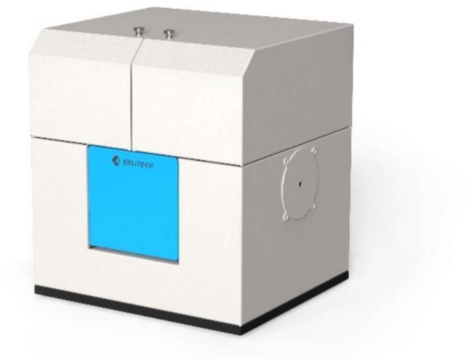
Photoluminescence and Luminescence Quantum Yield Test System: LQ-100X-PL

Introduction

What is PL?

PL (Photoluminescence): When a material absorbs a photon, the electron transitions to an excited state and then returns to a lower energy state, emitting the energy in the form of light.

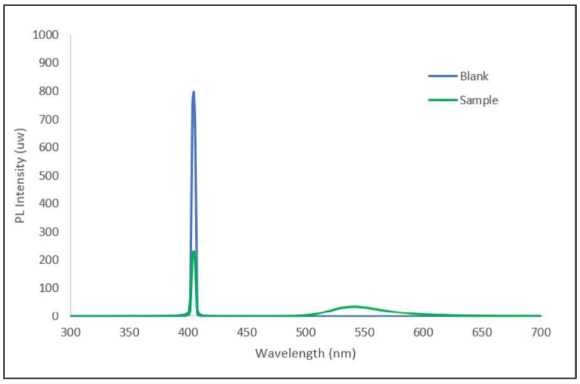


What is PLQY?

PLQY (Photoluminescence Quantum Yield): It is calculated as the number of photons emitted divided by the number of photons absorbed. PLQY is an important index for evaluating luminescent materials. In addition to the basic parameters that can be used for primary classification of materialsit's an important analytical method for luminescent systems and their carrier dynamics.

How LQ-100X-PL measure PLQY?

1. Measure the background signals.
2. Measure the Sample.
3. Calculate the PLQY of the sample:



$$PLQY = \frac{\text{number of photons emitted}}{\text{number of photons absorbed}}$$

PL and PLQY are important tools for material characterization. At present, the challenges in material testing are as follows:

(1) Cannot be tested in the glove box.
(2) In situ time spectral analysis is not applicable.
(3) It is not easy to expand the measuring range to infrared band.

LQ-100X-PL has the following advantages to meet the challenges of material characterization:

- LQ-100X-PL is NIST traceable and with a compact design. The size is 502.4mm(L) x 322.5mm(W) x 352mm(H), equipped a 4-inch outer diameter PTFE integrating sphere. LQ-100X-PL makes the glovebox integration possible.

- Using advanced instrument control programs, in situ time PL spectral analysis can be performed, and produce 2D and 3D graphs simultaneously. This will greatly help users to complete material characterization more quickly.

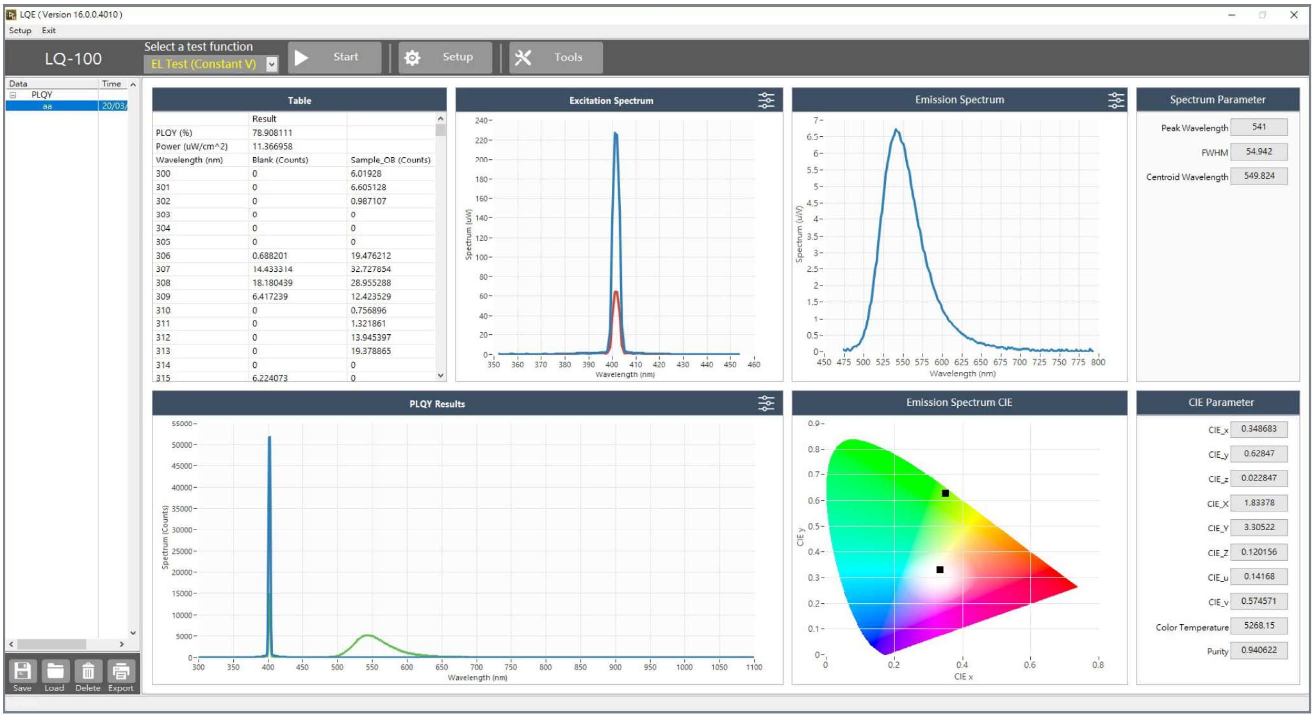
- The outstanding optical design expands the spectrum wavelength. It covers the wavelength range from 1000 nm to 1700 nm. LQ-100X-PL is compatible with powder, solution and thin film samples.

Application

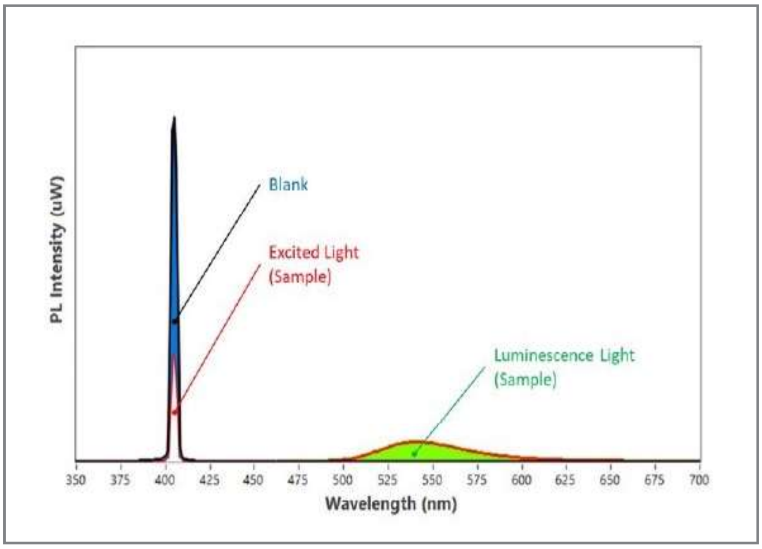
- Phosphor
- LED fluorescent material
- OLED fluorescent material
- Perovskite
- Laser dies
- Perovskite quantum dot powder and single crystal
- PbS quantum dot
- Visible and infrared absorbing dyes

Specification / Product Selection Guide

The standard configuration	–Omnidirectional light receiving system (100 mm integrating sphere) –Enhanced Multi-Channel Spectrometer Test System –Photoluminescence measuring module (365 nm LED excitation light source) –Software –IPC & monitor
Options	–EL spectrum testing module (SMU/PMT module/back-contact sample box/ Multi-channel manual switcher/EL software upgration) –Infrared Spectrum Expansion Module (900 — 1700 nm) –Glovebox integration kit –Excitation light source –LED light source (Wavelength: 385 nm / 405 nm / 430 nm / 470 nm / 532 nm) –Laser light source (Wavelength: 375 nm / 405 nm / 532 nm)



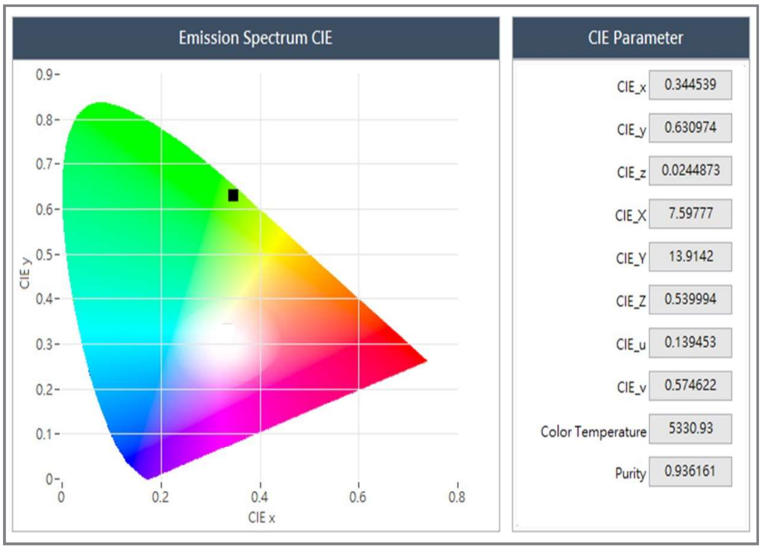
Testing Results / Publications



PL Spectrum

LQ-100X-PL system can perform PL and PLQY tests on a variety of materials. The procedures is are as follows:

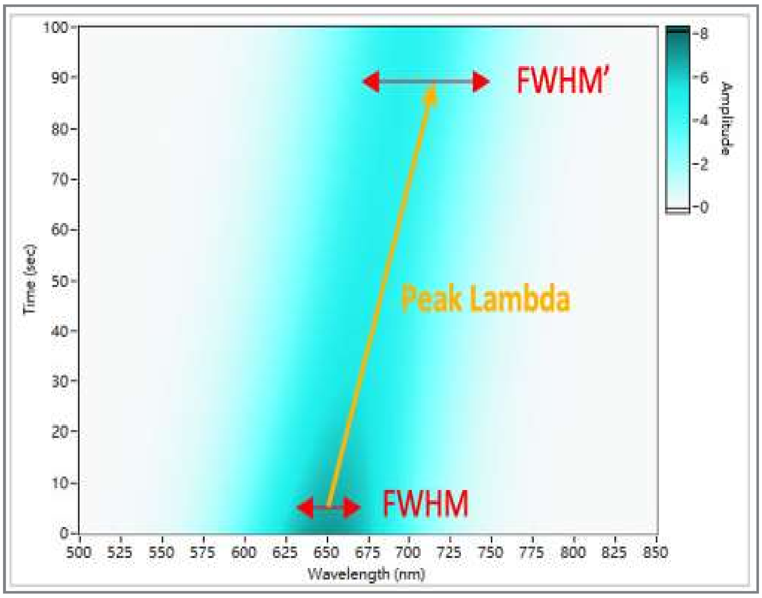
1. Measure the background signal, as shown in the blue curve, and calculate the total number of incident excitation photons.
2. Measure the sample spectrum, as shown in the green curve, and calculate the total number of emitted photons.
3. Calculate the rate of photons absorbed by the sample and the total number of absorbed photons from step 1 & 2.
4. PLQY can be calculated by dividing the number of step 1 & 3.



Emission spectrum

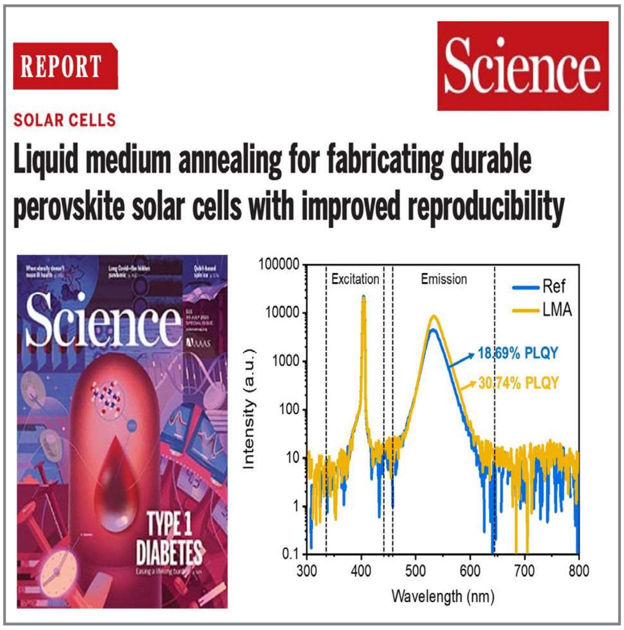
LQ-100X-PL software can perform a variety of analyses for PL emission spectra and help users to quantitatively characterize the properties of materials:

1. Luminous CIE color coordinates
2. CIE-xyz
3. CIE-XYZ
4. CIE-uv
5. Color temperature
6. Color Purity



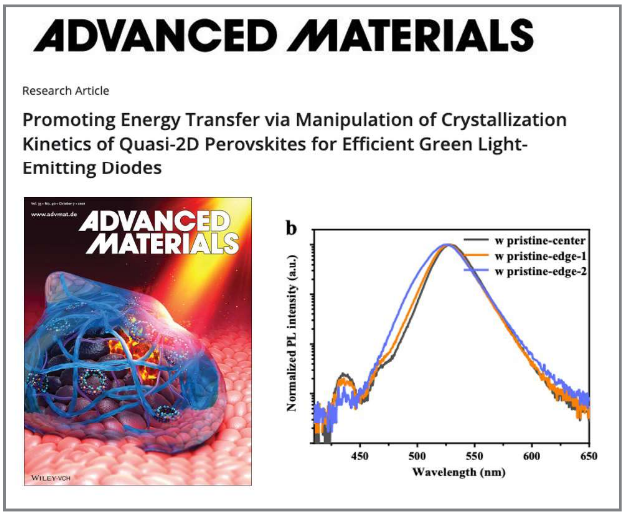
In situ time-resolved PL spectrum

In addition to the PLQY measurement, the LQ-100X-PL can also continuously measure the PL spectrum over time and plot it into a 2D or 3D diagram - called an in-situ time-resolved PL spectrum. As shown in the figure, the PL spectrum of the perovskite changes with time, and the wavelength half-width (FWHM) increases accordingly, and the phenomenon of red shift of the central wavelength (Peak Lambda) occurs. Analysis of in situ time-resolved PL spectra provides direct evidence for the stability or metastable properties of novel materials such as perovskites. It is the best tool for material characterization.



Quality characterization of high-performance perovskite films

Hybrid perovskites have potential in various device applications, but challenges remain in developing high-quality films while simultaneously improving processing reproducibility and scalability. In 2021, Science reported a liquid-medium annealing (LMA) technique that created a robust chemical environment and constant heating field to regulate crystal growth across a thin film. LQ-100 was used to characterize the performance of LMA surface treatment. The PLQY of the LMA-treated film increased from 18.69% to 30.74%. After the photovoltaic device was fabricated, a conversion efficiency of 23.15% was obtained. Using the PLQY function of LQ-100, it is verified that LMA is less dependent on environmental conditions. Moreover, LMA's scalability and high repeatability open up a new effective way to improve the quality of perovskite thin films and photovoltaic devices.



Quasi-2D Perovskite Heterogeneous Structure Characterization

Quasi-2D perovskites have a heterogeneous structure with abundant grain boundaries and interfaces, leading to nonradiative losses during energy transfer. Through the function of PL spectral analysis of LQ-100 system, the crystallization kinetics of quasi-two-dimensional perovskite and the energy transfer process can be realized. This is a valid and new method for optimizing Quasi-2D perovskite LEDs. This result was published in Journal of Advanced Materials (IF=30.849), 2021.