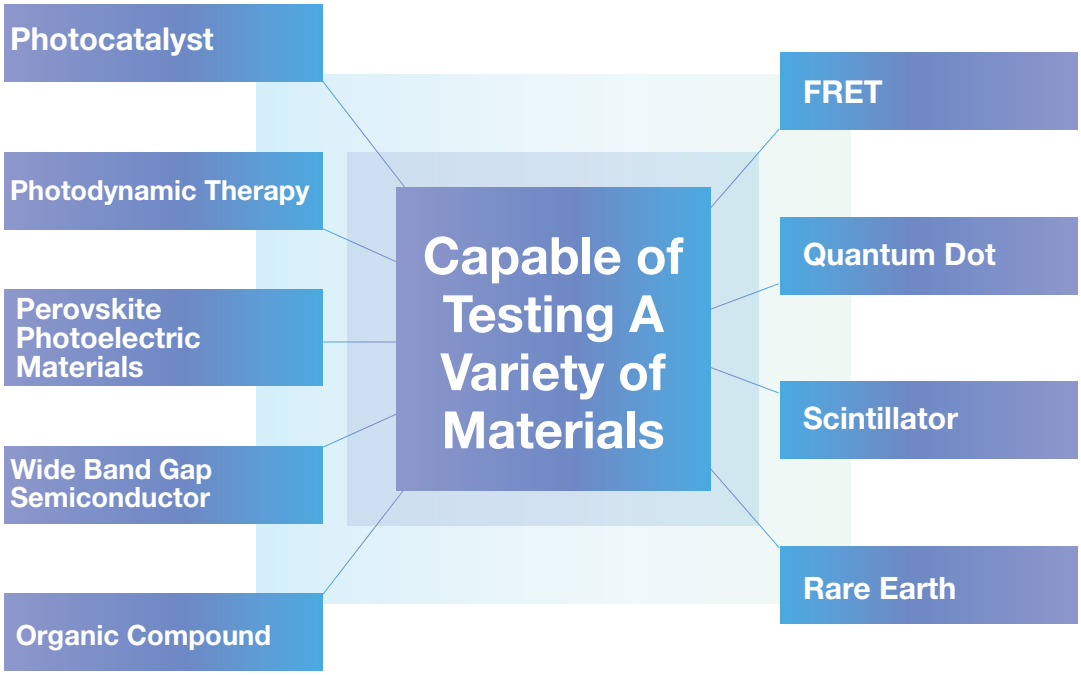
- Laser can been directed into the sample chamber by a side port. A variable neutral density filter is used to control the power of the laser.
- Standard sample holders: cuvette, bulk/ powder/ film clamps;
- Optional: rotating; magnetic stirring; temperature controlled or regulated stage;
- Optional software-controlled polarizers for fluorescence anisotropy.
- Optional cryostat: 77K-500K, 3-300K.

OmniFluo900 2D Diagram

Spectrometer Configuration




Steady-State Spectrum
Mechanoluminescence
Wide Spectral Range
Micro-spectroscopy
Multi-Dimension Test Function
Electroluminescence
Temperature Dependent Spectrum
Transient Spectrum


Photocatalyst
Photodynamic Therapy
Perovskite Photoelectric Materials
Wide Band Gap Semiconductor
Organic Compound
Capable of Testing A Variety of Materials
FRET
Quantum Dot
Scintillator
Rare Earth

Basic Features

Spectral Correction

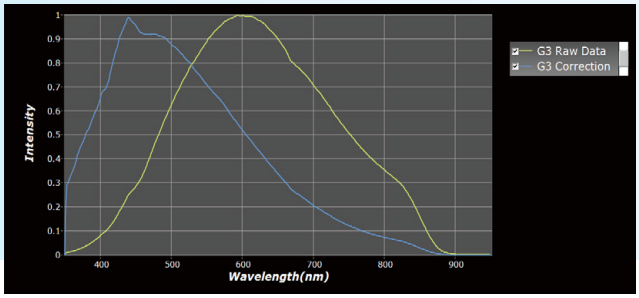
Spectral correction takes into account all instrumental effects to obtain the true excitation and emission spectra, such as mirrors, light source and detectors. Spectral correction, using factory measured correction files, is standard operation when using the Omnifluo 900 series.

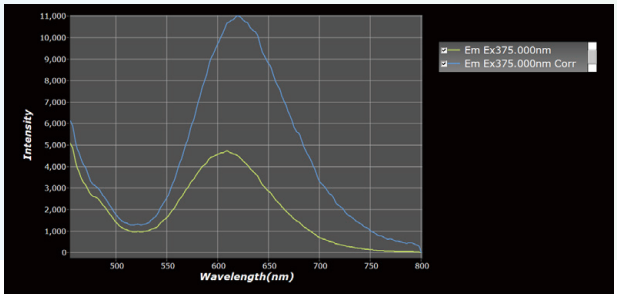
The figure below shows the calibration curves of grating G1 and grating G2 of the emission monochromator.

G1-1200g/mm, 300nm blaze wavelength

G2-1200g/mm, 500nm blaze wavelength

The yellow line in the figure below shows the original (not corrected) spectrum, and the blue line shows the corrected one. Comparing these two spectra, one can find that the peak of the corrected spectrum has a red shift of 10nm from the uncorrected spectrum.





The calibration spectrum can reflect the true luminescence condition of the sample, for example the true luminescence peak position.

For samples with multiple emission peaks, the corrected spectrum shows more accurate relative intensity relationship between these emission peaks.

Exceptional Sensitivity

Thanks to single photon counting technique, high quality optical pathways, the dedicated and optimized light sources and the most sensitive detectors, the Omnifluo 900 series' water Raman signal to noise ratio (SNR) can easily reach 10500: 1. Rather than employing complicated calculation procedures, we use the straightforward SQRT method for sensitivity validation:

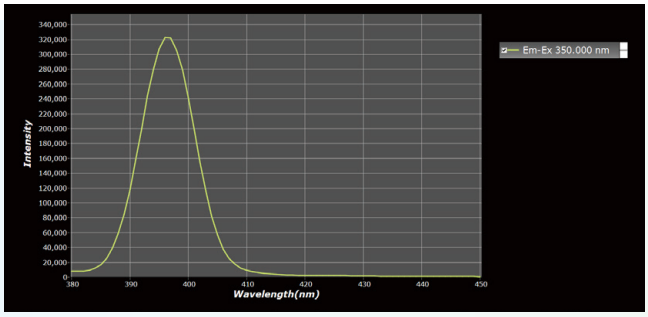
Sample: Pure Water

Excitation Wavelength: 350nm Scanning Step: 1nm

Emission Scanning: 380nm-450nm Integration Time: 1s

Peak Signal@397nm=322411 Noise Signal@450nm=680

$$SNR = \frac{Peak\ Signal_{@397nm} - Noise\ Signal_{@450nm}}{\sqrt{Noise\ Signal_{@450nm}}} = 12338$$



With single excitation and emission monochromator, SNR can reach more than 10500: 1 easily.

Basic Features

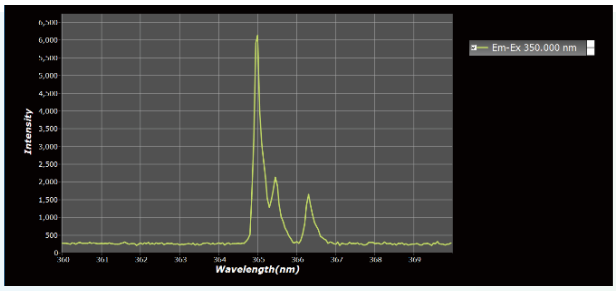
High Resolution and High Accuracy

Sample: Mercury lamp

Emission Scanning: 360nm-370nm Integration Time: 200ms

Scanning Step: 0.05nm Repeat Times: 1

Actual wavelength(nm)	Test wavelength(nm)
365.016	365.00
365.484	365.45
366.328	366.30



The Omnifluo900 series adopts 320mm imaging monochromator to suppress astigmatism for excellent image quality. The wavelength adjustment is driven by stepper motor with the minimum scanning step of 0.005nm. With 1200 g/mm grating, the spectral resolution is 0.08nm, the wavelength accuracy is ±0.2nm and the wavelength repeatability is ±0.1nm.

Applications

Standard Samples

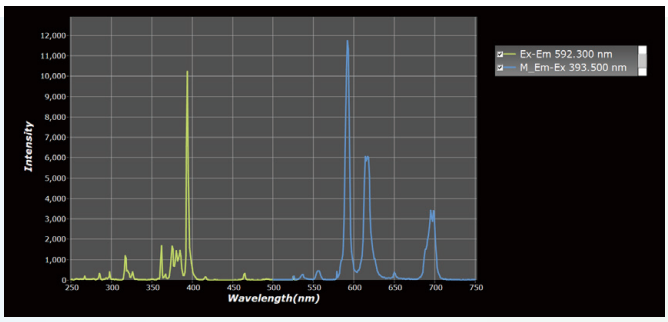
Sample: Europium, Solvent: Nitric Acid

Excitation & Emission Spectrum Test:

Excitation Light Source: 75W xenon lamp Scanning Step: 1nm

Excitation Spectrum: Excitation Scanning: 250nm-530nm, Emission Wavelength: 592.3nm

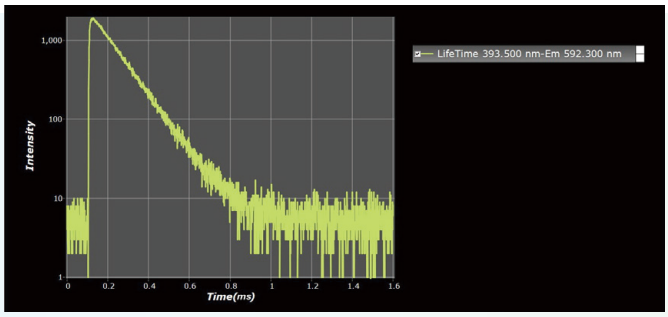
Emission Spectrum: Excitation Wavelength: 393.5nm, Emission Scanning: 500-750nm



Fluorescence Lifetime Test:

Excitation Wavelength: 393.5nm@ microsecond pulse Xenon Lamp Emission Wavelength: 592.3nm

Repeat Times: 1000 Fitting Lifetime: 117μs



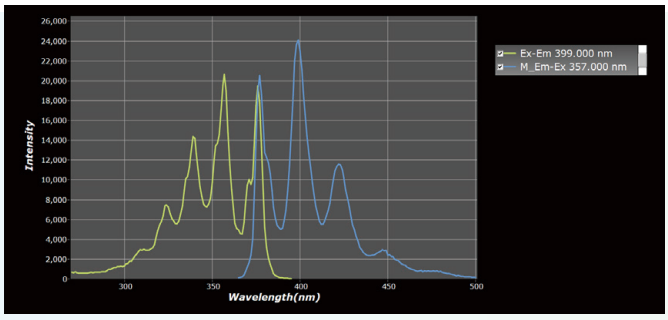
Sample: Anthracene, Solvent: Cyclohexane

Excitation & Emission Spectrum Test:

Excitation Light Source: 75W xenon lamp Scanning Step: 1nm

Excitation Spectrum: Excitation Scanning: 270nm-395nm, Emission Wavelength: 399nm

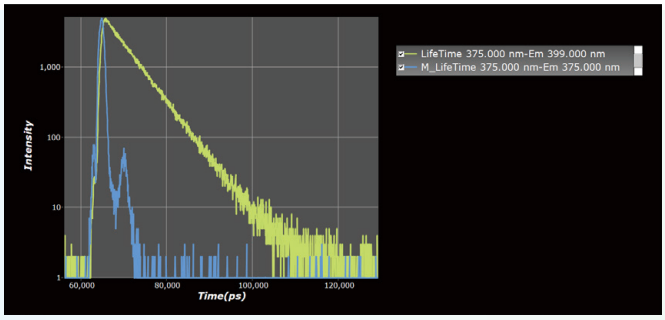
Emission Spectrum: Excitation Wavelength: 357nm, Emission Scanning: 365-500nm



Fluorescence Lifetime Test:

Excitation Wavelength: 375nm@ picosecond pulse laser Trigger Frequency: 1MHz

Emission Wavelength: 399nm Fitting Lifetime: 5.3ns



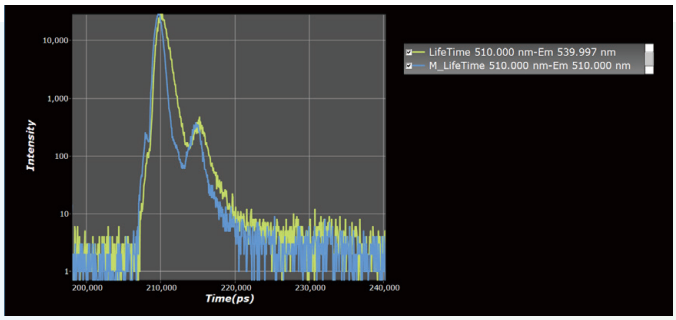
Sample: Erythrosin B, Solvent: Methanol

Fluorescence Lifetime Test

Excitation Wavelength: 510nm @super-continuum pulse laser

Trigger Frequency: 1MHz

Emission Wavelength: 540nm Fitting Lifetime: 460ps



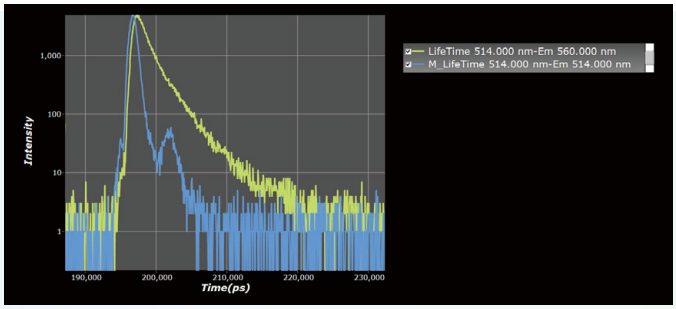
Sample: Rhodamine B Aqueous Solution

Fluorescence Lifetime Test

Excitation Wavelength: 514nm @super-continuum pulse laser

Trigger Frequency: 1MHz

Emission Wavelength: 560nm Fitting Lifetime: 1.6ns



Applications

Rare Earth Upconversion Fluorescence

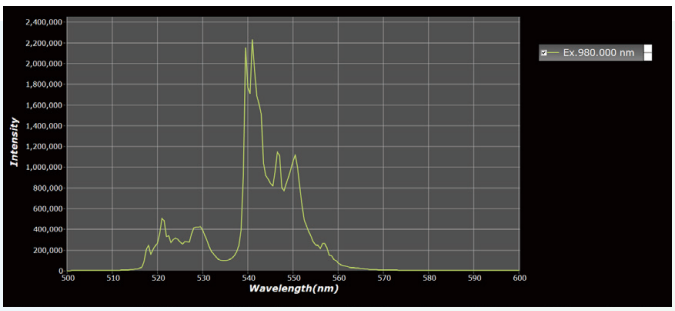
Sample: $NaYF_4YbEr$ Solution

Steady-State Spectrum:

Excitation Light Source: 980nm CW laser

Emission Scanning: 500nm-600nm

Scanning Step: 1nm

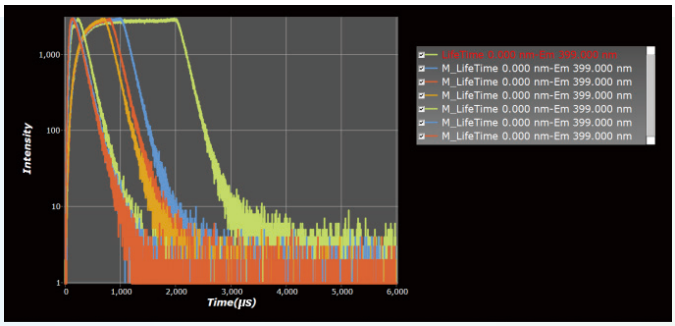


Lifetime Test:

Excitation Light Source: 980nm CW laser modulated

Output Trigger Frequency: 100Hz

Emission Wavelength: 544nm



Upconversion Fluorescence Spectrum at Different Excitation Power

The curves in figure b is to extract the peak data of several characteristic luminescence peaks at 521.5nm, 539.5nm, 541nm, and 546.5nm in figure a, with the logarithm of the intensity as the ordinate and the logarithm of excitation power as the abscissa. The slope of the four curves in figure b is approximately equal to 2, which characterizes the two-photon absorption process.

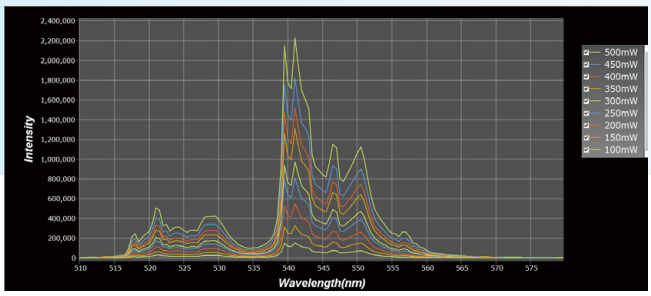


Figure a

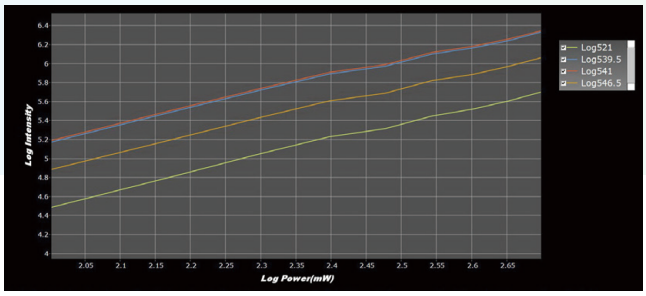


Figure b

Applications

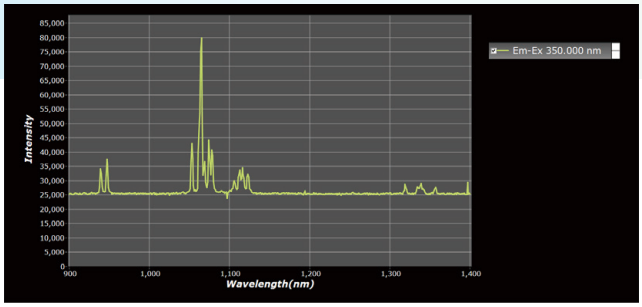
NIR Measurement

Sample: YAG: Er Crystal

Excitation Light Source: 532nm CW laser
Emission Scanning: 900nm-1400nm

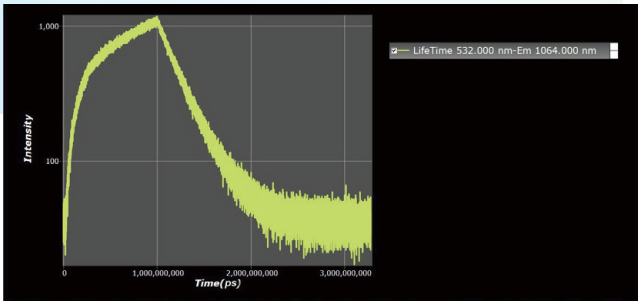
Detector: TE-PMT-H10330C075
Data Acquisition System: single photon counter

Slit: 10μm



Lifetime Test: Excitation Light Source: 532nm CW laser modulated output Trigger Frequency: 100Hz

Emission Wavelength: 1064nm

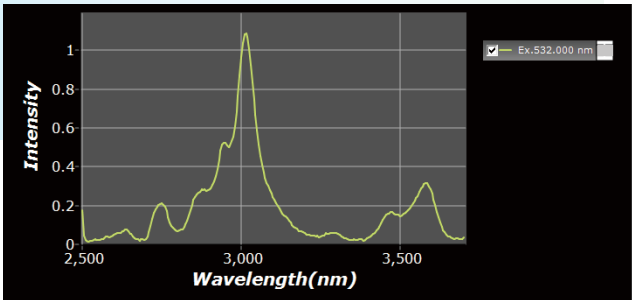


MIR Measurement

Sample: Zinc Sulfate Doped In Titanate Glass

Excitation Light Source: 532nm CW laser
Emission Scanning: 2500nm-3700nm

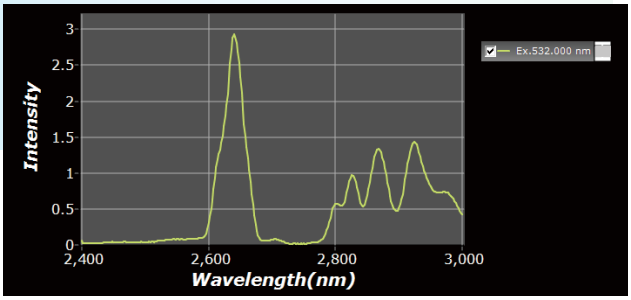
Detector: liquid nitrogen cooled InSb detector data
Acquisition: lock-in amplifier



Sample: YAG: Er Crystal

Excitation Light Source: 532nm CW laser
Emission Scanning: 2400nm-3000nm

Detector: liquid nitrogen cooled InSb detector data
Acquisition: lock-in amplifier



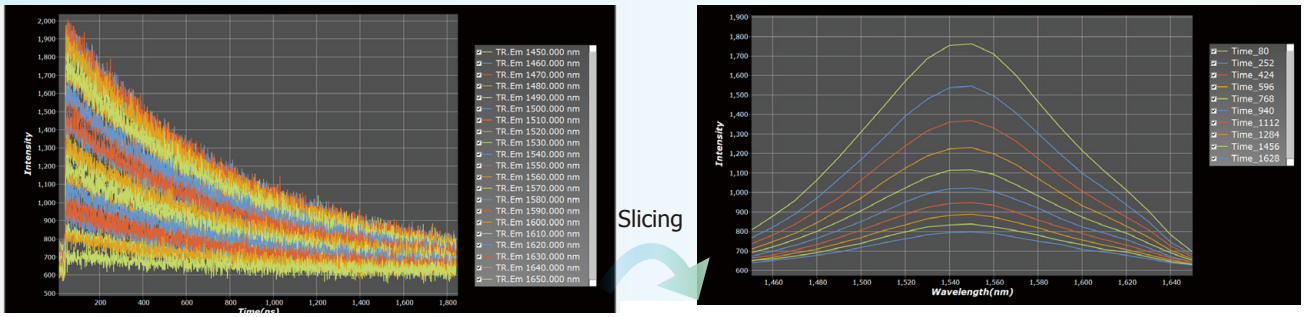
Applications

Time-Resolved Emission Spectra(TRES)

Sample: Pbs Quantum Dot Solution

Excitation Light Source: 488nm picosecond pulse laser Emission Scanning: 1450nm-1650nm

Detector: TE-PMT-H10330C075 Data Acquisition System: Time Correlation Single Photon Counter



Temperature-dependent Fluorescence

Sample: Perovskite Solar Cells $CsPbBr_3$

Temperature Environment: liquid nitrogen cooled cryostat

Test Temperature: 77K-100K-150K-200K-250K-300K

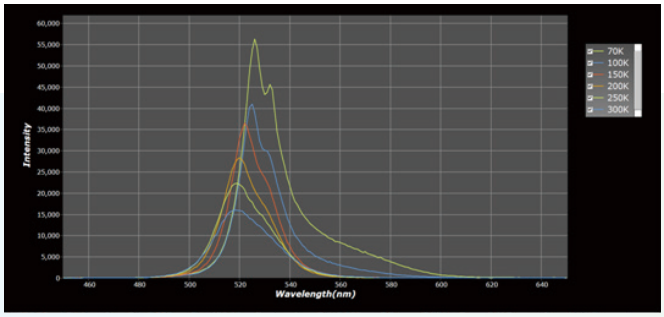
Temperature Dependent Steady-State Fluorescence：

Excitation Wavelength: 360nm@75W xenon lamp

Emission Scanning: 450nm-650nm

Detector: TE-cooled PMT

Data Acquisition: Time Correlation Single Photon Counter

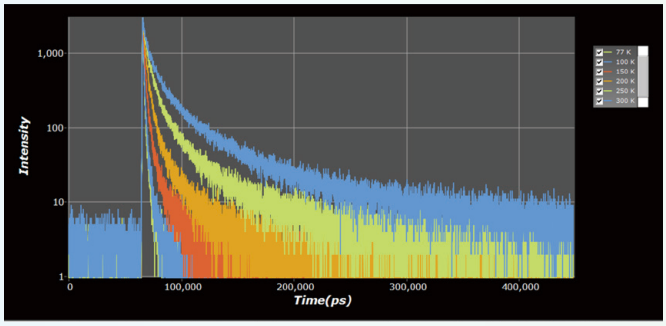


Temperature Dependent Fluorescence Lifetime:

Excitation Light Source: 375nm picosecond pulse laser

Trigger Frequency: 1MHz

Emission Wavelength: 520nm



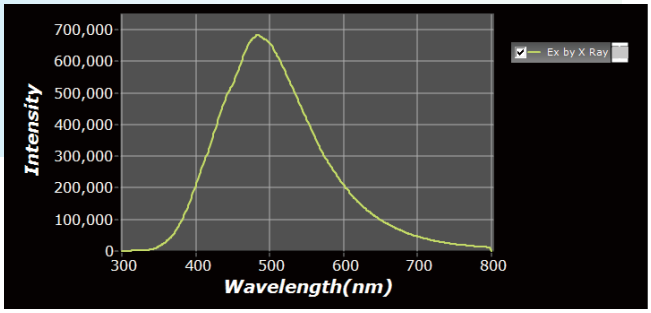
Applications

Spectra of X-Ray Excited Scintillator

Sample: $Bi_4Ge_3O_{12}$ Crystal

X-Ray Source: tube voltage: 60KV, Tube Current: 100uA

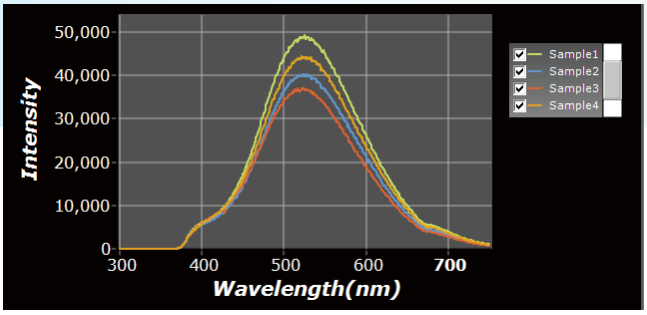
With the decrease of temperature, the luminescent intensity of the sample increases and the FWHM decreases.



Sample: CsI

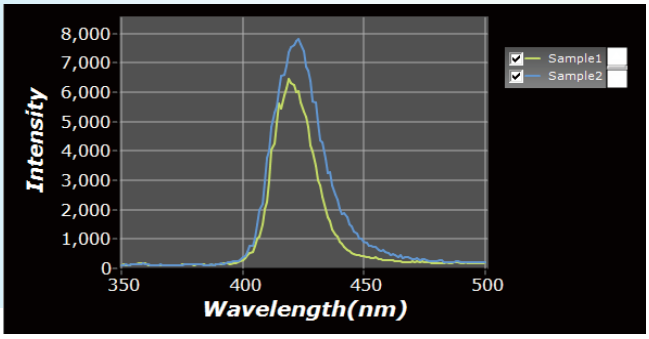
X-Ray Source: tube voltage: 60KV, Tube Current: 100uA

With the decrease of temperature, the fluorescence lifetime of the sample decreases from 4ns at 300K to 500ps at 77K gradually.



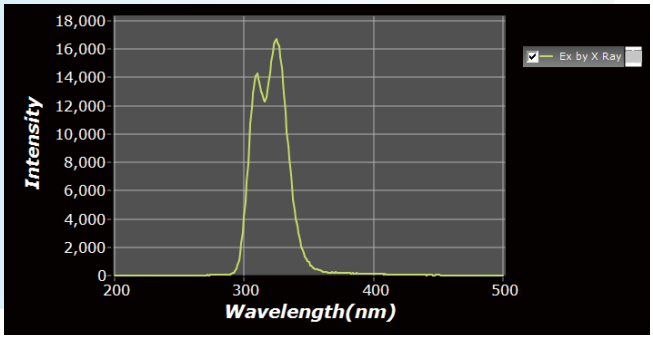
Oxide Thin Film Scintillator

X-Ray Source: tube voltage: 60KV, Tube Current: 100uA



YLF Crystal Doped With 5% Ce

X-Ray Source: tube voltage: 60KV, Tube Current: 100uA



Quantum Yield Measurement

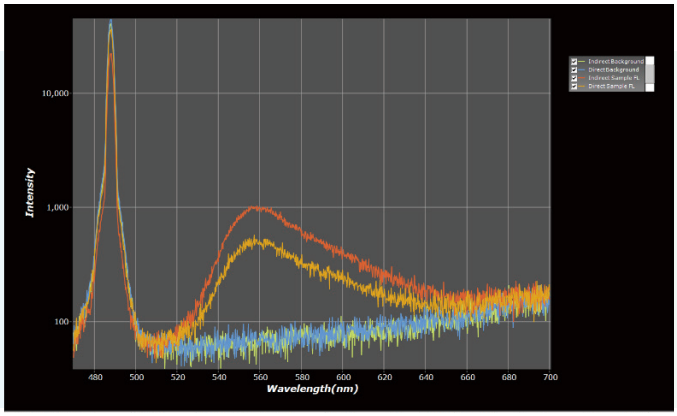
Sample: Rhodamine 6G Ethanol Solution

Excitation Wavelength: 488nm@75W xenon lamp

Scanning Step: 0.2nm integration time: 100ms

Emission Scanning: 470nm-700nm

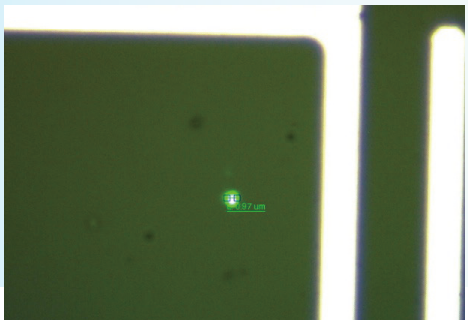
Test Result: QY=95%



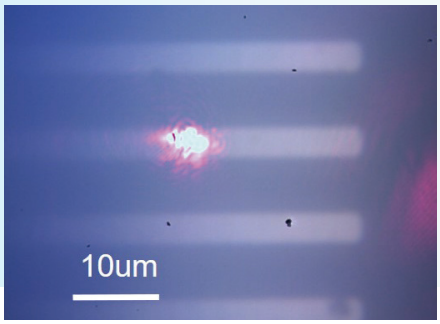
Applications

Steady-State and Transient Microscopic Measurement

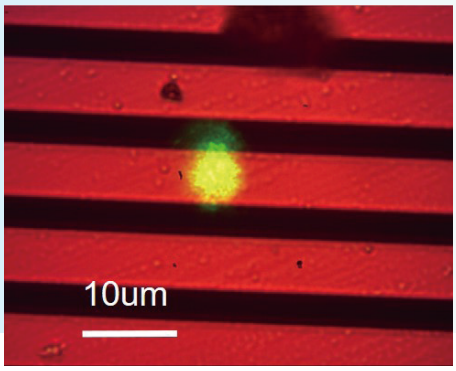
532nm single-mode CW laser coupled with micro-light path, the laser spot diameter is less 1μm under 100× objective lens.



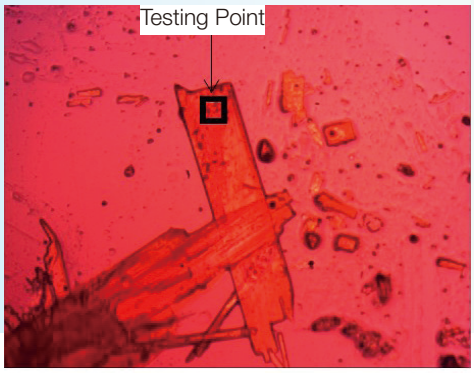
375nm picosecond pulse laser coupled with micro light path, the laser spot diameter is less 5μm under 100× objective lens.



The super-continuum laser is separated by a monochromator at 532nm coupled with micro light path, the light spot diameter is less 10μm under 100× objective lens.



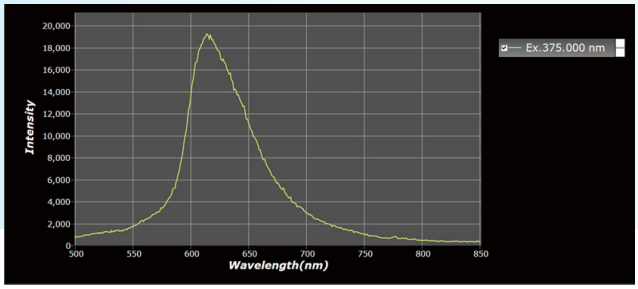
Microscopic image of organic molecular materials, objective lens 10×



Test Point Fluorescence Spectrum

Excitation Light Source: 375nm picosecond pulse laser

Emission Scanning: 500nm-850nm



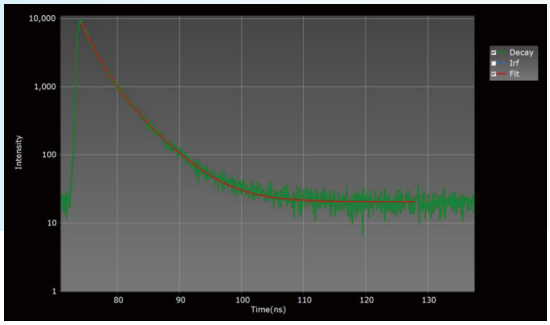
Test Point Fluorescence Lifetime Attenuation Curve

Excitation Light Source: 375nm picosecond pulse laser

Trigger Frequency: 1MHz

Emission Wavelength: 615nm

Double Exponential Fitting Life: τ1=1.76ns, τ2=4.64ns

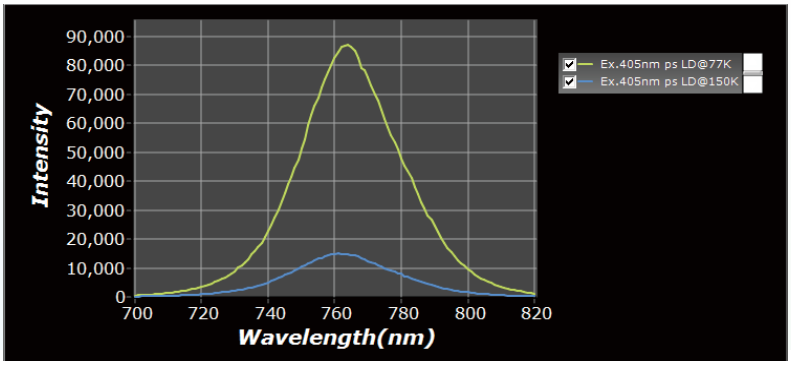


Applications

Microscopic Steady-State Fluorescence Measurement of Halide Perovskite Materials

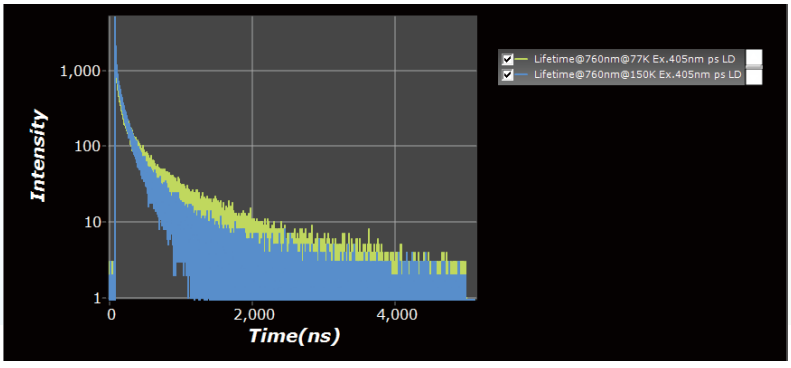
Excitation Light Source: 405nm picosecond laser

When temperature is 77K, the main peak wavelength is 763nm and the intensity value is 86000, when temperature is 150K, the main peak wavelength is 761nm and the intensity value is 15000. From 77K to 150K, the peak blue shifted by 2nm and the signal decreased.



Microscopic TRPL Measurement of Halide Perovskite Materials

Excitation Light Source: 405nm picosecond laser, the figure shows the 77K and 150K lifetime attenuation curve of 760nm emission. Through the comparison of the right figure, it can be found that the attenuation of lifetime at 150K is faster.



Upgrade Options

Excitation Light Sources

OPO Laser

Tunable Wavelength Nanosecond Pulse Laser

Output Wavelength Range: 200nm-2400nm,

Pulse Duration: 5ns, Repeat Frequency: 20Hz

Peak Energy: 9mJ@450nm

Higher Energy Version: 70mJ@450nm

Microsecond Pulse Xenon Lamp

Output Wavelength Range: 200nm-800nm,

Pulse Duration: 2.9μs

Typical Repeat Frequency: 60Hz, frequency adjustable

X-Ray Tube and Protective Lead Box

Voltage Range: 40-70kV

Current Range: 10-300μA@40kV

The Maximum Power: 12W

Target Material: tungsten

Window: Beryllium

It is used to excite scintillator crystal with protection and fluorescence collection path.

Picosecond Pulse LD and LED

LD: 375/405/488/520nm etc, pulse duration: 60ps

LED: 255/265/275/285/295/310/340/365nm etc, pulse duration: 800ps

Repeat Frequency Range: 0.2Hz-20MHz,

Adjustment Accuracy: 0.1Hz

Super-continuum Light Source

Output Wavelength Range: 400-2400nm

Pulse Duration: 100ps

Repeat Frequency: 0.01/0.1/0.2/0.5/1/5/10/20/40/80/200MHz

Spot divergence angle is less 2mrad.

Others

CW Laser: 266nm, 325nm, 405nm, 808nm, 980nm, 1064nm, 1550nm etc

Pulse Laser: DPSS laser, sapphire Femtosecond Laser

Upgrade Options

Detectors

UV-NIR PMT

TE-cooled UV-NIR PMT,
Cooling Temperature: -10℃

Response Range:
R13456: 185nm-980nm;
R2658: 185nm-1010nm

NIR PMT

TE-cooled NIR PMT,
Response Range: 950nm-1700nm,
Cooling Temperature: -60℃ .

Liquid Nitrogen Cooled NIR PMT,
Response Range: 300nm-1700nm, Cooling Temperature: 77K.

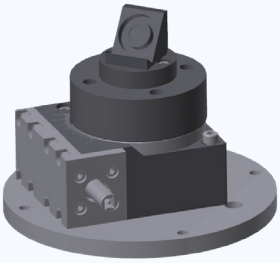
NIR detector

TE-cooled NIR InGaAs Detector,
Response Range: 800nm-1700nm/2600nm,
Cooling Temperature: -40℃ .

Liquid Nitrogen Cooled NIR InSb Detector,
Response Range: 1000nm-5500nm,
Cooling Temperature: 77K.

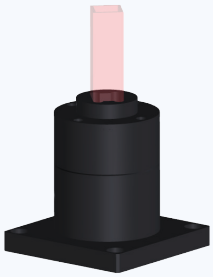
Sample Holders

Rotating Solid Sample Holder



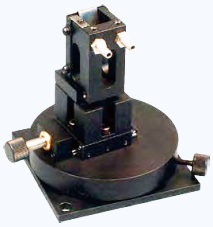
Manually rotate the sample table on the axis with scale, 0-360° adjustable angel.

Magnetic Stirring Sample Holder



It is convenient for measuring fluorescence of suspended solution to provide magnetic stirring function.

Water Bath Constant Temperature Sample Holder



It is used for constant temperature measurement of liquid sample. The water flow and water temperature are controlled by the controller to keep constant temperature in the sample holder.

Cryostat

65-500K Cryostat

Liquid nitrogen cryostat, temperature can be as low as 65K by using pressure reducing device

Sample environment: Vacuum/ exchange gas

Temperature stability: ±0.1K

77.2-300K Cryostat

Liquid nitrogen cryostat, temperature range: 77.2-300K, Sample environment: exchange gas

3-300K Cryostat

Liquid helium cryostat, temperature range: 77.2-300K, temperature stability: ±0.1K

Sample environment: Vacuum cooling technology: closed loop

Microscopic Spectrum Test Platform

Microscopic Path Module

CW laser and pulse laser can be coupled with the microscopic path module, spatial resolution is less 1μm(depending on the laser wavelength and objective lens selection), both the electric loading platform and cryostat are optional.

Electric Translation Platform

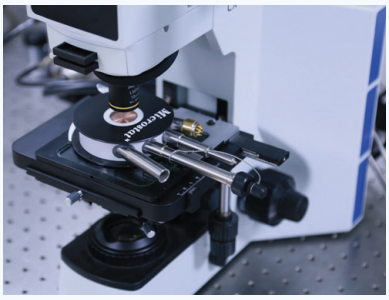
Travel: 76mm×52mm,
Resolution: 0.01μm

3.2-500K Microscopic Cryostat

Liquid Helium Cryostat,
Temperature Range: 3.2-500K,
Temperature Stability: ±0.1K
Sample Environment: Vacuum/Exchange Gas

77.2-500K Microscopic Cryostat

Liquid Nitrogen Cryostat,
Temperature Range: 77.2-500K,
Temperature Stability: ±0.1K
Sample Environment: Vacuum/Exchange Gas



The picture of cryostat coupled with microscope.

Quantum Yield Accessory

Integrating Sphere

The integrating sphere is used to measure the absolute quantum yield, which can fit into the sample chamber.

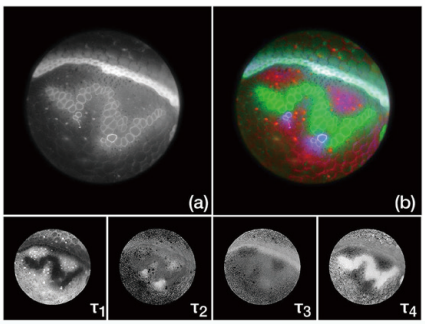
The integrating sphere with temperature regulation can be provided to measure the absolute quantum yield at different temperature.

Upgrade Options

Cameras

Single Photon Camera

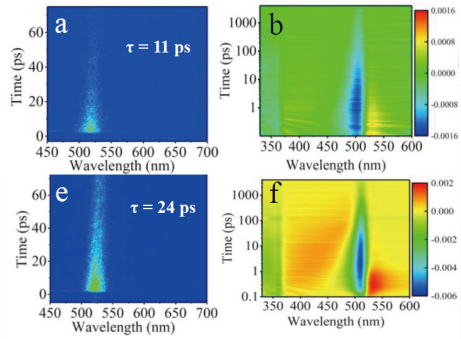
Micro fluorescence lifetime imaging single photon camera can provide temporal and spatial information simultaneously.



Fluorescence lifetime imaging(FLIM) of valley lily: (a)Intensity image. Lifetime analysis revealed four components: τ1=0.19ns, τ2=0.67ns, τ3=1.95ns, τ4=3.75ns. (b)Superposition of intensity image and average life image.

Streak Camera

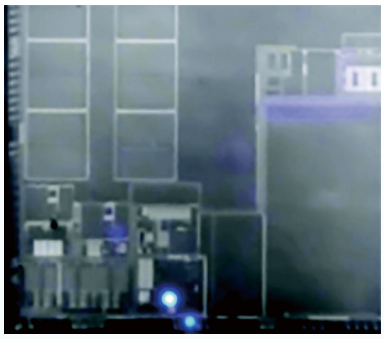
UV to NIR spectral response, up to 2ps temporal resolution and 50lp/mm spatial resolution, compatible with two working modes: high performance synchronous scanning / single low frequency scanning.



Fluorescence lifetime measurements of perovskite thin film solar cells taken by a streak camera. Faster lifetime components are Cs_4PbBr_6 (11ps) and $CsPbBr_3$ (24ps) respectively.

Infrared Camera

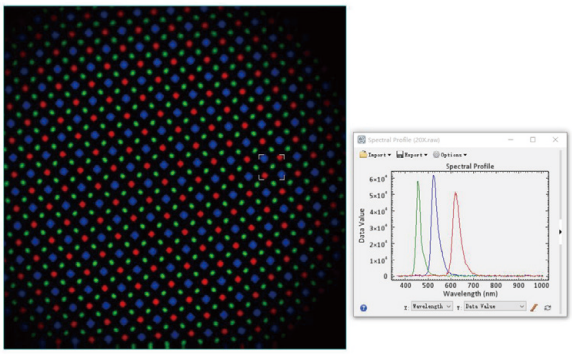
Cooled infrared InGaAs camera, spectral range: 900-1700nm, sensor size: 9.6mm×7.68mm; pixel resolution: 640×512; pixel size: 15μm×15μm.



NIR image of an IC chip, taken by cooled InGaAs camera with a 20x obj. Exposure time: 30s.

Hyperspectral Camera

Hyperspectral camera is a perfect combination of spectroscopic elements and area array camera, which can simultaneously and quickly obtain spectral and image information, and can be used in many fields of scientific research and industrial automatic detection.



Hyperspectral image of an OLED screen for cell phone, 20x magnification.

Hyperspectral Microscopy System

Omni-Image push-broom hyperspectral camera is mounted on the microscope to realize various spectrum test at the microscale.

Excitation Light Source: 385nm LED parallel light illumination

Objective Lens: 20×

Spectral Resolution: 3.5nm

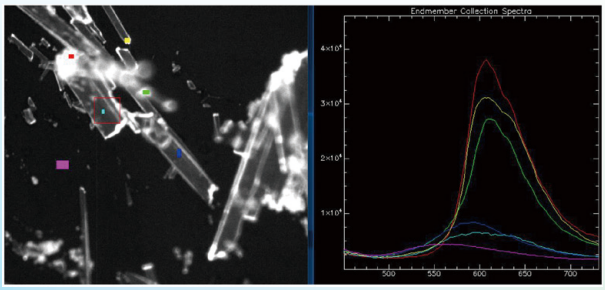
Spectral Range: 400-1000nm

CCD Integration Time: 300ms

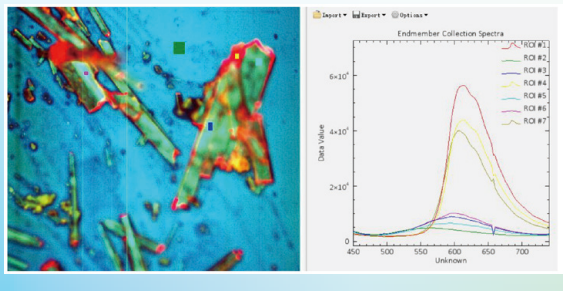
CCD Gain: 5×

CCD Pixel: 696×256

The following figure extracts the monochromatic image at 610nm and the spectrum at different positions.

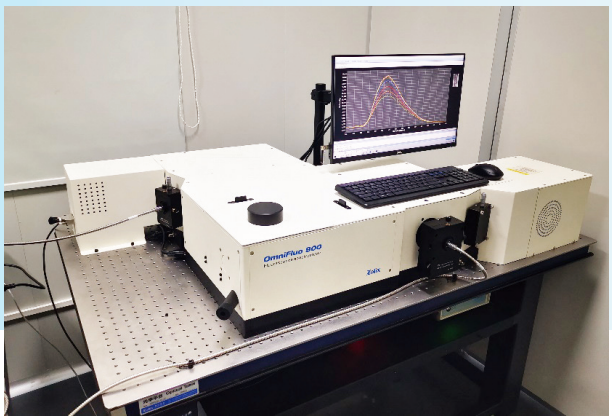


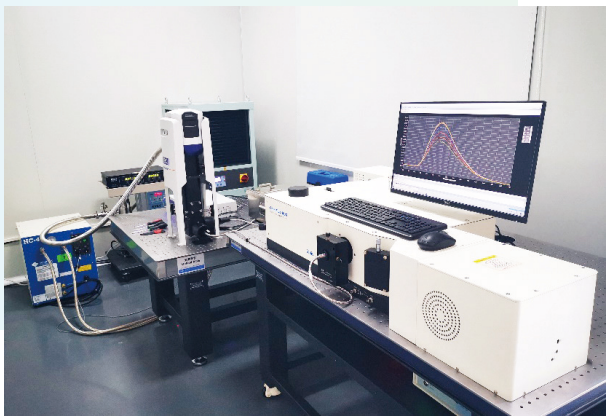
The following figure shows the full spectrum image after IPCA processing.



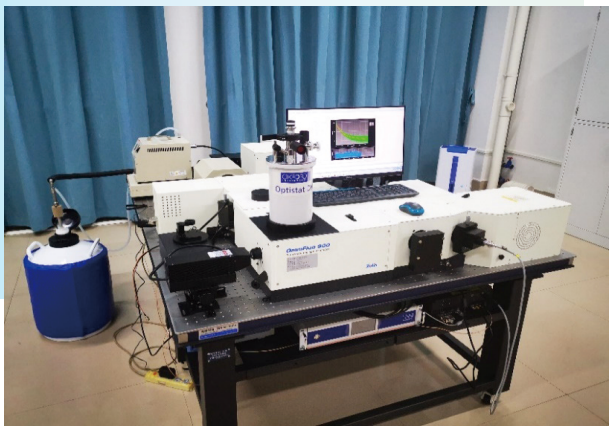
Example Systems

OmniFluo960+X-Ray Tube and Protective Lead Box +4k Closed Cycle Cryostat.

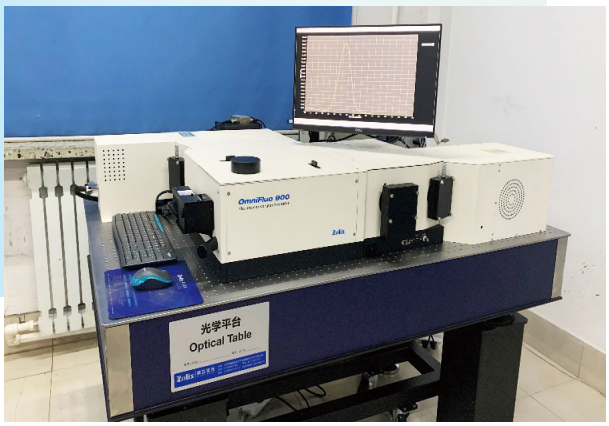




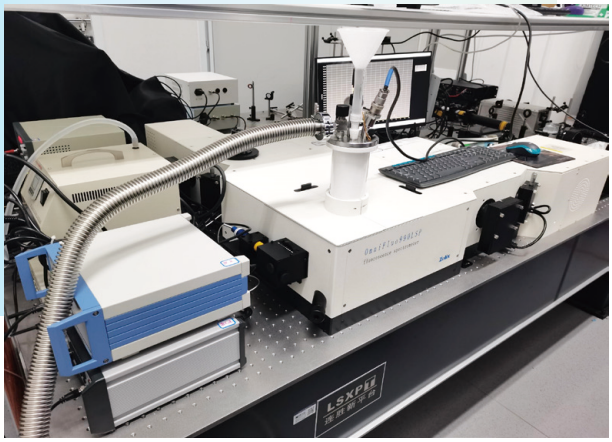
OmniFluo990+NIRPMT+77K Cryostat + Integrated Sphere+ 266nm Laser+ Supercontinuum Light Source + Microsecond Pulse Xenon Lamp



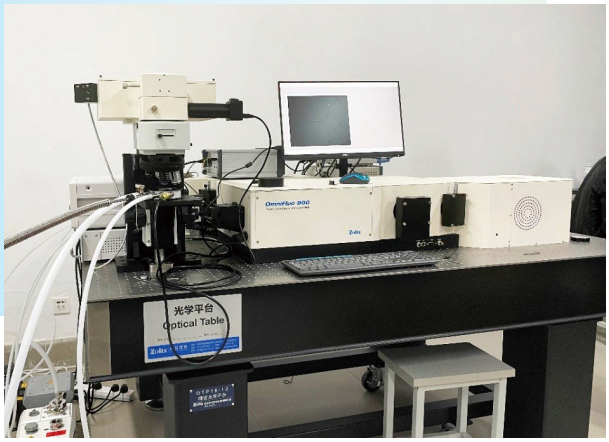
OmniFluo990+375nm Picosecond Pulse Laser +2600nm InGaAs Detector



OmniFluo990+NIRPMT+65K Cryostat + Picosecond Pulse Light Source + Integrated Sphere



OmniFluo990+405nm Picosecond Pulse Laser + 77K Microscopic Cryostat



Specification

System Performance	
Fluorescence Spectroscopy	Emission Spectrum: 200-870nm, Excitation Spectrum: 200-800nm
Spectral Resolution	0.08nm@435.84nm
Water Raman Signal To Noise Ratio ①	＞ 10500: 1
Lifetime Measurement	MCS: 10μs-10s, TCSPC: 500ps-ns-μs-10s
Extended Function	Multiple excitation sources, infrared spectrum test, temperature dependent spectrum test, microscopic spectrum test, quantum yield measurement
Excitation Light Source	
Steady-State Xenon Lamp	Power: 75W, output spectral range: 200nm-1800nm, lamp cup design, coupling efficiency better than 90%
Pulse Light Source	Microsecond pulse xenon, picosecond pulse laser, picosecond pulse LED, supercontinuum source, OPO wavelength tunable nanosecond laser, etc.
Optional Light Source	CW laser: such as 808nm, 980nm laser, X-ray tube, lamp pumped nanosecond DPSS laser.
Spectrometer	
Optical design	Czerny-Turner
Specification ②	Focal length: 320mm, stray light: $1*10^{-5}$, spectral resolution: 0.08nm, wavelength accuracy: ±0.2nm, wavelength repeatability: ±0.1nm
Grating	Excitation grating: 1200g/mm@300nm blaze wavelength, 600g/mm@500nm blaze wavelength Emission grating: 1200g/mm@500nm blaze wavelength, 600g/mm@750nm blaze wavelength, 300g/mm@1250nm blaze wavelength
Sample Chamber	
Sample Holder	Standard: liquid, powder and film holder; optional: rotating sample holder, magnetic stirring sample holder, water bath heated sample holder
Detector Protection	Automatically block the light once the cover is removed.
Detector	
PMT	Standard: TE-PMT-CR131: 185-900nm
	Optional: TE-PMT-R13456: 185-980nm, TE-PMT-R2658: 185-1010nm, TE-PMT-H10330C-75: 950-1700nm, LN-PMT-R5509-73: 300-1700nm
Optional Photo Diode	TE-InGaAs: 800-1700nm or 800-2600nm, LN-InSb: 1000-5500nm
Data Acquisition System	
Photon Counter	Single photon counter: counting rate: 100Mcps, sampling speed: 1MB/s, four channel analog input: 1-10V, AD: 16bits
Time Correlation Single Photon Counter	Counting rate: 100Mcps, resolution: 16/32/64/128/256/512/1024ps, channel: 65535
Lock-In Amplifier	Frequency Range: 50mhz-120khz, Dynamic Reserve: >100db, Gain Stability: <5ppm/℃
Software	
Control Software	Steady-State Test Function: Excitation Scanning, Emission Scanning, Synchronous Scanning, 3D Scanning Transient Test Function: Dynamic Scanning, Lifetime Scanning, Time Resolved Spectral Scanning Data Processing Function: Quantum Yield Calculation, Tres Slicing, Spectral Calibration Optional Function: Polarization Test, Temperature Control Scanning;
Optical Table	
Damping Optical Table	Size: 1500mm×1000mm×800mm

Zolix Instruments Co.,Ltd.

Address: No. 68B, LDUV, Tongzhou District, Beijing, China, 101102

TEL: +86 10 5637 0168 **Email:** info@zolix.com.cn **Website:** www.zolix.com.cn