First Development of the Standard LED Covering the Full Visible Light

– Toward evaluating next-generation lighting with higher accuracy –

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■Points■

- A standard LED has been developed to overcome the previously difficult characteristic of having sufficient light intensity over the full visible light.
- It was achieved using LED dies of multiple colors in combination with multiple fluorescent substances.
- It is expected to contribute to high-accuracy evaluation of LED and OLED lighting performance and improvement in their performance.

■Summary■

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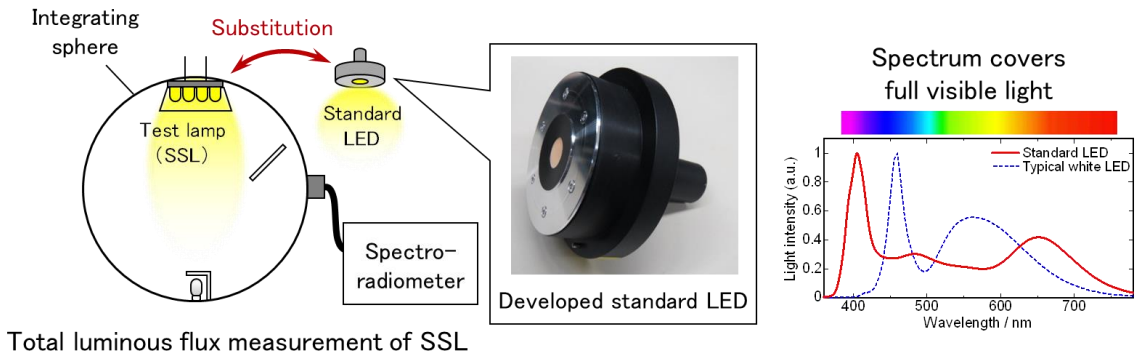
LED and OLED lighting, which is generally called solid-state lighting (SSL), is becoming more common as the next generation lighting. Evaluations of total luminous flux (a performance index for lighting) and color are important for SSL, and to evaluate those values, it is indispensable to measure the light intensity of each wavelength accurately based on spectral measurement. For accurate spectral measurement, the light source under test shall be compared to a standard light source as the reference standard. However, there has not been any standard light source covering the full visible light that suitable for high accuracy spectral measurement of SSL.

AIST and Nichia developed a standard LED having sufficient light intensity over the full visible light by introducing multiple LED dies with different central wavelengths in combination with multiple fluorescent substances. By using this standard LED, LED manufacturers and developers will be able to evaluate SSL characteristics more accurately, which is expected to help accelerate product development and enhance performance.

Details of the technology will be presented at the FY2015 National Metrology Institute of Japan research achievement meeting held on February 10, 2016, at AIST Tsukuba (Tsukuba, Ibaraki).



The developed standard LED and usage image

■Social Background of Research■

Lighting accounts for about one-sixth of residential energy consumption. LED and other forms of SSL consume less energy and are increasingly replacing traditional lighting such as incandescent and fluorescent lamps in order to conserve energy. For that reason, lighting manufacturers around the world are competing fiercely to research and develop SSL. Therefore it is important to inform users of correct performance of each product.

Energy efficiency and color are indices of the lighting product performance and are evaluated by a spectrum derived from spectral measurement. SSL, however, has different characteristics from those of traditional lighting. For example, radiation of SSL is emitted to the forward direction only and spectral distributions of SSL are rich in variety. Because of these differences, there have been no standard light sources suitable for spectral measurement of SSL, making it challenging to measure precisely.

Achieving a standard light source suitable for the spectral measurement of SSL necessitated the characteristic of emitting to the forward direction only, as well as that of having sufficient light intensity over the full visible light (380 nm - 780 nm). A white LED is suitable to fulfill the former requirement, but white LEDs developed to date have not been suitable as standard light sources because even the best of them did not have sufficient optical intensity in the short and long wavelength sides of visible range.

■History of Research■

AIST has conducted research and development of total luminous flux standards (as a reference

for lighting measurement) and spectral measurement technology, as well as measurement technology for SSL. Through these efforts, it has cultivated high-accuracy spectral measurement and analysis technologies.

Nichia, as a worldwide LED developer and manufacturer, has developed LEDs of high quality and reliability, but it has also sought measurement and evaluation technologies of higher accuracy.

In order to achieve high-accuracy evaluation of SSL characteristics, AIST and Nichia combined AIST's technology for accurate quantitative measurement and analysis of spectra with Nichia's advanced LED technology to develop a standard LED suitable for the spectral measurement of SSL.

■Details of Research■

Typical white LEDs do not have sufficient light intensity outside the wavelength range of 420 nm - 720 nm (Fig. 1, blue dotted line), and as such they are not suitable as a standard source for spectral measurement over the full visible range. The developed standard LED has improved light intensity over the wavelength range of 380 nm - 430 nm by using multiple LED dies with different central wavelengths. Light intensity of the developed standard LED in the wavelength range longer than 430 nm was improved by combining multiple fluorescent substances emitting blue, green, and red fluorescent light. That expands the spectrum of the standard LED to the wavelength range of 380 nm - 780 nm, thus providing sufficient light intensity over nearly the full visible light (Fig. 1, red line).

Additionally, the diameter of developed standard LED body is 62 mm, and that of the light-emitting part is 12 mm. To keep the temperature of the light-emitting part constant, it also has a temperature control mechanism. This mechanism keeps changes in the standard LED's light intensity relative to ambient temperature within 0.01 %/°C (Fig. 2, left). This is about 20 times as stable as typical white LEDs, whose temperature dependence is about 0.15 %/°C - 0.2 %/°C. Furthermore, although the light intensity of typical white LEDs changes greatly after turning on, the light intensity of the developed standard LED changes minimally after turning on (Fig. 2, right).

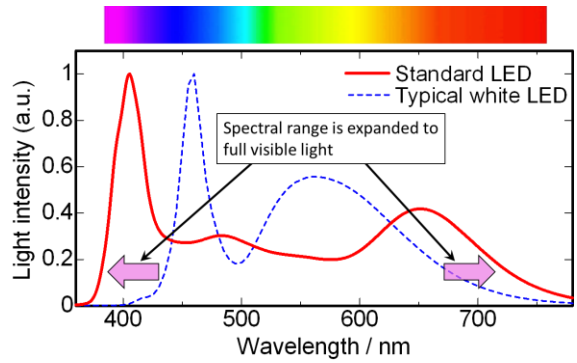


Figure 1: Example spectra of the developed standard LED (red line) and a typical white LED (blue dotted line)

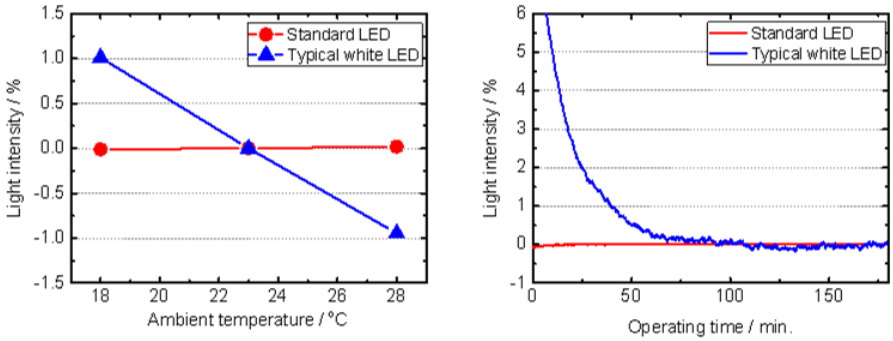


Figure 2: Ambient temperature dependence of light intensity of each LED (left) and changes in optical intensity of each LED against operating time (right)

■Future Plans■

Nichia plans to prepare for mass production of the developed standard LED. AIST aims to further advance the accurate spectrum-measuring technology introduced in the development of the standard LED and will conduct research and development of evaluation technologies for surface emitting light sources and light sources in the ultraviolet and infrared regions.