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Fine ceramics (advanced ceramics, advanced technical ceramics) — Absolute measurement of internal quantum efficiency of phosphors for white light emitting diodes using an integrating sphere

Céramiques fines (céramiques avancées, céramiques techniques avancées) — Mesurage absolu du rendement quantique interne des luminophores des diodes électroluminescentes blanches en utilisant une sphère intégrante

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.

Introduction

White light-emitting diode (LED) based solid-state lighting (SSL) has been widely used for a variety of applications as alternatives for incandescent and fluorescent lamps. In the beginning, white LEDs (comprising blue LEDs and yellow phosphors) became popular as backlight sources for small-size liquid-crystal displays (LCDs) used in mobile phones and digital cameras. These were followed by white LEDs (consisting of blue LEDs combined with green and red phosphors) applied to backlight sources for large-area LCDs. Subsequently, LED lamps have been commercialized for general lighting, replacing conventional luminaires and capitalizing on their advantages, such as compactness, high luminous efficiency, high brightness below 0 °C or higher ambient temperatures, long life, and controllability of light intensity and colour temperature.

The optical performance of a phosphor for use in a white LED is one of the most important factors influencing the performance of the white LED. Accordingly, it is of great importance, not only for researchers and manufacturers of phosphors for use in white LEDs but also for researchers and manufacturers of white LED devices, to evaluate the optical properties of the phosphors in a well-established manner. However, standard measurement methods of studying the optical properties of luminescent powder materials commercially used for white LEDs have never been developed.

Photoluminescence quantum efficiency is one of the key parameters of phosphors for use in white LEDs and has been measured extensively by using an integrating sphere-based absolute method. This method was originally developed to determine the photoluminescence quantum efficiency for fluorophore-doped organic thin films and solutions, and has also been applied to phosphor powders. However, those who measure the quantum efficiency of phosphor materials have frequently noted that the measured quantum efficiency may deviate beyond their tolerance level, depending on the measurement equipment, the geometrical configuration of the integrating sphere and the arrangement of the sample cell, even if the measurement procedure is common in principle. This document provides the absolute measurement method of internal quantum efficiency of phosphors for use in white LEDs with reduced deviation of measured values. In this document, measurement equipment and procedures, which can be the sources of the deviation, are described in detail, helping those who address the high performance phosphors for competitive SSL products to obtain the proper information on their competitiveness.

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1 Scope

This document specifies a method of absolute measurement (using an integrating sphere) of internal quantum efficiency of phosphor powders which are excited by UV or blue light and emit visible light, and which are used for white light-emitting diodes (LEDs).

This document can be adopted for the measurement of phosphors used in non-white LEDs, for example, green, orange, pink or purple LEDs.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CIE S 017/E:2011, *International Lighting Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CIE S 017/E:2011 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
internal quantum efficiency
ratio of the number of photons emitted in free space from the phosphor to the number of excitation light photons absorbed by the phosphor

3.2
cell
container filled with a sample or a white material such as barium sulfate

Note 1 to entry: A cell is typically a flat plate sample holder with a cylindrical hollow, a Petri dish or a rectangular cell used in a spectrophotometer.

3.3
reference cell
cell (3.2) filled with a white powder which has a high spectral diffuse reflectance over the whole visible spectrum (such as barium sulfate or alumina), used when measuring the excitation light spectrum

3.4
white diffuser
white plate which has a high spectral diffuse reflectance over the whole visible spectrum [such as barium sulfate or polytetrafluoroethylene (PTFE)], used when measuring the excitation light spectrum