

# ODPL measurement system

C15993-01



**HAMAMATSU**  
PHOTON IS OUR BUSINESS

# Easy and instant measurement of IQE (internal quantum efficiency), which is necessary to evaluate GaN single crystals and perovskite crystals

The ODPL measurement system uses an integrating sphere to measure the spectrum of omnidirectional photoluminescence and determine the emission efficiency of samples. This process is non-destructive and non-contact, and can instantly calculate IQE (internal quantum efficiency). IQE is necessary for quality evaluation of GaN single crystals, which have attracted attention as power device materials. It is also necessary for quality evaluation of perovskite crystals, which are expected to be useful for improving the efficiency of solar power generation and LEDs.

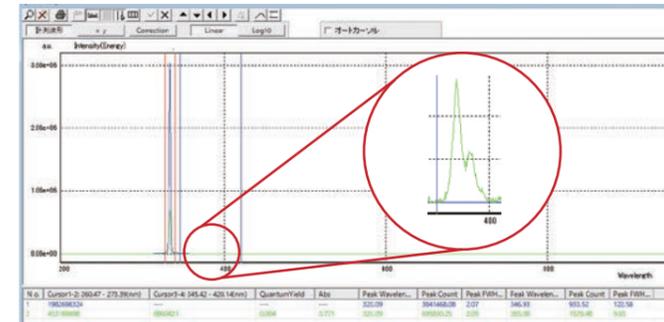
\*ODPL: Omnidirectional photoluminescence

## Measurement / Analysis Items

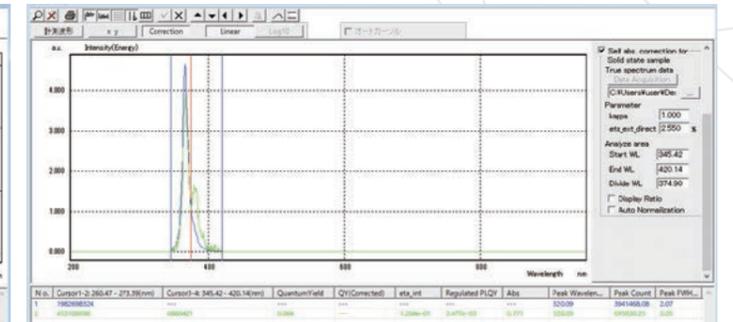
- EQE measurement
- Absorption ratio measurement
- IQE calculation
- PL spectrum measurement



## Measurement example of EQE (Simultaneous measurement of excitation light and light emission)

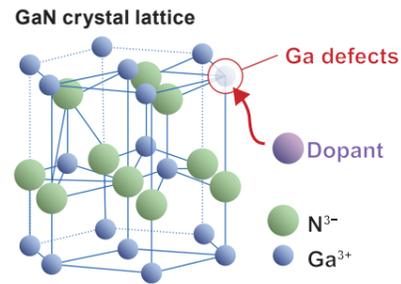


## Calculation example of IQE (Calculated IQE from EQE)



## "IQE" is a parameter for quality evaluation

Semiconductor crystals have the property of emitting light when they are excited by light emitted from outside (photoluminescence). IQE is a parameter that expresses the efficiency of this light emission, and its value changes with great sensitivity due to dislocations, defects, and dopants. Therefore, it is expected that IQE will be used as an indicator of the quality of semiconductor materials.



$$IQE = \frac{\text{Amount of light emission}}{\left( \text{Light emission amount} + \text{Non light emission amount} \right)}$$

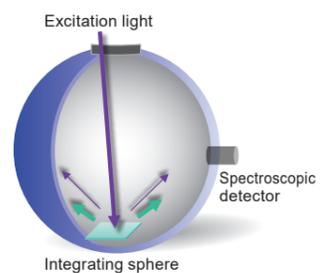
Reflects dislocations, defects, and dopants

## What is ODPL measurement ?

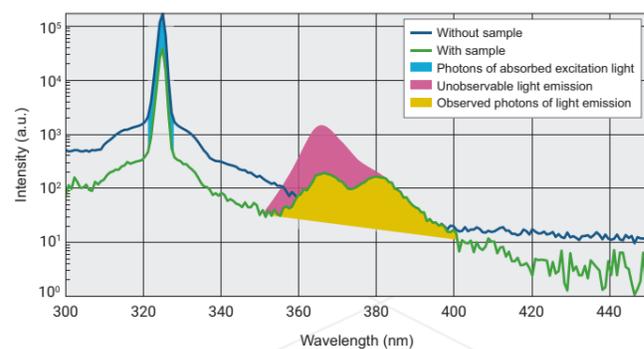
ODPL measurement is a method of photoluminescence measurement using an integrating sphere to obtain the ratio of the number of photons emitted from a sample to the number of photons of excitation light absorbed by the sample. Semiconductor crystals have a wavelength region where photon absorption and emission overlap. Some light emission cannot be observed due to light extraction efficiency and photon recycling in that region. Therefore only EQE (emission external quantum efficiency) can be observed among emitted light. \*Except when IQE is 100 %.

The ODPL measurement system can calculate IQE instantly by combining the measured EQE with analysis taking into consideration the unobservable light.

### Structure of integrating sphere



### ODPL measurement



### Calculation of EQE

$$EQE = \frac{\text{Observed photons of light emission}}{\text{Photons of absorbed excitation light}}$$

### Calculation of IQE

IQE is calculated by analyzing the following information from EQE.

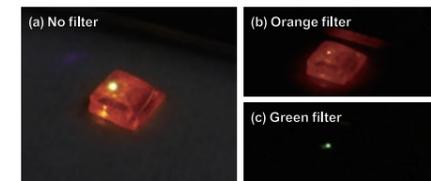
- **Light extraction efficiency**  
Calculates the light emission amount absorbed by the sample
- **Photon Recycling**  
Considers the process by which light emission is absorbed and emitted again in a GaN single crystal

[Ex.] EQE 0.65 % → **IQE 15 %**

## Measurement example of perovskite material

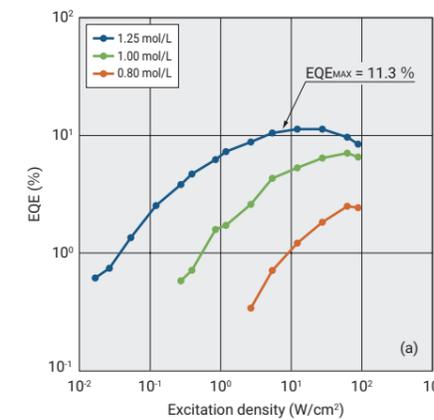
Similar to semiconductor crystals, we have succeeded with perovskite crystals to calculate IQE from ODPL measurement by utilizing the property of these crystals to only make green light emission upwards. As a result of this, IQE reached at least 62.5 %, and we found IQE fluctuates greatly depending on whether methylammonium ions are excessive or deficient.

### Diagram imaging a point-excited crystal that is emitting light

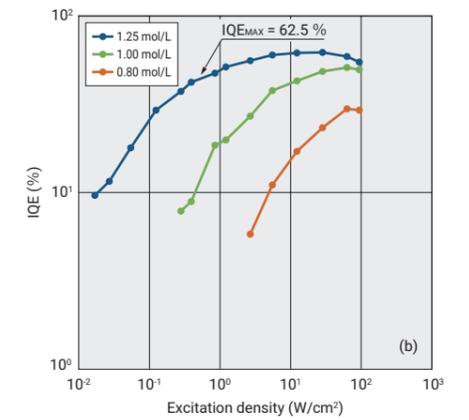


- (a) Without a filter for selecting colors
- (b) With a filter that allows only orange light (of wavelengths that can pass through the crystal) to pass through
- (c) With a filter that allows only green light (of wavelengths absorbed by the crystal) to pass through

### Photoexcitation density / EQE



### Photoexcitation density / IQE



Measurement results from 3 types of bulk MAPbBr<sub>3</sub> crystals, adjusted using different MABr<sub>3</sub> concentrations (MA : CH<sub>3</sub>NH<sub>2</sub>)

### Data provision

Prof. Kazunobu Kojima and Prof. Shigefusa Chichibu, Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Prof. Yasuhiro Yamada and Mr. Kohei Matsumori, Graduate School of Science, Chiba University, Prof. Yoshihiko Kanemitsu, Institute for Chemical Research, Kyoto University.  
K. Kojima, K. Ikemura, K. Matsumori, Y. Yamada, Y. Kanemitsu, and S. F. Chichibu, *APL Materials*, 7, 071116 (2019); licensed under a Creative Commons Attribution (CC BY) license.

| Type no.                        |  | C15993-01  |
|---------------------------------|--|--|
| PL measurement wavelength range |  | 300 nm to 950 nm   |
| Multichannel spectroscope       | Photo-detector                           | BT-CCD linear image sensor   |
|                                 | Measurement wavelength range             | 200 nm to 950 nm   |
|                                 | Wavelength resolution                    | ≤ 2 nm   |
|                                 | Number of photosensitive device channels | 1024 ch  |
|                                 | Device cooling temperature               | -15 °C   |
|                                 | AD resolution                            | 16 bit   |
|                                 | Spectroscope optical arrangement         | Czerny-Turner type   |
| Integrating sphere              | Material                                 | Spectralon   |
|                                 | Size                                     | 3.3 inch   |
| Sample holder                   | Size                                     | Substrate (6 mm × 6 mm × 1 mm to 17 mm × 17 mm × 1 mm)<br>A10095-01 or A10095-03 can be mounted. |
| Epi-illumination part           | Light sources for illumination           | White LED  |
|                                 | Observation camera                       | Color CMOS camera  |
|                                 | Field of view size                       | Approx. φ6 mm  |
| Software                        | Measurement / Analysis items             | EQE measurement  |
|                                 |  | IQE calculation  |
|                                 |  | Absorption ratio measurement   |
|                                 |  | PL spectrum measurement  |
| Dimensions / weight             |  | 725 mm(W) × 417 mm(H) × 380 mm(D) / Approx. 39.5 kg  |

\*Excitation laser is not included in C15993. Please contact us for details.

## Options

### ■ Sample Stand

- **Sample stand (3 pieces) A10095-10**  
This optional item required for measurement. Not included with the main unit (C15993-01).

### ■ Sample Case

- **Laboratory dish with caps (5 pieces) A10095-03**
- **Laboratory dish without caps (5 pieces) A10095-01**  
A set of five laboratory dishes used for quantum efficiency measurements of solid samples (powder/thin film). When measuring powders, always use the A10095-03 to avoid contamination of the integrating sphere. Not included with the main unit (C15993-01).
- **Tweezers for A10095-03 A13712**  
Tweezers for grasping petri dishes.

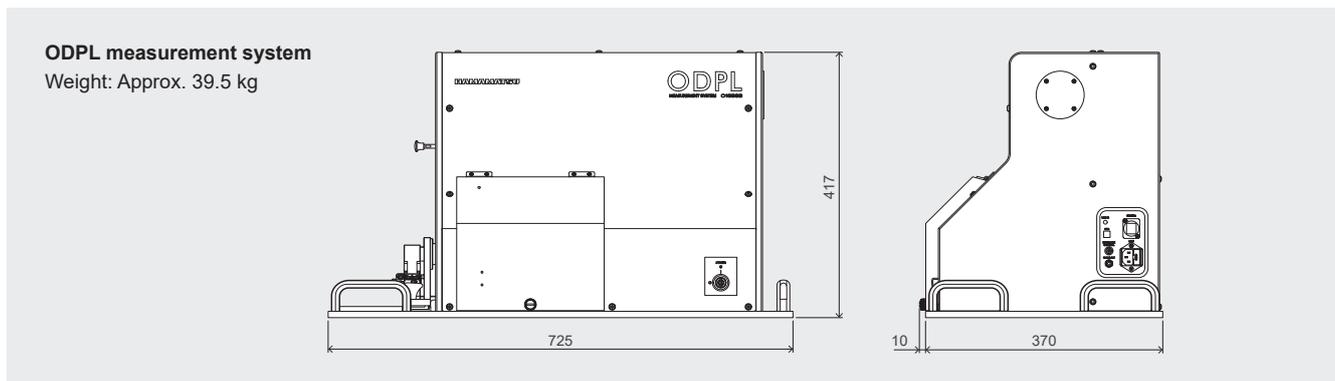
### ■ Excitation laser connection optics

- **Fiber input optics A16773-01**  
An optical system for connecting an optical fiber to C15993-01 (Compatible with FC and SMA types). Excitation laser with fiber output is not included.
- **Laser mount for UV laser A16656-01**  
A laser mount compatible with CNI's UV-FN-320 (excitation laser) and TC-02-FS (heat sink). Excitation laser and heat sink are not included.

### ■ Measurement filters

- **Measurement filter for light attenuation A16454-01**  
A set of NF filters (10 %, 2 %, 1 %) used for measuring EQE with high excitation power. Calibration data is included.

## Dimensional outlines (Unit: mm)



- The product and software package names noted in this brochure are trademarks or registered trademarks of their respective manufacturers.
- Subject to local technical requirements and regulations, availability of products included in this brochure may vary. Please consult your local sales representative.
- The product described in this brochure is designed to meet the written specifications, when used strictly in accordance with all instructions.
- The university, institute, or company name of the researchers, whose measurement data is published in this brochure, is subject to change.
- The measurement examples in this brochure are not guaranteed.
- Specifications and external appearance are subject to change without notice.

© 2023 Hamamatsu Photonics K.K.

## HAMAMATSU PHOTONICS K.K. [www.hamamatsu.com](http://www.hamamatsu.com)

### Systems Division

812 Joko-cho, Higashi-ku, Hamamatsu City, 431-3196, Japan, Telephone: (81)53-431-0124, Fax: (81)53-433-8031, E-mail: [export@sys.hpk.co.jp](mailto:export@sys.hpk.co.jp)

U.S.A.: HAMAMATSU CORPORATION: 360 Foothill Road, Bridgewater, NJ 08807, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218

Germany: HAMAMATSU PHOTONICS DEUTSCHLAND GMBH: Arzbergerstr. 10, 82211 Herrsching am Ammersee, Germany, Telephone: (49)8152-375-0, Fax: (49)8152-265-8 E-mail: [info@hamamatsu.de](mailto:info@hamamatsu.de)

France: HAMAMATSU PHOTONICS FRANCE S.A.R.L.: 19 Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10 E-mail: [infos@hamamatsu.fr](mailto:infos@hamamatsu.fr)

United Kingdom: HAMAMATSU PHOTONICS UK LIMITED: 2 Howard Court, 10 Tewin Road, Welwyn Garden City, Hertfordshire, AL7 1BW, UK, Telephone: (44)1707-294888, Fax: (44)1707-325777 E-mail: [info@hamamatsu.co.uk](mailto:info@hamamatsu.co.uk)

North Europe: HAMAMATSU PHOTONICS NORDEN AB: Torshamnsgatan 35 16440 Kista, Sweden, Telephone: (46)8-509 031 00, Fax: (46)8-509 031 01 E-mail: [info@hamamatsu.se](mailto:info@hamamatsu.se)

Italy: HAMAMATSU PHOTONICS ITALIA S.R.L.: Strada della Moia, 1 int. 6, 20044 Arese (Milano), Italy, Telephone: (39)02-93 58 17 33, Fax: (39)02-93 58 17 41 E-mail: [info@hamamatsu.it](mailto:info@hamamatsu.it)

China: HAMAMATSU PHOTONICS (CHINA) CO., LTD.: 1201 Tower B, Jiaming Center, 27 Dongsanhuan Beilu, Chaoyang District, 100020 Beijing, P.R. China, Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866 E-mail: [hpc@hamamatsu.com.cn](mailto:hpc@hamamatsu.com.cn)

Taiwan: HAMAMATSU PHOTONICS TAIWAN CO., LTD.: 13F-1, No.101, Section 2, Gongdao 5th Road, East Dist., Hsinchu City, 300046, Taiwan(R.O.C.), Telephone: (886)3-659-0080, Fax: (886)3-659-0081 E-mail: [info@hamamatsu.com.tw](mailto:info@hamamatsu.com.tw)

Cat. No. SDSS0018E02  
SEP/2023 HPK  
Created in Japan