



TECHNICAL SPECIFICATION

**Nanomanufacturing – Material specifications –
Part 4-2: Luminescent nanomaterials – Detail specification for general lighting
and display applications**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 07.030; 07.120

ISBN 978-2-8322-5742-5

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

| | |
|--|----|
| FOREWORD..... | 3 |
| INTRODUCTION..... | 5 |
| 1 Scope..... | 7 |
| 2 Normative references | 7 |
| 3 Terms, definitions and abbreviated terms | 7 |
| 3.1 Terms and definitions..... | 7 |
| 3.2 Abbreviated terms..... | 9 |
| 4 Measurement standards | 10 |
| 5 General requirements | 10 |
| 6 Specifications | 11 |
| 6.1 General procurement | 11 |
| 6.2 Luminescent nanomaterial key control characterization..... | 11 |
| 6.2.1 Physical and chemical key control characteristics | 11 |
| 6.2.2 Optical key control characteristics | 13 |
| 7 An overview of test methods and analysis techniques..... | 13 |
| Bibliography..... | 15 |
| | |
| Table 1 – Format for general information | 11 |
| Table 2 – Physical and chemical key control characteristics..... | 12 |
| Table 3 – Minimum requirements for optical key control characteristics by emission colour | 13 |
| Table 4 – Summary of test methods | 14 |

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**NANOMANUFACTURING –
MATERIAL SPECIFICATIONS –****Part 4-2: Luminescent nanomaterials –
Detail specification for general lighting and display applications**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a Technical Specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62565-4-2 has been prepared by IEC technical committee 113: Nanotechnology for electrotechnical products and systems.

The text of this Technical Specification is based on the following documents:

| | |
|---------------|------------------|
| Enquiry draft | Report on voting |
| 113/361/DTS | 113/417/RVDTS |

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62565 series, published under the general title *Nanomanufacturing – Material specifications*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

Lighting devices and displays are transitioning from incandescent illumination sources based on heated filaments to solid-state lighting (SSL) sources. In devices such as lamps and luminaires used for general illumination, light emitting diodes (LED) form SSL sources that provide light, and a wide variety of lighting colours are commercially available. In display products such as liquid crystal devices, white backlights are used in conjunction with colour filters to provide red, green and blue colours, and these backlights are also increasingly leveraging breakthroughs in LED technologies to increase the colour gamut. There are several key drivers for this change including increased energy efficiency, increased product lifetime, flexibility in colours produced and good colour rendering properties. For example, solid-state lighting (SSL) sources can achieve luminous efficacies that are significantly higher than conventional incandescent lamps. Since approximately 20 % of the world's electricity consumption is attributed to providing illumination, the impact of such a large gain in luminous efficacy provided by changing to SSL technologies is significant. Likewise, SSL backlights consume less energy than other backlight technologies, which is especially important in battery powered portable electronics.

The structures of SSL sources used for general lighting and display backlights often are similar. In a common structure, these devices consist of a blue LED and at least one photoluminescent material to provide one or more additional wavelengths. When energized, some photons emitted by the LEDs are absorbed by the luminescent material and produce secondary photons of different wavelengths through the process of photoluminescence (PL). The light produced by the SSL source is a mixture of the emissions from the blue LED and the photoluminescent material. A variety of luminescent materials can be used in these applications including phosphors and luminescent nanomaterials.

Luminescent nanomaterials are comprised of semiconductor nanocrystals like spherical quantum dots and elongated quantum rods and inorganic nanophosphors. Semiconductor nanocrystals with sizes typically below 10 nm show size-tunable optical properties (size-dependent band gap and hence, size-dependent onset of absorption and spectral position of the emission band or emission colour) and electrochemical properties (size-dependent energetic positions of the valence and conduction band and hence, redox potentials of the charge carriers) due to particle size-dependent quantum confinement effects. Particularly favourable are their broad absorption bands (increasing absorption for all wavelengths shorter than the onset of absorption), their narrow emission bands, (often revealing a symmetric shape), their high photoluminescence quantum yields, and excellent photostability.

Light-emitting phosphors can also be used for lighting and display applications and in some instances phosphors with particle diameters less than 100 nm (i.e. nanoparticles) can be used. Such inorganic materials (also termed nanophosphors) include materials such as YAG:Ce. These nanophosphors are characterized by broad absorption bands, broad emission bands, good photoluminescence quantum efficiency, and a high photostability. The spectral position of the absorption and emission of inorganic nanophosphors is not affected by size, but the scattering properties will have a size dependence. However, the enhanced surface-to-volume ratio with decreasing particle size can favour luminescence quenching at surface defects, thereby affecting the photoluminescence quantum efficiency and PL decay behaviour and rendering both properties size-dependent.

Other nanomaterials like dye-doped or -labelled polymer nanoparticles, inorganic particles or hybrid organic–inorganic nanoparticles are commonly not used for such applications and are beyond the scope of this document.

Generally, luminescent nanomaterials used in lighting and display applications are classified according to excitation spectrum, emission spectrum (including a specific emission wavelength peak and a narrow emission peak shape as measured by the full-width at half maximum (FWHM)), quantum efficiency, chemistry and others. Generally, these properties are achieved in a monodisperse material, with particles of similar sizes (allowing for manufacturing tolerances). Imparting multiple colours to a lighting or display product may involve the use of nanomaterials of multiple sizes, each of which may be specified individually. As a result of the properties of luminescent nanomaterials, lighting and display devices incorporating these materials can have excellent luminous efficacy and extraordinary colour quality.

This document codifies the format for specifying, reporting, and validating the essential properties of luminescent nanomaterials for use in lighting and display products.

NANOMANUFACTURING – MATERIAL SPECIFICATIONS –

Part 4-2: Luminescent nanomaterials – Detail specification for general lighting and display applications

1 Scope

This part of IEC 62565, which is a Technical Specification, specifies the essential general and optical requirements of monodisperse luminescent nanomaterials used in general lighting and display products to enable their reliable mass production and quality control during the manufacturing process. This document does not address mixtures or agglomerations of luminescent nanomaterials.

In addition, this document enables the customer to specify requirements in a standardized manner and to verify through standardized methods that the luminescent nanomaterial meets the required properties.

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.

IEC 62607-3-1, *Nanomanufacturing – Key control characteristics – Part 3-1: Luminescent nanomaterials – Quantum efficiency*

IEC TS 62607-3-2, *Nanomanufacturing – Key control characteristics – Part 3-2: Luminescent nanoparticles – Determination of mass of quantum dot dispersion*