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Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for optical properties of ceramic phosphors for white light-emitting diodes using an integrating sphere

PROOF

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Contents

Foreword

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

This second edition cancels and replaces the first edition (ISO 20351:2017), which has been technically revised.

The main changes are as follows:

— scope of the document is expanded by additionally implementing the reference material-based substitution measurement method to measure external quantum efficiency and absorptance.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Field Code Changed

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. Initially, 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 were commercialised for general lighting, replacing conventional luminaires and capitalising 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 previous edition of this document (ISO 20351:2017) was developed ~~in accordance with~~based on the ~~demand~~need for standardizing ~~the~~a test method for internal quantum efficiency of phosphors using an integrating sphere. This standard test method has the advantage of a short measurement time and being available to those with no expertise in precise optical measurement. The external quantum efficiency and absorptance ~~are~~were out of the scope of ISO 20351:2017 due to an insufficient understanding of the source of variation in these measurement values.

ISO 23946 was then developed to provide alternative absolute measurement methods for the external quantum efficiency, internal quantum efficiency and absorptance using a gonio-spectrofluorometer. The application of ISO 23946 is assumed to be limited to those who intend to determine the optical properties of phosphor materials to be utilized as reference materials due to its complicated equipment and time-consuming procedure. ISO 13915 was developed following ISO 23946 and provides substitution measurement methods comparing ~~to~~with reference materials with values evaluated in accordance with ISO 23946 to provide external quantum efficiency, internal quantum efficiency and absorptance by using a commercially available fluorescence spectrophotometer.

It was found that the external quantum efficiency and absorptance of a phosphor material under test can also be appropriately obtained using and integrating sphere-based spectrometer with the substitution measurement method as described in ISO 13915, where the measurement using and integrating sphere-based equipment is excluded.

Therefore, the ~~revision of ISO 20351 as the~~revised second edition of this document is intended to expand the scope by additionally implementing the substitution measurement method for obtaining external quantum efficiency and absorptance using an integrating sphere to the existing absolute method to obtain internal quantum efficiency. This expanded scope will benefit those who routinely use ~~the~~ integrating sphere-based equipment.

In this document, measurement conditions and procedures that can affect the measurement values are described in detail, helping those who address high-performance phosphors for competitive SSL products to obtain appropriate information on their competitiveness.

This document can also be adopted for phosphors used in non-white LEDs, e.g. green, orange, pink and purple.

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test ~~methods~~method for optical properties of ceramic phosphors for white light~~-~~-emitting diodes using an integrating sphere

1 Scope

This document specifies test methods for the use of an integrating sphere to measure the optical properties of ceramic phosphor powders, which are used in white light-emitting diodes (LEDs) and emit visible light when excited by UV or blue light. ~~It~~This document specifies an absolute method to measure internal quantum efficiency and a substitution method to measure external quantum efficiency and absorptance. The substitution method uses reference materials whose external quantum efficiency and absorptance have been obtained in accordance with ISO 23946.

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.

ISO 23946, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test methods for optical properties of ceramic phosphors for white light-emitting diodes using a gonio-spectrofluorometer*

CIE S 017/E:2020, *ILV: International Lighting Vocabulary, 2nd edition*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 23946 and CIE S 017/E and the following apply.

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

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

— ~~—~~IEC Electropedia: available at ~~https://www.electropedia.org/~~https://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
external quantum efficiency
ratio of the number of photons emitted in free space from the phosphor to the number of excitation light photons incident on the phosphor

3.3
absorptance
ratio of the number of excitation light photons absorbed by the phosphor to the number of excitation light photons incident on the phosphor

3.4
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.

3.5
reference cell
cell 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

Note 1 to entry: This term is only for use in the absolute method.

3.6
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

Note 1 to entry: This term is only for use in the absolute method.

3.7
secondary absorption
absorption of indirect incident light from every direction of the sphere wall by the phosphor sample

Note 1 to entry: The excitation light illuminating the sample is not entirely absorbed by the sample but is partially scattered or reflected and then repeatedly reflected on the sphere wall. Some of the scattered/reflected light can illuminate the sample again and be absorbed.

3.8
self absorption
absorption of photoluminescent photons emitted by the sample itself

4 Measurement apparatus

4.1 Apparatus configuration

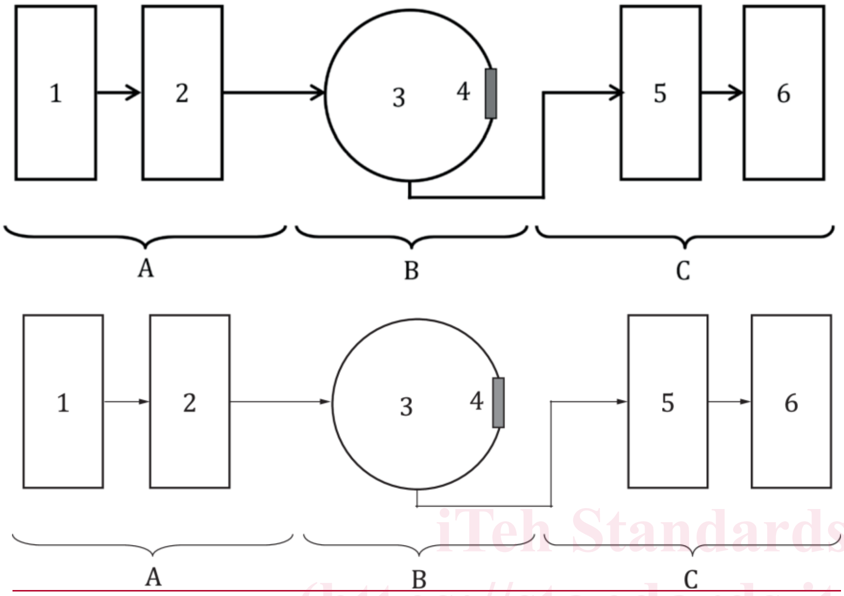
The apparatus includes a light source unit, a sample unit, a detection unit and a signal and data processing unit. ~~Figure 1 and Figure 2~~Figure 1 and Figure 2 illustrate the typical configurations of a measurement apparatus.

The light source unit generates monochromatic excitation light and comprises a white light source, a power supply for the light source, a focusing optical system, a wavelength selection unit (monochromator for the white light source) and an optical system for irradiation. A collimated laser beam can also be used as the monochromatic light source.

The sample unit comprises a cell and an integrating sphere.

The detecting unit comprises directing optics for collecting light, a spectrometer, a detector and an amplifier.

A fluorescence spectrophotometer equipped with a sample unit (including an integrating sphere), and equipment combining a light source unit and an array spectrometer together with the sample unit, are typical examples.

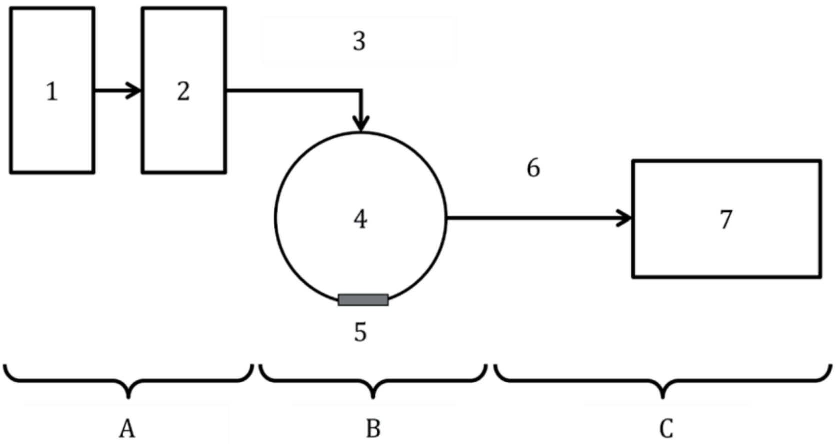


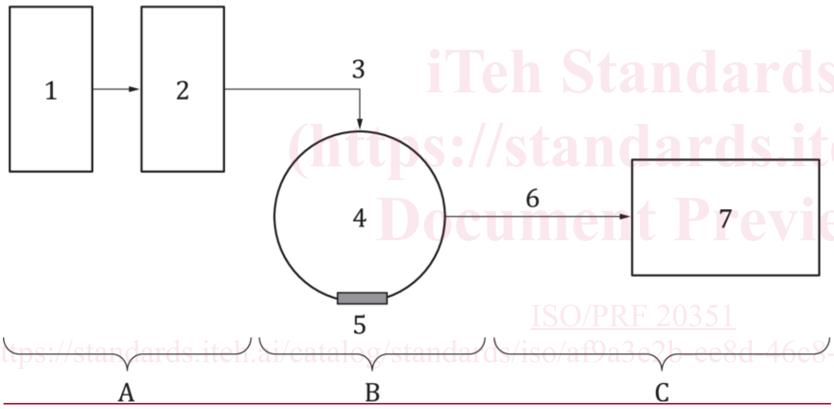
Key

A light source unit
B sample unit
C detecting unit

1 light source
2 excitation monochromator
3 integrating sphere
4 cell (sample)
5 emission monochromator
6 detector

Figure 1 — Example configuration of measuring equipment (fluorescence spectrophotometer type)





Key

A light source unit
B sample unit
C detecting unit

1 light source
2 monochromator
3 optical fibre
4 integrating sphere
5 cell (sample)
6 optical fibre
7 array spectrometer

Figure 2 — Example configuration of measuring equipment (array spectrometer type)

4.2 Light source unit

The spectral width of the excitation light is limited by the monochromator. The half-width of the excitation light spectrum should be 15 nm or less.

The generated excitation light is introduced into the integrating sphere via the excitation light port to illuminate a cell or a white diffuser. It is important to ensure that the beam diameter of the excitation light

