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TECHNICAL REPORT

Semiconductor devices –
Part 5-12: Optoelectronic devices – Light emitting diodes – Test method of LED efficiencies

INTERNATIONAL
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IEC TR 60747-5-12 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices. It is a Technical Report.

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

Draft	Report on voting
47E/741/DTR	47E/748/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 60747 series, published under the general title *Semiconductor devices*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

The latest international standards for light emitting diode (LED) devices are IEC 60747-5-6:2016, IEC 60747-5-8:2019, IEC 60747-5-9:2019, IEC 60747-5-10:2019, and IEC 60747-5-11:2019, where terminology and measuring methods of basic electrical and optical characteristics of LEDs are given.

This technical report gives guidance on the terminology and the measuring methods of various efficiencies of single light emitting diode (LED) chip or package without phosphor. White LEDs for lighting applications are out of the scope of this part of IEC 60747-5-12.

The efficiencies whose measuring methods are described in this technical report are the power efficiency (PE), the external quantum efficiency (EQE), the voltage efficiency (VE), the internal quantum efficiency (IQE), and the light extraction efficiency (LEE). To measure these efficiencies separately, one needs the measurement data of the internal quantum efficiency (IQE).

The IQE is a key performance parameter that represents the quality of epitaxial wafers and contains essential information on operational mechanisms. Requirements for accurate and reliable IQE measurements are suggested. The various IQE measurement methods reported so far are reviewed in detail from a theoretical and practical point of view. Subsequently, the technical limitations for these IQE measurement methods to meet the requirements for accurate and reliable IQE measurements are discussed.

In particular, two different measuring methods of the IQE that can meet the requirements are described in detail both experimentally and theoretically. They are known as the temperature-dependent electroluminescence (TDEL) and the room-temperature reference-point method (RTRM).

A measuring procedure of PE, EQE, VE, IQE, and LEE are demonstrated. But the injection efficiency (IE) and the radiative efficiency (RE) are described for definitions only.

Separate knowledge of various efficiencies of the LED chip or package is able to improve optoelectronic performances of LED chip itself and to design LED application systems such as LED lamps more efficiently and reliably.

SEMICONDUCTOR DEVICES –

Part 5-12: Optoelectronic devices – Light emitting diodes – Test method of LED efficiencies

1 Scope

This technical report discusses the terminology and the measuring methods of optoelectronic efficiencies of single light emitting diode (LED) chip or package without phosphor. White LEDs for lighting applications are out of the scope of this part.

This technical report provides guidance on

- terminology of optoelectronic efficiencies of single LED chip or package without phosphor, such as the power efficiency (PE), the external quantum efficiency (EQE), the voltage efficiency (VE), the light extraction efficiency (LEE), the internal quantum efficiency (IQE), the injection efficiency (IE), and the radiative efficiency (RE) [1][1];
- test methods of optoelectronic efficiencies of the PE, the EQE, the VE, the LEE, and the IQE [1];
- review of various IQE measurement methods reported so far in view of accuracy and practical applicability;
- the measuring method of the LED IQE based on the temperature-dependent electroluminescence (TDEL) [2];
- the measuring method of the LED IQE based on the room-temperature reference-point method (RTRM) [3];
- the measuring method of the radiative and nonradiative currents of an LED [4];
- the relationship between the IQE and the VE, which leads to introduction of a new LED efficiency, the active efficiency (AE) as AE = VE × IQE.

2 Normative reference

The following document is 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 60747-5-6, *Semiconductor devices – Part 5-6: Optoelectronic devices – Light emitting diodes*

[1] Numbers in square brackets refer to the Bibliography.