IEC TS 62607-3-3

Edition 1.0 2020-09

TECHNICAL SPECIFICATION

colour inside

Nanomanufacturing – Key control characteristics – Part 3-3: Luminescent nanomaterials – Determination of fluorescence lifetime of semiconductor quantum dots using time correlated single photon counting (TCSPC)

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 07.030, ICS 07.120

ISBN 978-2-8322-8881-8

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

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 3
INTRODUCTION 5
1 Scope 6
2 Normative references 6
3 Terms, definitions, and abbreviated terms 6
3.1 Terms and definitions 6
3.2 Abbreviated terms 7
4 Test principle 7
5 Sample preparation 8
6 Measurement 8
6.1 TCSPC fluorescence spectrometer 8
6.2 Measurement procedure 8
6.2.1 Instrument preparation 8
6.2.2 Fluorescence lifetime decay curve measurement 9
6.2.3 IRF measurement 10
6.2.4 Data analysis 10
7 Test reports 10
8 Uncertainty source 10
Annex A (informative) Case study for determining fluorescence lifetime of semiconductor quantum dots 11
A.1 General 11
A.2 QDs sample 11
A.3 Instruments 11
A.4 Measurement conditions for TCSPC 11
A.5 Procedures for measurement 11
A.5.1 Instrument preparation 11
A.5.2 Fluorescence lifetime decay curve measurement 11
A.5.3 IRF measurement 12
A.6 Results of fluorescence lifetime decay curve 12
A.7 Data analysis 13
Annex B (informative) Typical laser input excitation sources used in TCSPC 14
Bibliography 15

Figure 1 – The schematic of start-stop times in time-resolved fluorescence measurement with TCSPC 7
Figure 2 – The working schematic of TCSPC fluorescence spectrometer 8
Figure 3 – Examples for typical single exponential decay curves obtained in different measurement ranges 9
Figure A.1 – Typical fluorescence lifetime decay curve 12
Figure A.2 – Fitting result curve and IRF curve 13

Table B.1 – Typical laser input excitation sources used in TCSPC 14
Table B.2 – Fluorescence lifetime of commonly used semiconductor QDs 14

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 3-3: Luminescent nanomaterials – Determination of fluorescence lifetime of semiconductor quantum dots using time correlated single photon counting (TCSPC)

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 62607-3-3, which is a Technical Specification, has been prepared by IEC technical committee 113: Nanotechnology standardization for electrotechnical products and systems.

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

Enquiry draft	Report on voting
113/490/DTS	113/529/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 62607 series, published under the general title *Nanomanufacturing – Key control characteristics*, 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 "http://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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Fluorescence lifetime is considered as the average time that luminescent materials spend in the excited state before emitting a photon and returning to the ground state. Fluorescence lifetime can vary widely from picoseconds to hundreds of nanoseconds, even to microseconds or milliseconds, depending on the type of luminescent nanomaterials.

Fluorescence lifetime is an important property of luminescent materials. Fluorescence lifetime does not depend on fluorophore concentration, absorption by the sample, thickness of the sample, method of measurement, fluorescence intensity, photo-bleaching, and/or excitation intensity. It is affected by external factors, such as temperature, polarity of solvent, and the presence of fluorescence quenchers. Fluorescence lifetime is sensitive to internal factors that are dependent on fluorophore structure.

The possible applications of measuring fluorescence lifetime include the following:

a) determine the environment that the sample molecules inhabit, e.g. viscosity, pH value, temperature, polarity, and solvation, etc.;

b) uncover the size and shape of the sample molecules, and the distances between different parts of the molecules;

c) learn about the contributions of each component in a mixture of sample molecules, through time-resolved spectra of overlapping emissions;

d) reveal the molecular interactions;

e) obtain the kinetic and dynamic rates.

Time-correlated single photon counting (TCSPC) is a widely used, sensitive, reproducible and precise technique to measure the photon arrival time in applications characterized by a strong demand in terms of temporal resolution such as fluorescence lifetime spectroscopy and imaging, photon migration and time of flight measurements.

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 3-3: Luminescent nanomaterials – Determination of fluorescence lifetime of semiconductor quantum dots using time correlated single photon counting (TCSPC)

1 Scope

This part of IEC 62607, which is a Technical Specification, provides a method for determining the fluorescence lifetime of semiconductor quantum dots (QDs) using the time correlated single photon counting (TCSPC) technique. TCSPC is suitable for testing fluorescence lifetime in the range from picoseconds to nanoseconds. This document is only applicable to liquid samples that are stable dispersions of QDs. It is not applicable to solid samples.

This document includes:

– outlines of the experimental procedures,
– data processing, and
– case study.

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 3696, *Water for analytical laboratory use – Specification and test methods*

ISO 385, *Laboratory glassware – Burettes*

ISO 648, *Laboratory glassware – Single-volume pipettes*

ISO 1042, *Laboratory glassware – One-mark volumetric flasks*