OmniFluo900 series

Fluorescence Spectrometer

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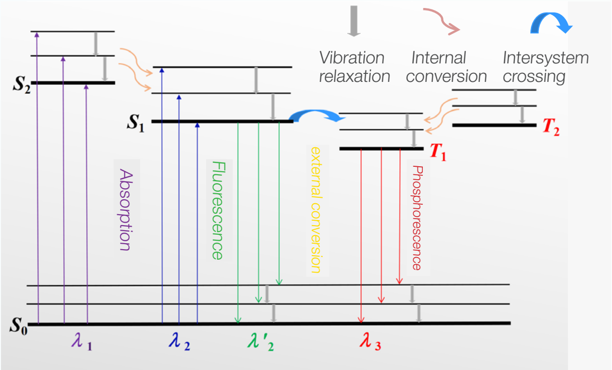
The mechanism of fluorescence

Fluorescence describes a phenomenon wherein a molecular system absorbs light at one wavelength and then emits light at a different wavelength. During absorption, the energy of the photon absorbed changes the ground state of the molecule: this is called "excitement". When electrons in an excited state jump back to their ground state, they release the extra energy in form of light.



The intensity of the fluorescence depends on the wavelength of the excitation; it can be shown through spectra, called "excitation spectroscopy"; similarly, the wavelengths of the emitted fluorescence can be examined by a technique called "emission spectroscopy". Both techniques help to understand the energy-level structure of a molecule.

Since there is usually some energy loss due to non-radiative relaxation, 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 called the Stokes shift. Once excited, a molecule will return to its ground state after a short time. The avarage of time that a molecule is expected to stay at the excited state is called its fluorescence lifetime.

Steady-state fluorescence

Steady-state fluorescence spectra are observed when molecules excited by a continuous light source, and emit fluorescence; the intensity of the emission is 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 by emission wavelength;

Excitation spectrum: when the emission wavelength is fixed and the excitation wavelength is scanned to get a plot of intensity by excitation wavelength;

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

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

Fluorescence lifetime

Fluorescence lifetime is the intensity of a sample's fluorescence monitored as a function of time, after excitation by a pulsed light. This can be obtained in a number of ways, depending on the required sensitivity and timespan. Zolix instruments attain the highest sensitivity for a time correlated single photon counting with a lifetime range that covers 500ps to 10s.

Fluorescence spectrometer
OmniFluo900 series

The OmniFluo900 series is a high-performance, versatile, modular fluorescence spectrometer for research applications in material science, physics, chemistry, life sciences 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 and for lifetime measurements ranging from hundreds of picoseconds to seconds.

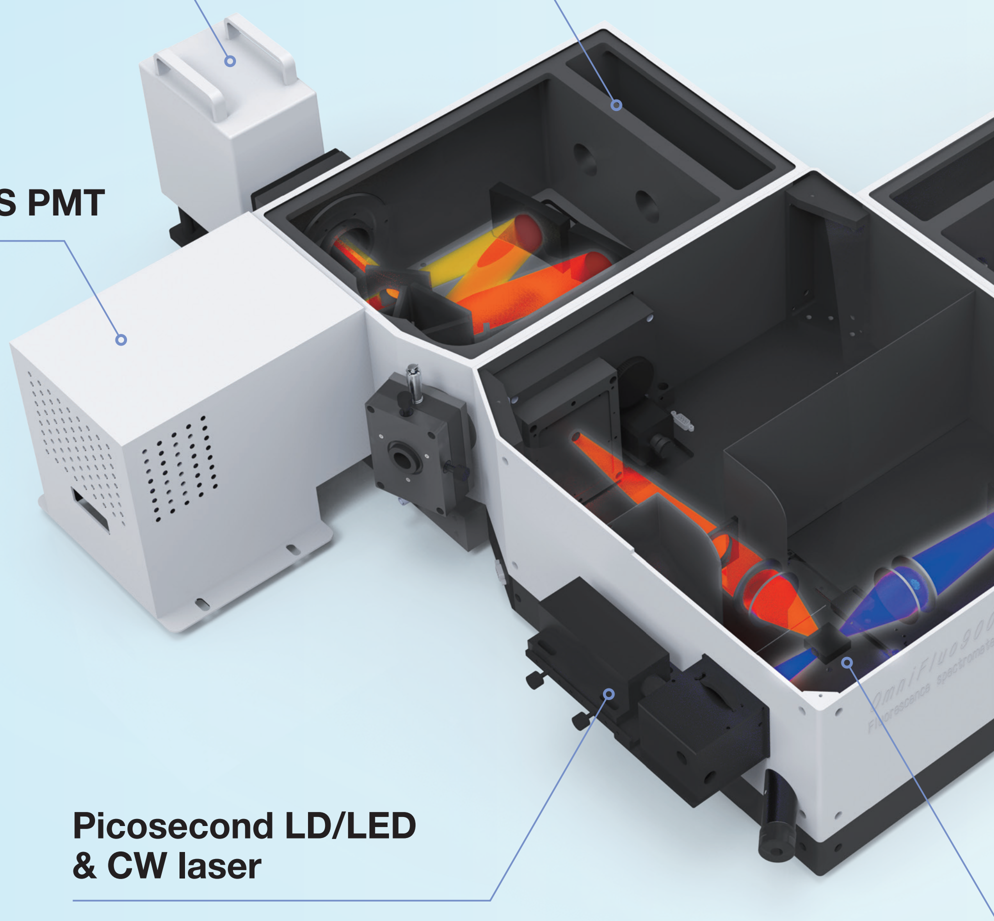
The instrument features extraordinary sensitivity and exceptional stray light suppression, which is very important for the detection of weak fluorescence. Its signal-to-noise ratio (SNR) for the Raman scattering of water – an index commonly used to represent the sensitivity of a fluorescence spectrometer – can reach or exceed 10,000:1.

Optional microscope and a cryostat can be added to achieve high spatial resolution and temperature-dependent measurement.

Main features

- Modular design for maximum flexibility and extendibility;
- A water Raman SNR greater than 10,000:1;
- Large spectral coverage ranging from UV to MIR (200nm ~ 5500nm);
- Excellent stray light suppression;
- Multiple light sources and detectors are available; optional double-monochromator configuration;
- Intuitive software for steady-state and time-resolved measurements with lifetime fitting function

Spectrometer configuration



Detector

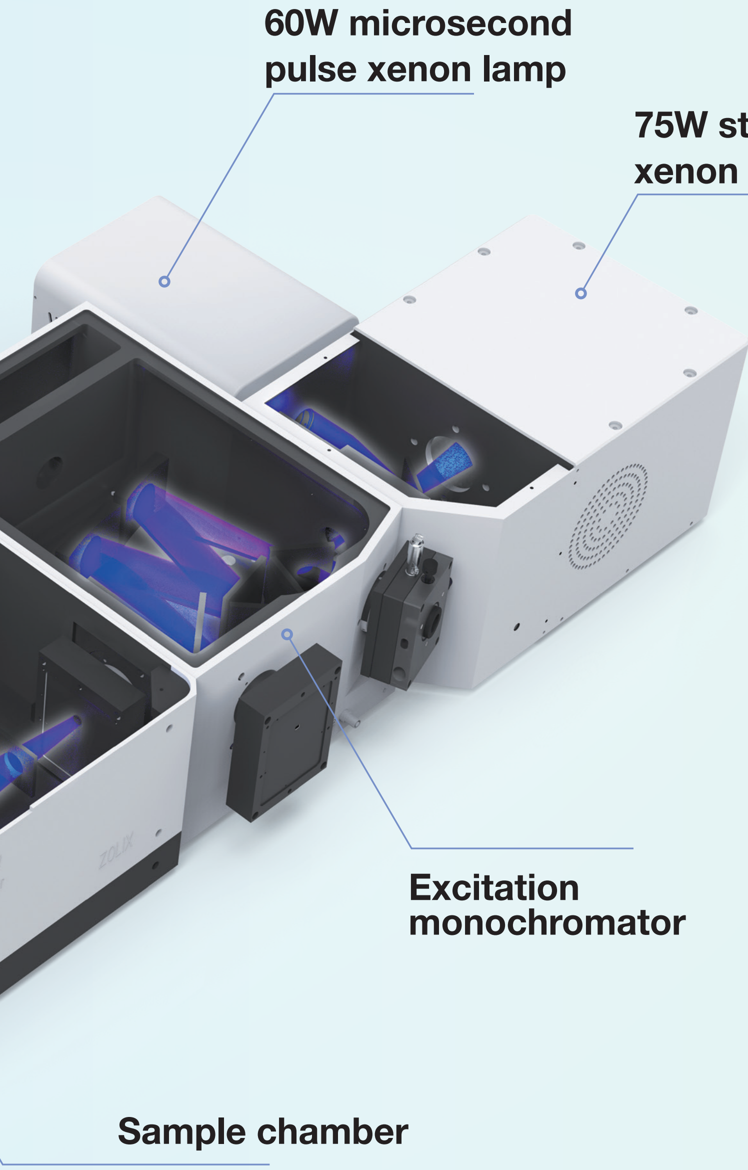
The standard detector for the UV-VIS range is a photon counting photomultiplier (PMT) with TE cooling down to -10 ℃ , covering a wavelength range from 185–900nm.

Infrared PMTs and analog detectors can be added to extend the spectral range up to 5500nm.

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 spectroscopy and fluorescence lifetime measurements ranging from hundreds of picoseconds to seconds.

OmniFluo900 **3D Diagram**



Excitation light source

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

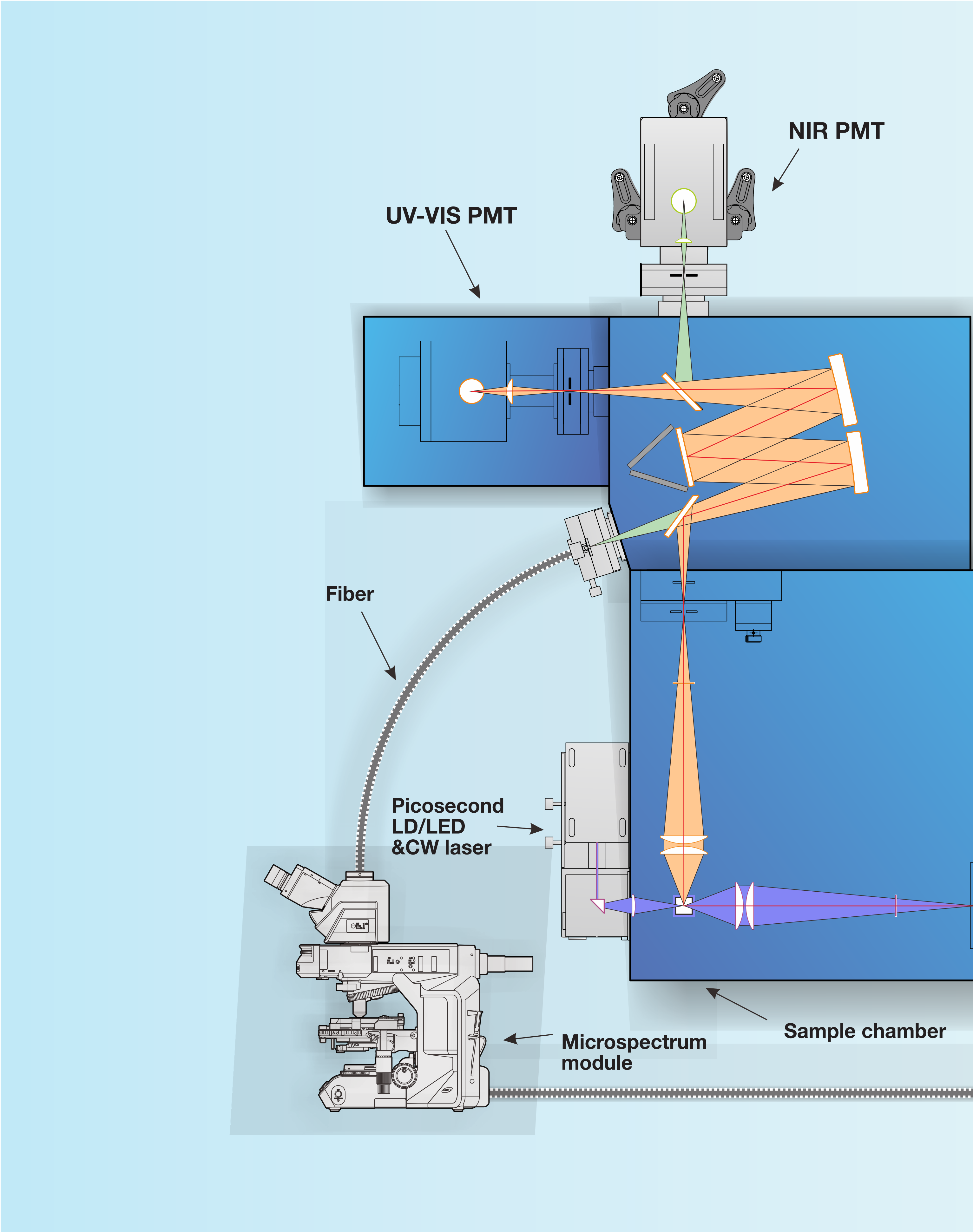
Excitation / emission monochromator

Both the single monochromator of 320mm focal length and the double monochromator of 2×180mm focal length are optional; they use image correction technology to reduce astigmatism to the greatest possible extent, and the stray light suppression ratio is 10^{-5} (10^{-9} for double monochromators). Installed on each monochromator is a triple-grating turret capable of holding and switching between three gratings for different wavelength ranges. The turret can be driven in steps as small as 0.005nm, ensuring a spectral resolution of 0.1nm for the whole system. Six-position filter wheels are equipped in both the excitation and emission arms. Filters to suppress the higher order diffraction from a monochromator are switched automatically during wavelength scanning. The monochromators are also equipped with motorized slits that feature software-controlled continuous adjustment from 0.01mm to 3mm.

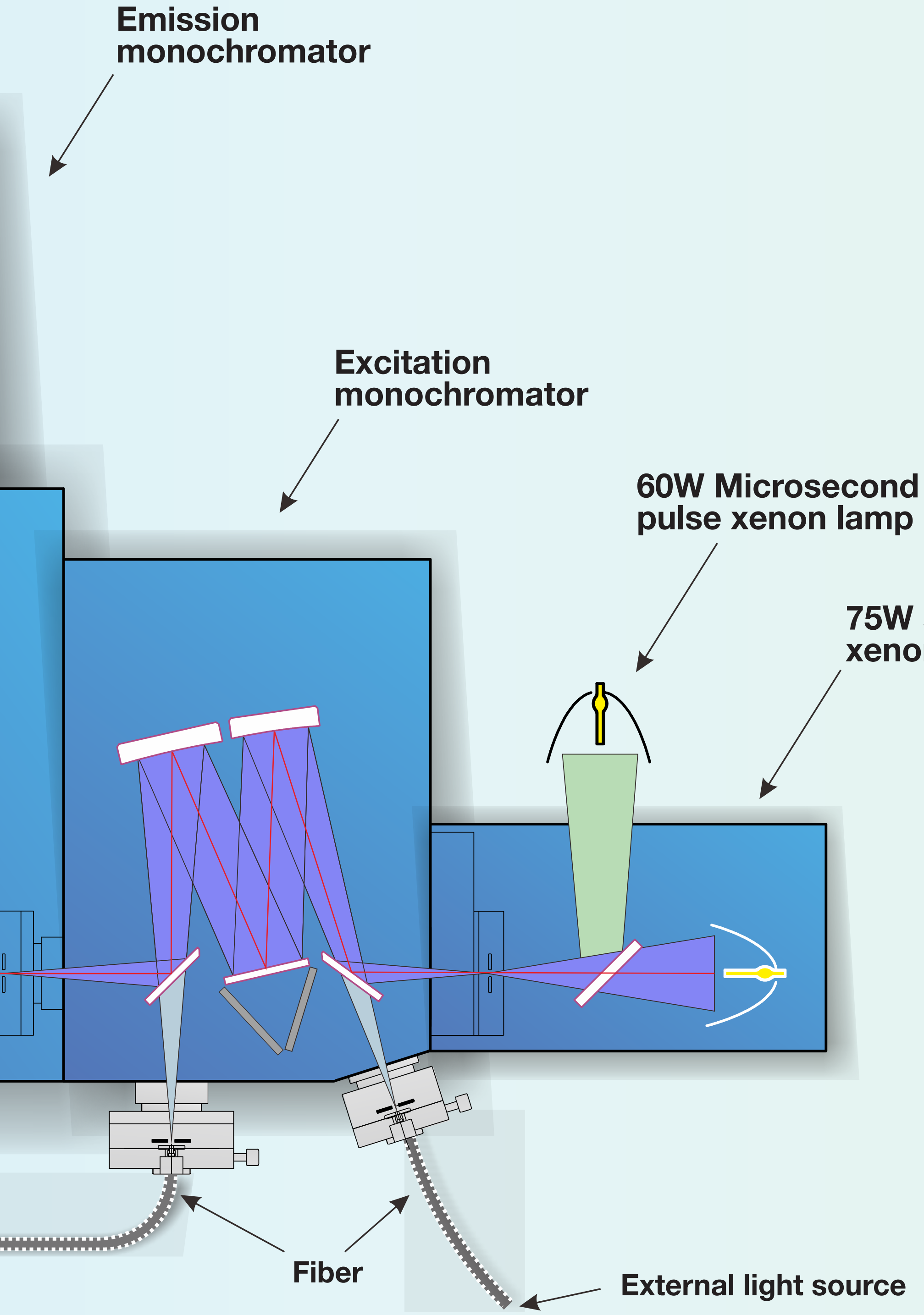
Sample chamber

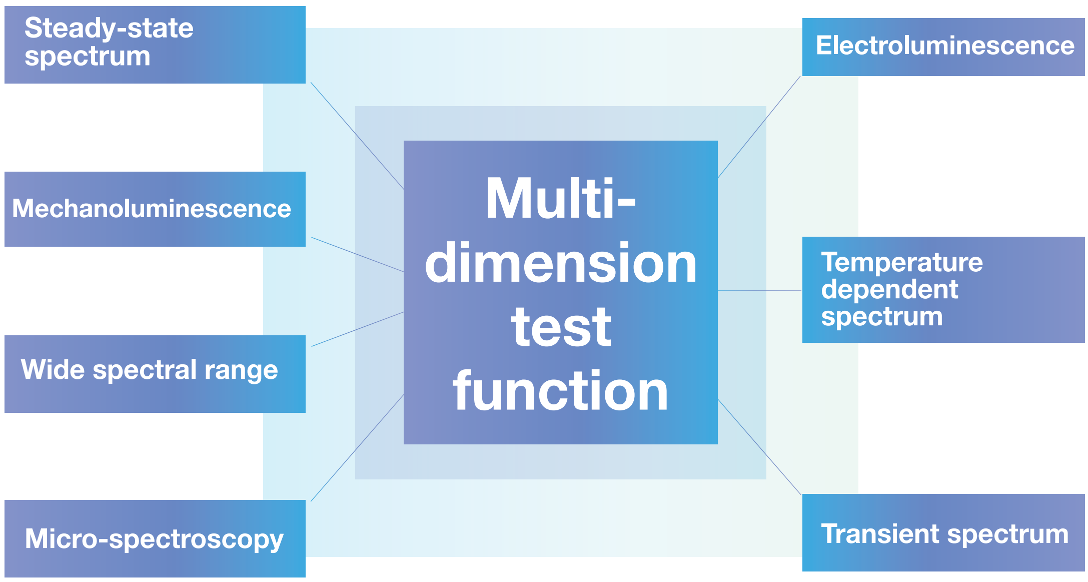
At the heart of the OmniFluo900 there is a large sample chamber that features a dedicated design for best results . Large-aperture fused silica lenses provide highly efficient excitation and emission collection. A filter holder in the emission arm can accommodate 50mm×50mm or 25mm×25mm filters, allowing the user to select low-pass, high-pass or band-pass filters for special purposes.

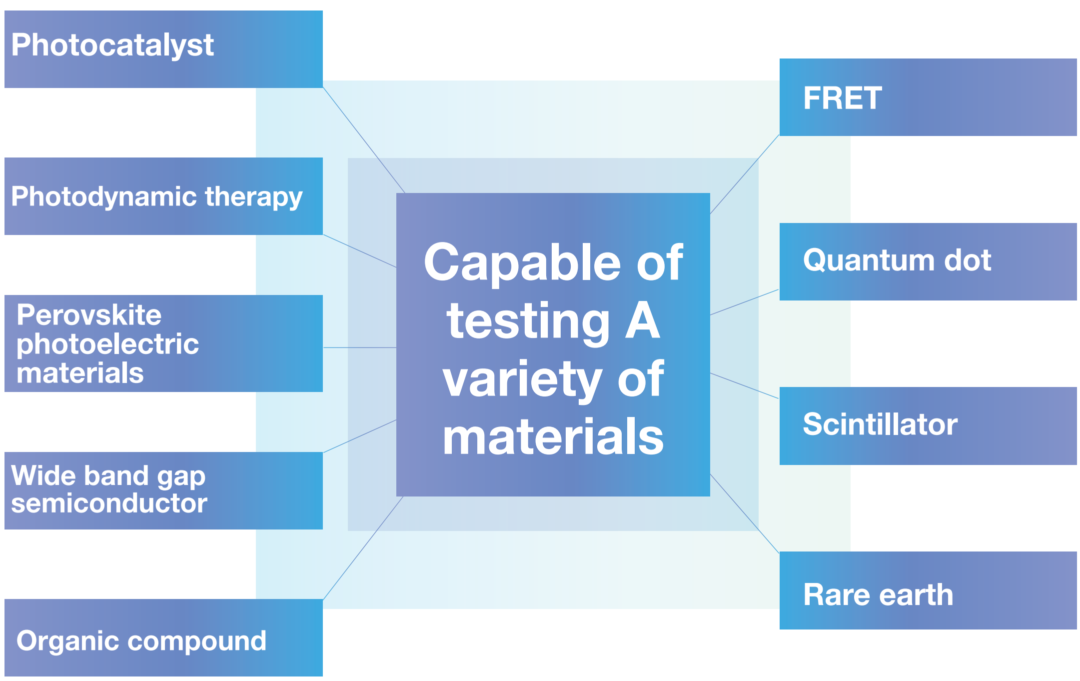
- A laser can be directed into the sample chamber through a side port. A variable. neutral-density filter is used to control the power of the laser
- Standard sample holders: cuvette, bulk/ powder/ film clamps;
- Optional rotating stage; magnetic stirrer; temperature-controlled or -regulated stage
-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


NIR PMT
UV-VIS PMT
Fiber
Picosecond
LD/LED
&CW laser
Microspectrum
module
Sample chamber

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

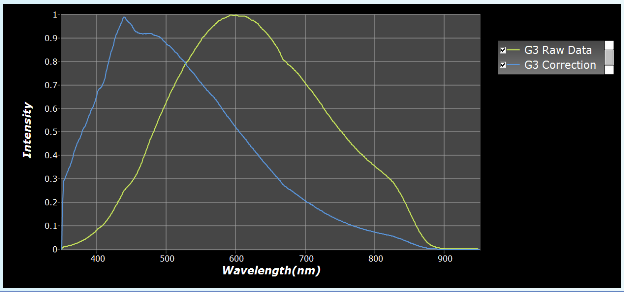
Spectral correction

Spectral correction accounts for all instrumental effects, such as those from mirrors, light sources and detectors, to obtain the true excitation and emission spectra. Spectral correction, using factory-measured correction files, is a standard operating procedure for the OmniFluo900 series.

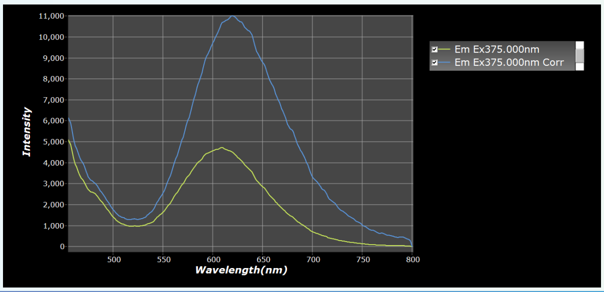
The figure below shows the calibration curves of grating G1 and grating G2 of the emission monochromator.

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. The peak has 10nm red shift in the corrected spectrum compared to the raw data.



The calibration spectrum can reflect the sample' s true luminescence condition, for example the true position of the peak. For samples with multiple emission peaks, the corrected spectrum more accurately shows the relative intensity relationship between these emission peaks.

Exceptional sensitivity

Thanks to the OmniFluo900 series' single-photon counting technique, its high-quality optical pathways, the dedicated and optimized light sources and its ultra-sensitive detectors, the instrument' s water Raman signal-to-noise ratio (SNR) can easily reach 10,500:1. Rather than employing complicated calculation procedures, we use the straightforward square-root (SQRT) method for sensitivity validation:

Sample: pure water

Excitation wavelength: 350nm

Integration time: 1s

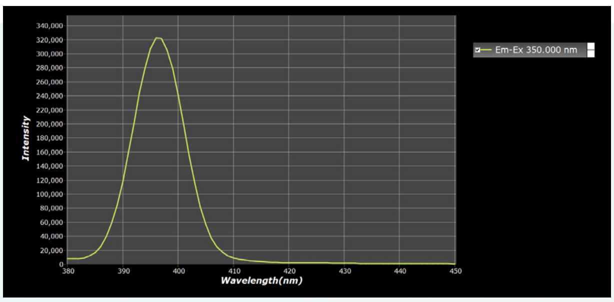
Scanning step: 1nm

Peak signal at 397nm = 322,411

Emission scanning: 380–450nm

Noise signal at 450nm = 680

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



With a single excitation and emission monochromator, a SNR of more than 10,500:1 can easily be attained.

High resolution and high accuracy

Sample: mercury lamp

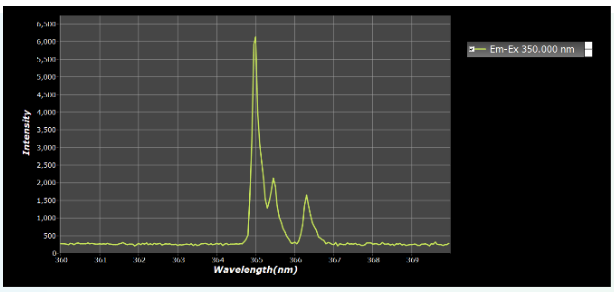
Emission scanning: 360–370nm

Scanning step: 0.05nm

Integration time: 200ms

Repeats: 1

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



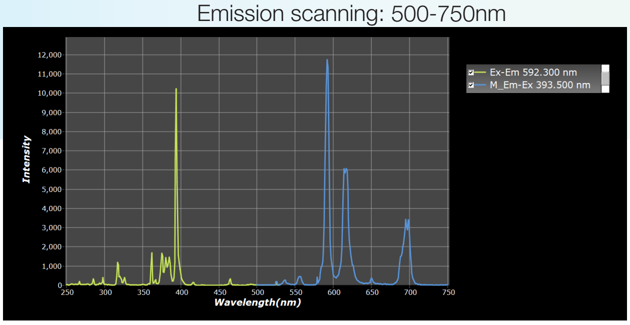
The OmniFluo900 series uses a 320mm imaging monochromator to suppress astigmatism for excellent image quality. The wavelength adjustment is driven by a stepper motor in increments of 0.005nm. With a 1200g/mm grating, the spectral resolution is 0.08nm, the wavelength accuracy is ±0.2nm and the wavelength repeatability is ±0.1nm.

Applications

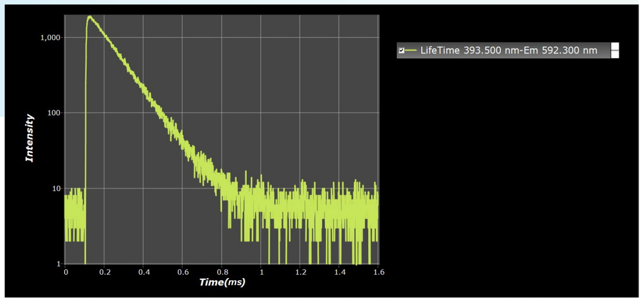
Standard samples

Sample: Europium, solvent: nitric acid

Excitation & emission spectrum test:
Excitation light source: 75W xenon lamp
Scanning step: 1nm
Excitation spectrum: Excitation scanning: 250–530nm
Emission wavelength: 592.3nm
Emission spectrum: Excitation wavelength: 393.5nm
Emission scanning: 500-750nm

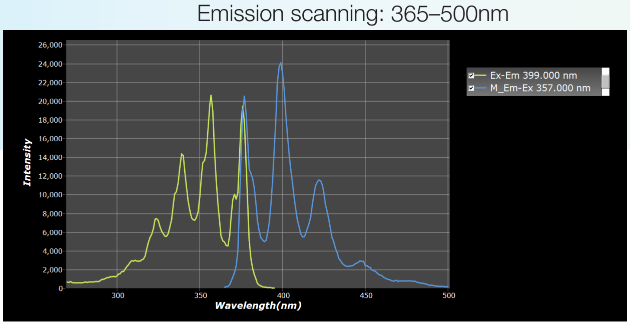


Fluorescence lifetime test:
Excitation wavelength: 393.5nm at microsecond pulse
Xenon lamp emission wavelength: 592.3nm
Repeats: 1000
Fitting lifetime: 117μs

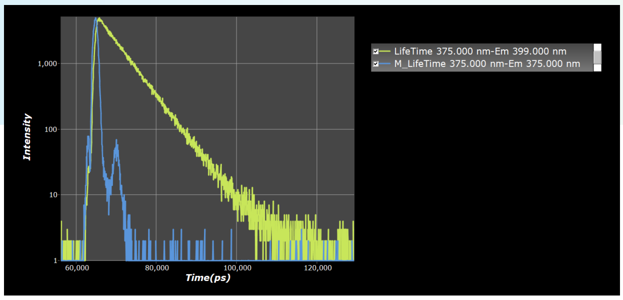


Sample: Anthracene; solvent: cyclohexane

Excitation & emission spectrum test:
Excitation light source: 75W xenon lamp
Scanning step: 1nm
Excitation spectrum: Excitation scanning: 270–395nm
Emission wavelength: 399nm
Emission spectrum: Excitation wavelength: 357nm
Emission scanning: 365–500nm

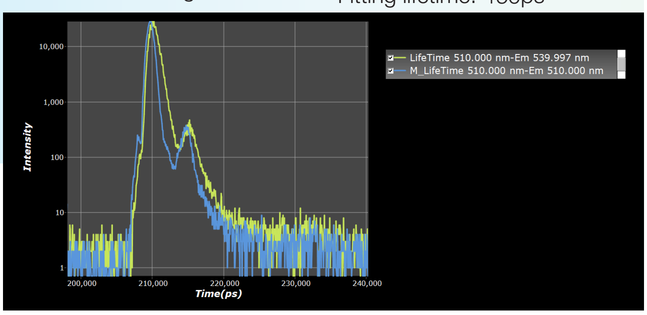


Fluorescence lifetime test:
Excitation wavelength: 375nm picosecond pulse laser
Trigger frequency: 1MHz
Emission wavelength: 399nm
Fitting lifetime: 5.3ns



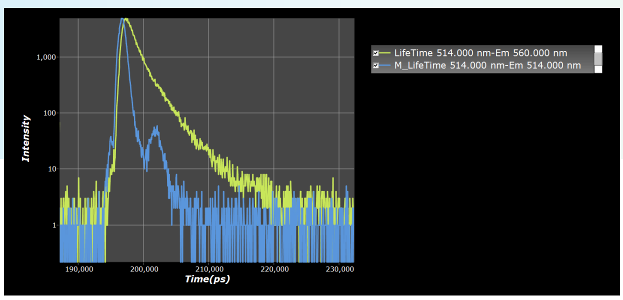
Sample: Erythrosin B, solvent: methanol

Fluorescence lifetime test
Excitation wavelength: 510nm supercontinuum laser
Trigger frequency: 1MHz
Emission wavelength: 540nm Fitting lifetime: 460ps



Sample: Rhodamine B aqueous solution

Fluorescence lifetime test
Excitation wavelength: 514nm supercontinuum laser
Trigger frequency: 1MHz
Emission wavelength: 560nm Fitting lifetime: 1.6ns



Rare earth upconversion fluorescence

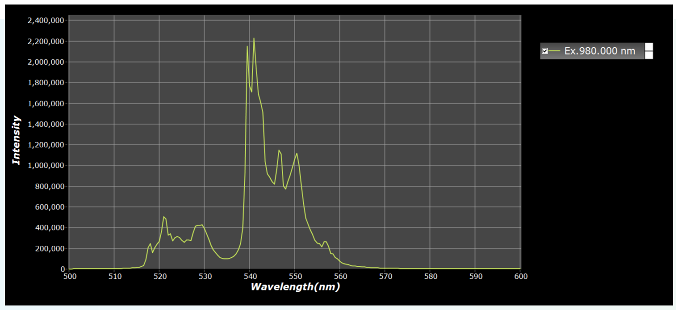
Sample: $NaYF_4YbEr$ solution

Steady-state spectrum:

Excitation light source: 980nm CW laser

Emission scanning: 500–600nm

Increment: 1nm

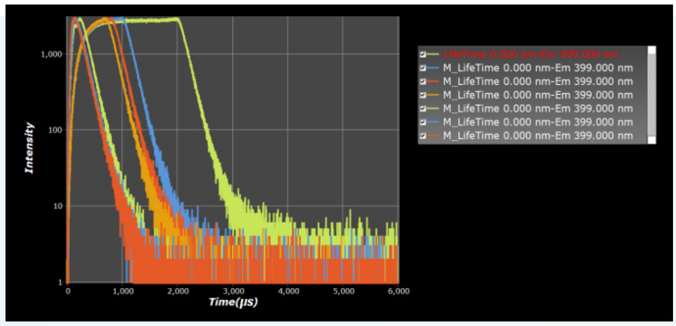


Lifetime test:

Excitation light source: 980nm CW laser with modulated output

Trigger frequency: 100Hz

Emission wavelength: 544nm



Upconversion fluorescence spectrum at different excitation powers

The curves in Figure B extract the peak data of several characteristic luminescence peaks at 521.5nm, 539.5nm, 541nm, and 546.5nm as shown 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 indicates a two-photon absorption process.

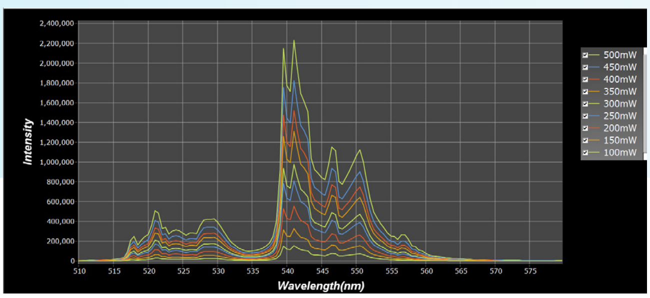


Figure A

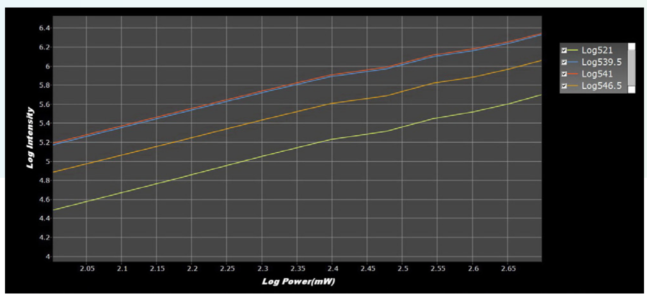


Figure B

Applications

NIR measurement

Sample: YAG: Er crystal

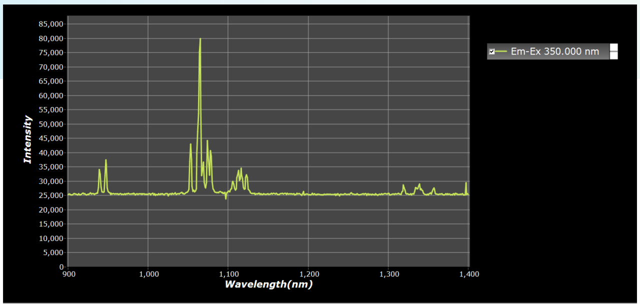
Excitation light source: 532nm CW laser

Emission scanning: 900–1400nm

Detector: TE-PMT-H10330C075

Data acquisition system: single-photon counter

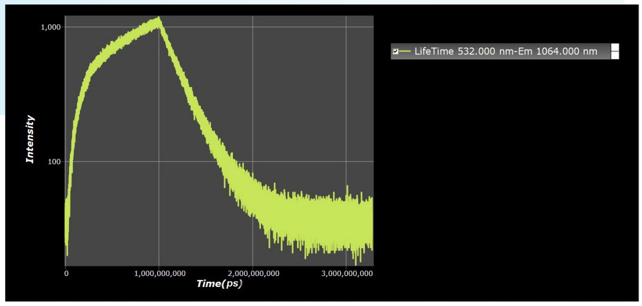
Slit: 10μm



Lifetime test: Excitation light source: 532nm CW laser modulated output

Trigger frequency: 100Hz

Emission wavelength: 1064nm



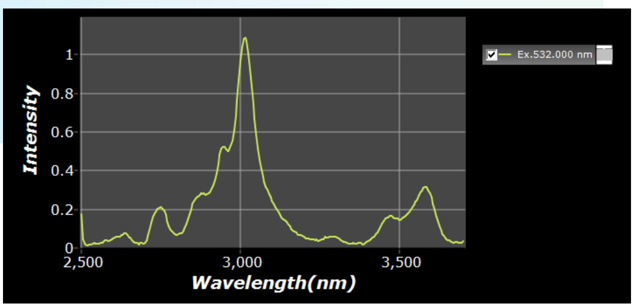
MIR measurement

Sample: Zinc sulfate doped in titanate glass

Excitation light source: 532nm CW laser

Emission scanning: 2500–3700nm

Detector: liquid-nitrogen-cooled InSb detector Data acquisition : lock-in amplifier



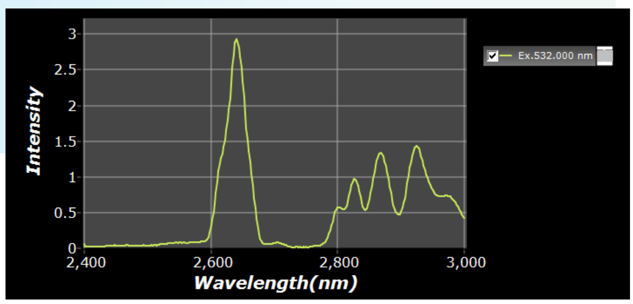
Sample: YAG: Er crystal

Excitation light source: 532nm CW laser

Emission scanning: 2400–3000nm

Detector: liquid-nitrogen-cooled InSb detector

Data acquisition: lock -in amplifier



Time-resolved emission spectra (TRES)

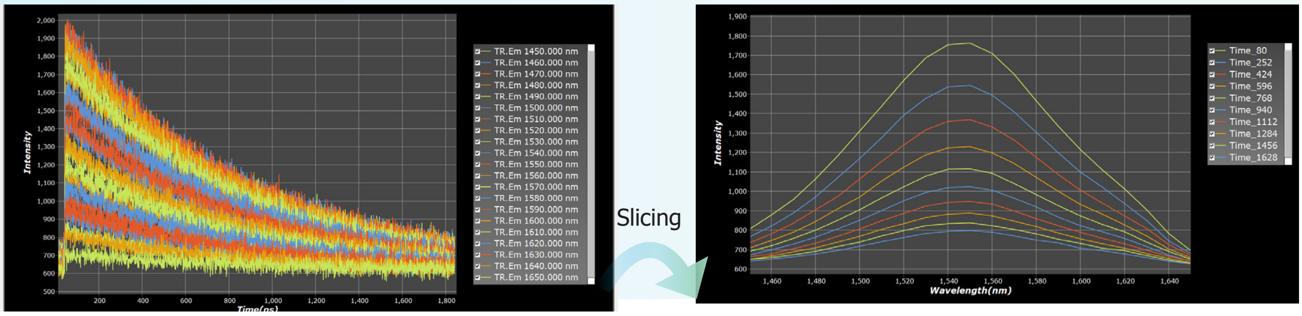
Sample: PbS quantum dot solution

Excitation light source: 488nm picosecond pulse laser

Emission scanning: 1450–1650nm

Detector: TE-PMT-H10330C075

Data acquisition system: time correlation single-photon counter



Temperature-dependent fluorescence

Sample: Perovskite solar cells $CsPbBr_3$

Temperature controller: liquid-nitrogen-cooled cryostat

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

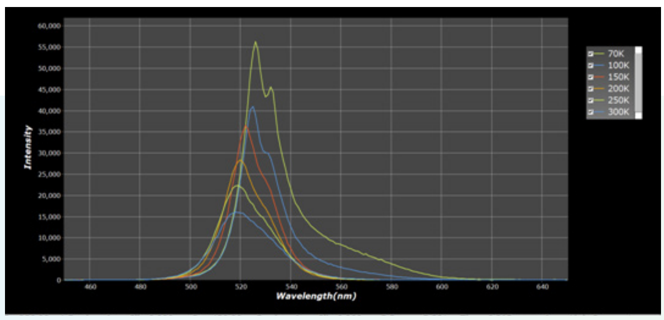
Temperature-dependent steady-state fluorescence:

Excitation wavelength: 360nm,75W xenon lamp

Emission scanning: 450–650nm

Detector: TE-cooled PMT

Data acquisition: Time correlation single-photon counter

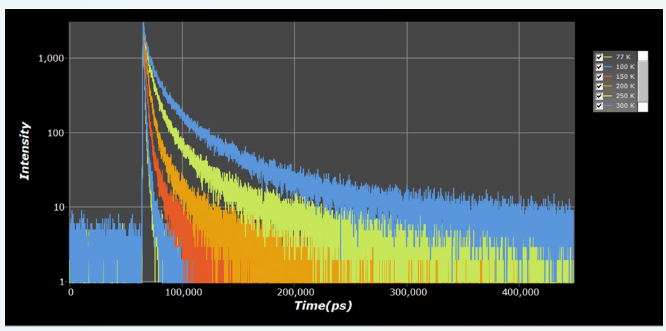


Temperature-dependent fluorescence lifetime:

Excitation light source: 375nm picosecond pulse laser

Trigger frequency: 1MHz

Emission wavelength: 520nm

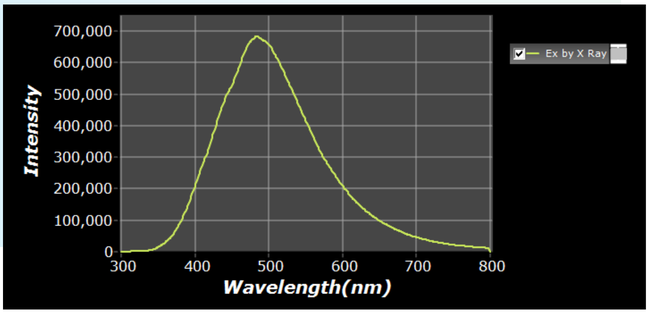


Applications

Spectra of X-ray excited scintillator

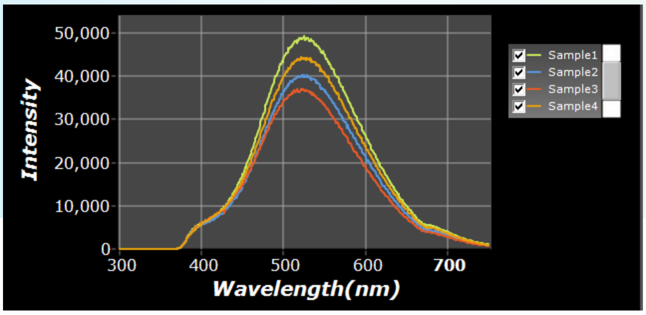
Sample: $Bi_4Ge_3O_{12}$ crystal

X-ray source: tube; voltage: 60KV; tube current: 100uA



Sample: CsI

X-ray source: tube; voltage: 60KV; tube current: 100uA

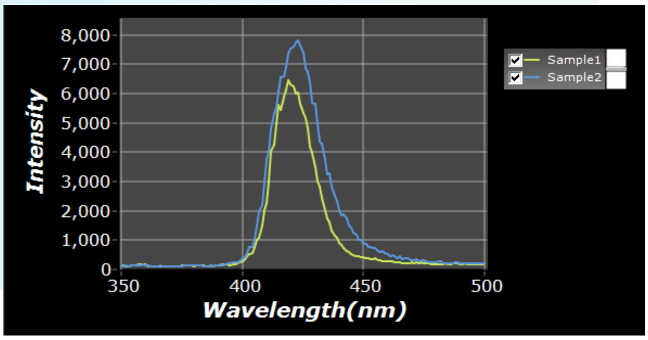


Oxide thin-film scintillator

X-ray source: tube

Tube current: 100uA

Voltage: 60KV

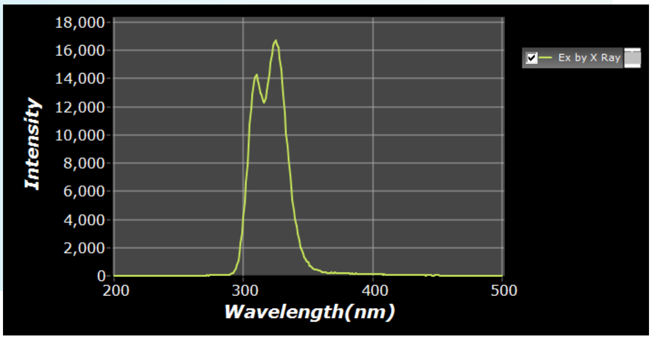


YLF crystal doped with 5% Ce

X-ray source: tube

Tube current: 100uA

Voltage: 60KV



Quantum yield measurement

Sample: rhodamine 6G in ethanol solution

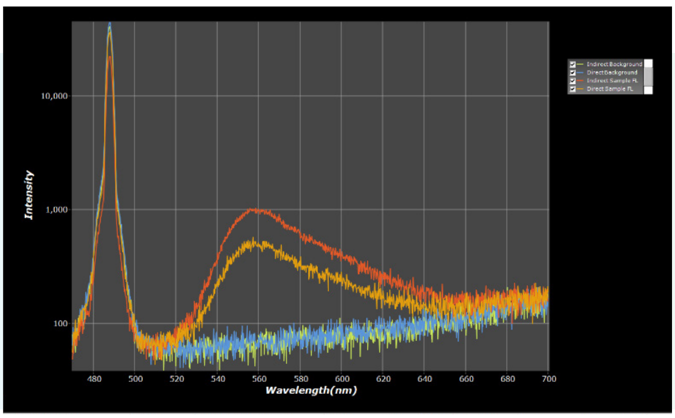
Excitation wavelength: 488nm at 75W xenon lamp

Increment: 0.2nm

Integration time: 100ms

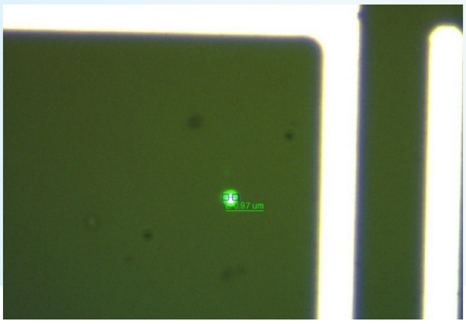
Emission scanning: 470–700nm

Test result: QY = 95%

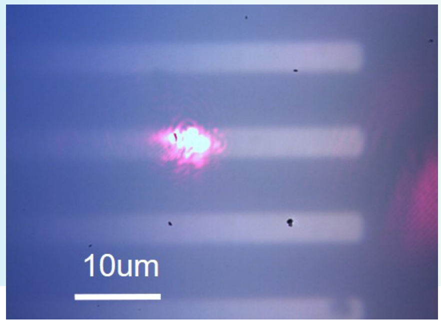


Spectrum and lifetime measured under microscope

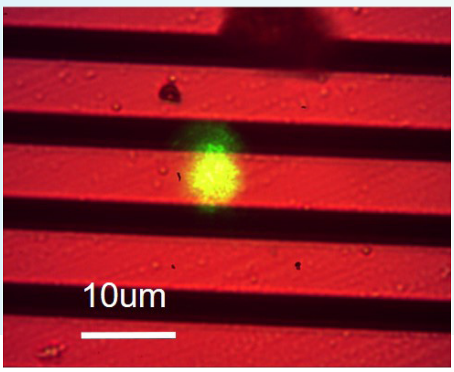
532nm single-mode CW laser coupled with microscope; the laser spot diameter is less than 1μm under a 100× objective lens.



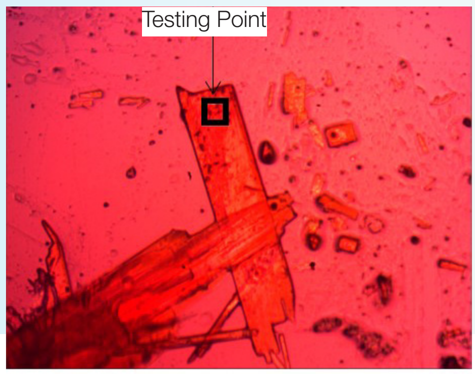
375nm picosecond pulse laser coupled with microscope; the laser spot diameter is less than 5μm under a 100× objective lens.



532nm laser from a superconttinuum laser is selected by a monochromator and used as the excitation on the microscope. the light spot diameter is less than 10μm under 100× objective lens.



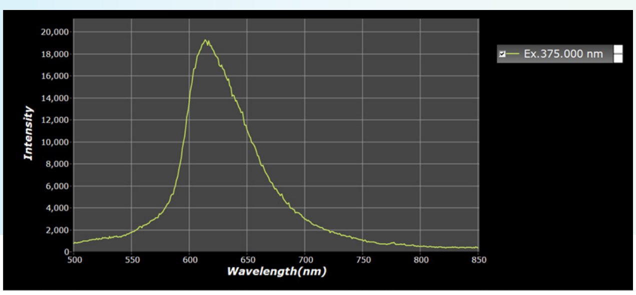
Microscopic image of organic molecular materials, 10× objective lens



Fluorescence spectrum at a selected point

Excitation light source: 375nm picosecond pulse laser

Emission scanning: 500–850nm



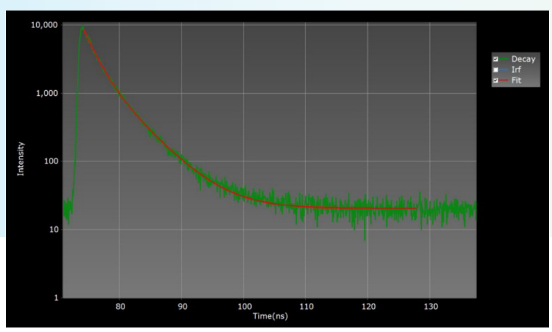
Decay at a selected point

Excitation light source: 375nm picosecond pulse laser

Trigger frequency: 1MHz

Emission wavelength: 615nm

Double exponential fitting : $\tau 1 = 1.76$ns, $\tau 2 = 4.64$ns

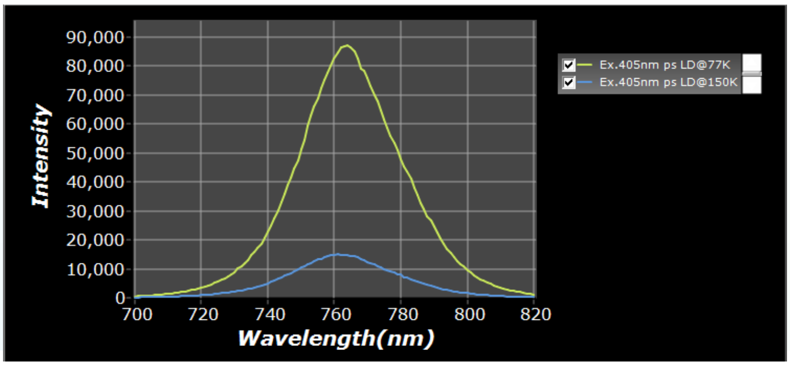


Applications

Microscopic steady-state fluorescence measurement of halide perovskite materials

Excitation light source: 405nm picosecond laser

When the temperature is 77K, the main peak wavelength is 763nm and the intensity value is 86,000; when the temperature is 150K, the main peak wavelength is 761nm and the intensity value is 15,000. From 77K to 150K, the peak is blueshifted by 2nm and the signal decreases.

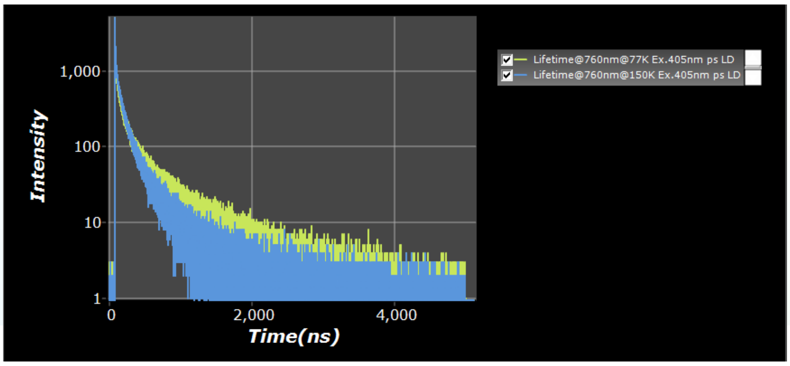


Microscopic TRPL measurement of halide perovskite materials

Excitation light source: 405nm picosecond laser.

The figure shows the 77K and 150K lifetime curve of 760nm emission.

The lifetime becomes shorter when temperature decreases to 150K.



Upgrade Options

Excitation light sources

OPO laser

Tunable wavelength nanosecond pulse laser

Output wavelength range: 200–2400nm,

Pulse duration: 5ns, Repeat frequency: 20Hz

Peak energy: 9mJ at 450nm

Higher-energy version: 70mJ at 450nm

Microsecond pulse xenon lamp

Output wavelength range: 200–800nm,

Pulse duration: 2.9μs

Typical repeat frequency: 60Hz, frequency is adjustable

X-ray tube with protective lead box

Voltage range: 40–70kV

Current range: 10–300μA at 40kV

Maximum power: 12W

Target material: tungsten

Window: beryllium

Usage: excites the scintillator crystal while protecting the 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

supercontinuum 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 than 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: 800–1700nm/2600nm

Cooling temperature: -40℃

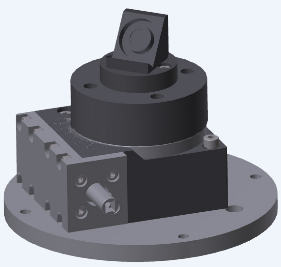
Liquid-nitrogen-cooled InSb detector

Response range: 1000–5500nm

Cooling temperature: 77K.

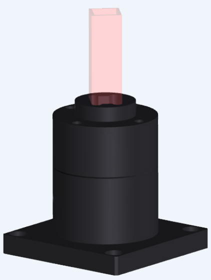
Sample holders

Rotating solid sample holder



Manually rotates the sample stage around an axis with scale,0-360° adjustable angle.

Magnetic stirring sample holder



Convenient for measuring the fluorescence of suspended solutions, magnetically provides stirring function.

Water-bath constant-temperature sample holder

Keeps the liquid sample at a constant temperature while measuring. Water flow and temperature are controlled to maintain constant temperature in the sample holder.

Cryostat

65-500K cryostat

Liquid nitrogen cryostat

Temperature can be as low as 65K when using a 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

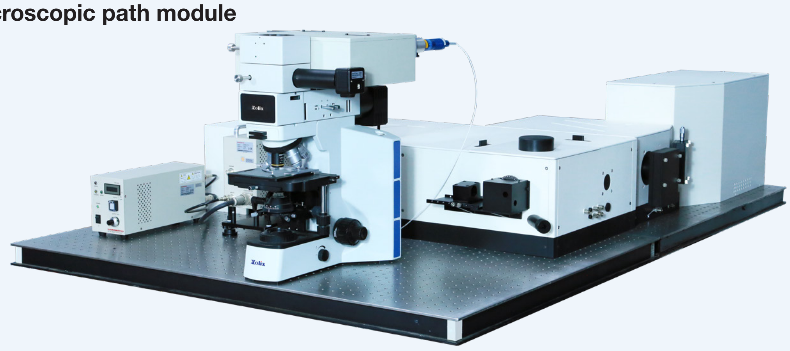
Temperature stability: ±0.1K

Sample environment: vacuum

Cooling technology: closed loop

Microscopic spectrum test platform

Microscopic path module



Either a CW laser or a pulse laser can be coupled with the microscopic path module; the spatial resolution is less than 1μm (depending on the laser wavelength and choice of objective lens).Both the automatic XY stage and the cryostat are optional.

Automatic XY stage

Travel: 76mm×52mm,

Resolution: 0.01μm

3.2–500K microscopic cryostat

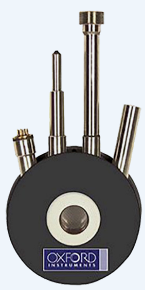
Liquid helium cryostat.

Temperature range: 77.2–300K

Temperature stability: ±0.1K

Sample environment: vacuum/exchange gas

77.2–500K microscopic cryostat

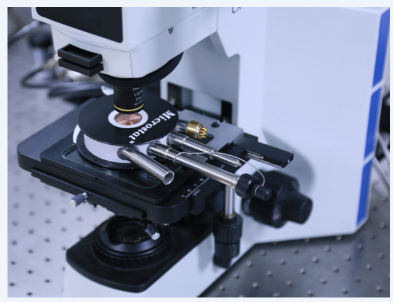


Liquid nitrogen cryostat

Temperature range: 77.2–500K

Temperature stability: ±0.1K

Sample environment: vacuum/exchange gas



The cryostat, here pictured coupled to a microscope.

Quantum yield accessory

Integrating sphere

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

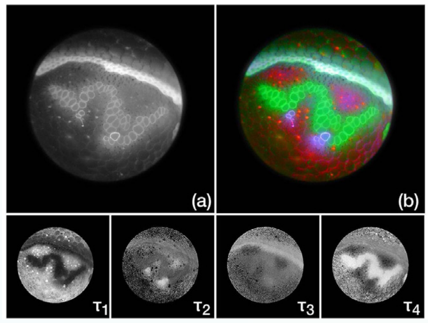
The integrating sphere with temperature control measures the absolute quantum yield at different temperatures.

Upgrade Options

Cameras

Single-photon camera

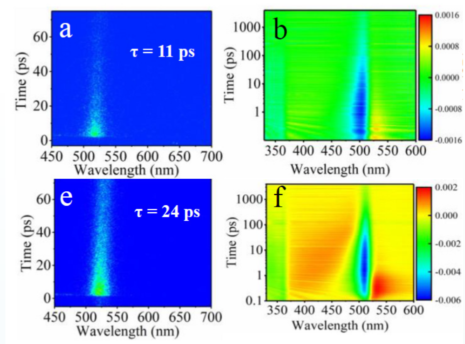
The micro-fluorescence single-photon camera can simultaneously provide temporal and spatial information for lifetime imaging.



Fluorescence lifetime imaging (FLIM) of Convallaria (lily of the valley): (a) Intensity image. Lifetime analysis reveals four components: $\tau 1$=0.19ns, $\tau 2$=0.67ns, $\tau 3$=1.95ns, $\tau 4$=3.75ns. (b) Superposition of intensity image and average life image.

Streak camera

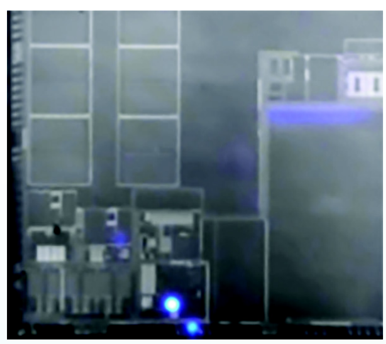
This camera offers UV to NIR spectral response, up to 2ps temporal resolution and 50lp/mm spatial resolution, compatible with two working modes: high-performance synchronous scanning and single, low-frequency scanning.



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

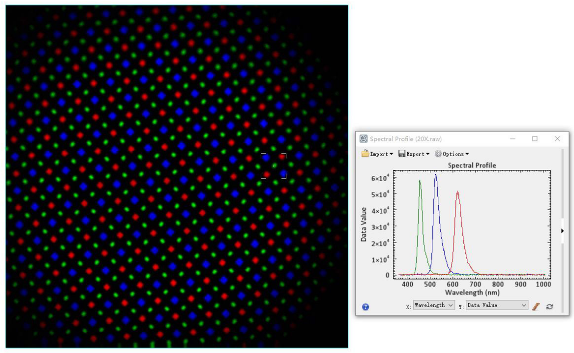
Cooled infrared InGaAs camera, spectral range: 900–1700nm, sensor size: 9.6mm×7.68mm; pixel resolution: 640×512; pixel size: 15μm×15μm.



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

Hyperspectral camera

The hyperspectral camera perfectly combines spectroscopic elements with an area-array camera, so it quickly obtains both spectral and image information; it can be used in many fields of scientific research and automated industrial detection.



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

Hyperspectral microscope system

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

Excitation light source: 385nm LED parallelized illumination

Objective lens: 20×

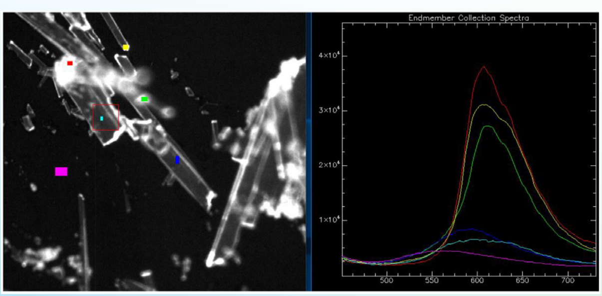
Spectral resolution: 3.5nm

Spectral range: 400–1000nm CCD

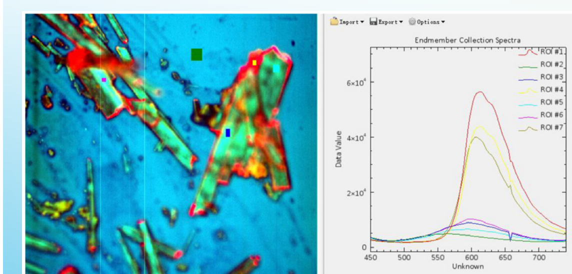
Integration time: 300ms CCD gain: 5×

CCD pixel: 696×256

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

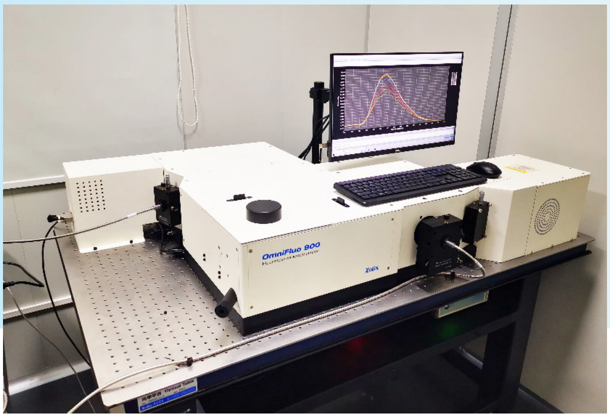


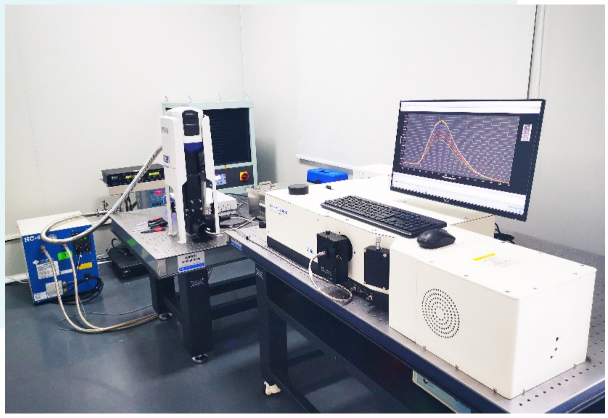
The following figure shows the full spectrum image after IPCA processing.



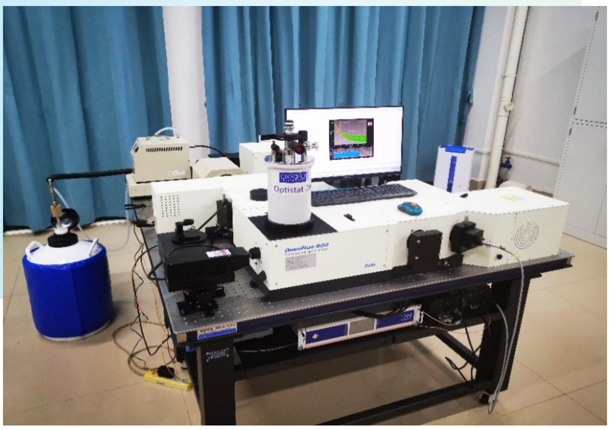
Example systems

OmniFluo960 + X-ray tube with protective lead box + 4k closed-cycle cryostat.

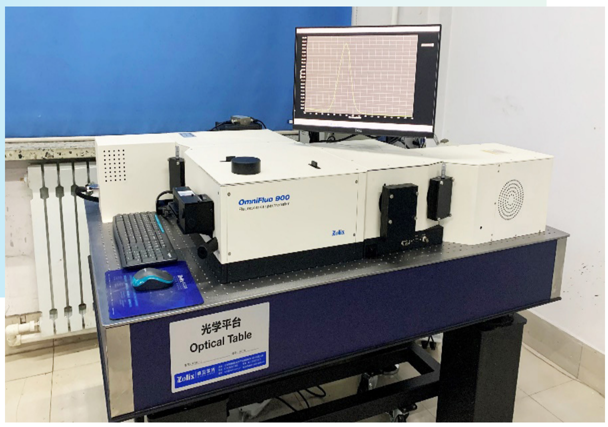




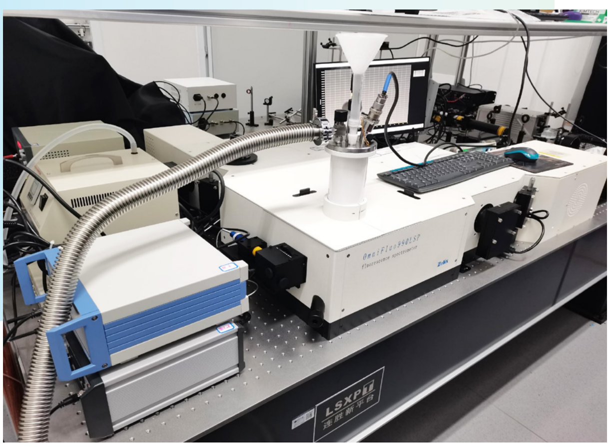
OmniFluo990 + NIRPMT + 77K cryostat + integrating sphere + 266nm Laser + supercontinuum light source + microsecond pulse xenon lamp



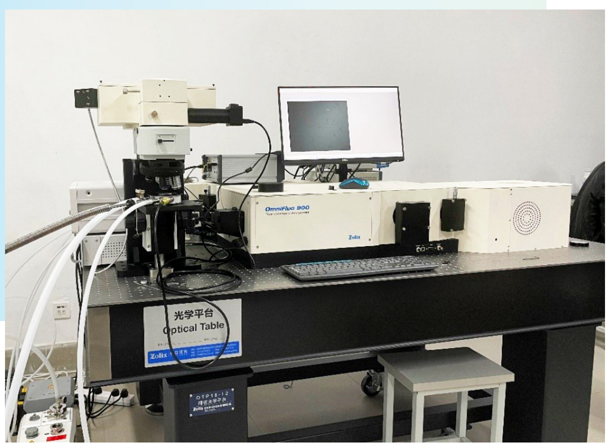
OmniFluo990 + 375nm picosecond pulse laser + 2600nm InGaAs detector



OmniFluo990 + NIRPMT + 65K cryostat + picosecond pulse light source + integrating sphere



OmniFluo990 + 405nm picosecond pulse laser + 77K microscopic cryostat



Specification

System performance	
Spectral range	Emission spectrum: 200–870nm, excitation spectrum: 200–800nm
Spectral resolution	0.08nm@435.84nm
Water Raman SNR①	>10,500:1
Lifetime range	MCS: 10μs-10s, TCSPC: 500ps-ns-μs-2.2s
Extended function	Multiple excitation sources, infrared spectrum test, temperature-dependent spectrum test, microscopic spectrum test, quantum yield measurement
Excitation light Source	
Xenon arc source	Power: 75W, output spectral range: 200nm-1800nm, lamp cup design, coupling efficiency better than 90%
Pulse light source	Microsecond pulse xenon flashlamp, 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
Specification②	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 at 300nm blaze wavelength, 600g/mm at 500nm blaze wavelength Emission grating: 1200g/mm at 500nm blaze wavelength, 600g/mm at 750nm blaze wavelength, 300g/mm at 1250nm blaze wavelength
Sample chamber	
Sample holders	Standard: liquid, powder and film holders; optional: rotating sample holder, magnetic stirring sample holder, water-bath heated sample holder
Detector protection	Automatically blocks 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 analog detectors	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	spectral acquisition modes： excitation scan, emission scan, synchronous scan， 3D scan Lifetime acquisition modes： kinetic scan, lifetime scan, TRES scan Data processing: Quantum yield, TRES slicing, Spectrum calibration Optional function： Anisotropy scan, Temperature dependant scan

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