PD IEC TS 62607-8-1:2020

BSI Standards Publication

Nanomanufacturing — Key control characteristics

Part 8-1: Nano-enabled metal-oxide interfacial devices — Test method for defect states by thermally stimulated current

Documents
Document Sharing Hub

Full document details: PD IEC TS 62607-8-1:2020

National foreword

This Published Document is the UK implementation of IEC TS 62607-8-1:2020.

The UK participation in its preparation was entrusted to Technical Committee NTI/1, Nanotechnologies.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2020
Published by BSI Standards Limited 2020

ISBN 978 0 539 13558 9

ICS 07.120; 07.030

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 April 2020.

Amendments/corrigenda issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: PD IEC TS 62607-8-1:2020

IEC TS 62607-8-1

Edition 1.0 2020-04

TECHNICAL SPECIFICATION

colour inside

Nanomanufacturing – Key control characteristics – Part 8-1: Nano-enabled metal-oxide interfacial devices – Test method for defect states by thermally stimulated current

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 07.120; 07.030

ISBN 978-2-8322-7978-6

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

® Registered trademark of the International Electrotechnical Commission

Documents
Document Sharing Hub

Full document details: PD IEC TS 62607-8-1:2020

CONTENTS

FOREWORD 4
INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms, definitions, and abbreviated terms 7
3.1 Terms and definitions 7
3.2 Abbreviated terms 8
4 Measurement of TSC 8
4.1 General 8
4.2 Sample preparation 8
4.3 Experimental procedures 8
5 Reporting data 9
6 Data analysis / interpretation of results 9
6.1 General 9
6.2 Peak method [1] 10
6.3 T_{start}–T_{stop} method [2] [3] 10
6.4 Initial rise method [4] 10
Annex A (informative) Case study 11
A.1 TSC measurement of Au/GaAs (reference sample) 11
A.1.1 General 11
A.1.2 Estimating activation energy of defect states by peak method 14
A.2 TSC measurement of Ir/Ta_2O_5 18
A.2.1 General 18
A.2.2 Estimating activation energy of defect states by Peak method 23
Annex B (informative) Possible methods to analyse TSC spectra 26
B.1 Peak method 26
B.2 T_{start}–T_{stop} method 26
B.3 Initial rise method 27
Bibliography 29

Figure 1 – Structure of TSC measurement device 8
Figure 2 – Visualization of TSC measurement sequence 9
Figure A.1 – Photos of (a) the Au electrode configuration on GaAs reference sample, and (b) sample setting 11
Figure A.2 – Structure of TSC measurement device 12
Figure A.3 – TSC data comparison by samples 13
Figure A.4 – TSC data comparison by heating rate 14
Figure A.5 – Determination of TSC peak positions using the second derivative curves 16
Figure A.6 – Arrhenius plots of (a) $\ln(T_m^2/\beta)$ vs. $1/T_m$ and (b) $\ln(T_m^4/\beta)$ vs. $1/T_m$ 17
Figure A.7 – TSC data comparison by samples 19
Figure A.8 – TSC data comparison of Sample A by heating rate 20
Figure A.9 – TSC data comparison of Sample B by heating rate 20
Figure A.10 – TSC data comparison of Sample C by heating rate 21

AVA Documents
Document Sharing Hub
Full document details: PD IEC TS 62607-8-1:2020

Figure A.11 – TSC data comparison by carrier injection method (Samples A, B and C) 22
Figure A.12 – Samples A, B and C: Determination of TSC peak positions using the second derivative curves 23
Figure A.13 – Arrhenius plots for TA1, Sample A 24
Figure B.1 – Peak method 26
Figure B.2 – T_{start}–T_{stop} method 27
Figure B.3 – Determination of trap level energy through initial rise method 28

Table 1 – TSC measurement sequence steps and parameters 9
Table A.1 – TSC measurement sequence steps and parameters / case study 13
Table A.2 – Activation energies of T1 to T6 for y = ln (T_m^2/β) 17
Table A.3 – Activation energies of T1 to T6 for y = ln (T_m^4/β) 17
Table A.4 – TSC measurement sequence steps and parameters / case study (2) 18
Table A.5 – Conditions of Ta_2O_5 sputtering deposition 19
Table A.6 – Activation energies of Samples A, B and C 24

Documents
Document Sharing Hub

Full document details: PD IEC TS 62607-8-1:2020

INTERNATIONAL ELECTROTECHNICAL COMMISSION

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 8-1: Nano-enabled metal-oxide interfacial devices – Test method for defect states by thermally stimulated current

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 62607-8-1, which is a Technical Specification, has been prepared by IEC technical committee 113: Nanotechnology for electrotechnical products and systems.

Documents
Document Sharing Hub

Full document details: PD IEC TS 62607-8-1:2020

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

DTS	Report on voting
113/493/DTS	113/510/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 publication 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 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

- 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.

Documents
Document Sharing Hub

Full document details: PD IEC TS 62607-8-1:2020

INTRODUCTION

Thermally stimulated current (TSC) measurement has been a simple and widely used method to get information about charge trapping and electric polarization phenomena of various materials such as dielectrics, ferroelectrics, semiconductors, ceramics, plastics, and other organic materials for the past several decades. Recently, TSC measurement has been recognized as a versatile tool to evaluate defect states and structures in advanced electronic materials including nano-enabled materials and devices. The defect states in devices such as metal-oxide interfacial devices, C-60 FETs, organic LEDs and emerging photovoltaic cells act as charge carrier traps influencing their performance and reliability. As such, a standardized protocol for TSC measurement will be useful to add validity of the experimental data for the purposes of productization of nano-enabled materials and devices. The reference sample for the reproducible TSC measurement is also required.

This document offers a measurement method to be developed for determining defect states of nano-enabled metal-oxide interfacial devices, which is suitable for evaluating the electronic state even though the resistance of the device changes widely.

Documents
Document Sharing Hub

Full document details: PD IEC TS 62607-8-1:2020

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 8-1: Nano-enabled metal-oxide interfacial devices – Test method for defect states by thermally stimulated current

1 Scope

There are two types of thermally stimulated current (TSC) measurement methods, classified by the origin of the current. One is generated by the detrapping of charges. The other one is generated by depolarization. This part of IEC 62607 focuses on the former method, and specifies the measurement method to be developed for determining defect states of nano-enabled metal-oxide interfacial devices.

This document includes:

– outlines of the experimental procedures used to measure TSC,
– methods of interpretation of results and discussion of data analysis, and
– case studies.

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/TS 80004-1, *Nanotechnologies – Vocabulary – Part 1: Core terms*

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TS 80004-1 and the following apply.

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
device under test
DUT
representative sample device used in testing

[SOURCE: IEC 62876-2-1:2018, 3.1.2, modified – In the definition, the word "sample" has been added.]

Documents
Document Sharing Hub

Full document details: PD IEC TS 62607-8-1:2020

3.1.2
thermally stimulated current
TSC
current flowing through an external circuit connecting to DUT, originated from the electricity trapped at low temperature and released due to raising temperature

3.2 Abbreviated terms

DUT device under test

sccm standard cubic centimetres per minute

TSC thermally stimulated current

GaAs gallium arsenide

Ta_2O_5 ditantalum pentaoxide, tantalum oxide

4 Measurement of TSC

4.1 General

The typical test set-up for measuring TSC is shown in Figure 1.

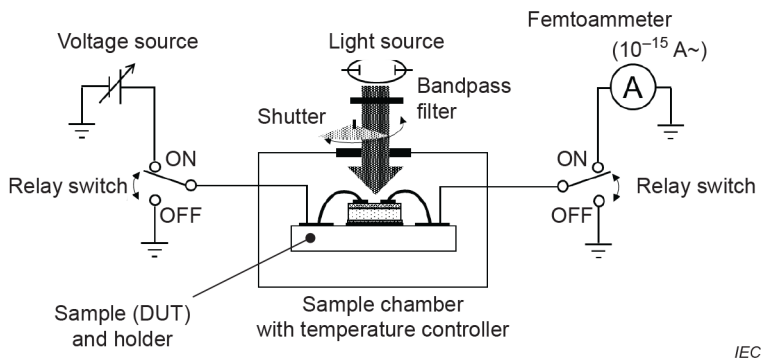

Figure 1 – Structure of TSC measurement device

Temperature dependence of TSC value shall be expressed by plotting TSC (A) on the ordinate against temperature on the abscissa.

4.2 Sample preparation

TSC signal is very sensitive to physical and chemical conditions at the sample/electrode interface. The surface preparation before the electrode formation process should be mentioned in the standardization protocol, as shown in Figure 1 and Table 1.

4.3 Experimental procedures

- Step 1: Conditioning (Pre-treatment conditions) – Restore the sample to a state where all trapped charges are released.
- Step 2: Cooling – Cool the sample to the trapping temperature.
- Step 3: Holding time – Keep the sample at the trapping temperature to stabilize the sample condition.
- Step 4: Trapping – Done by optical injection or voltage injection, or a combination of both.
- Step 5: Measurement – Measure TSC while heating up to the targeted end temperature.
- Step 6: Ending (Post-measurement treatment) – Set back to the room temperature before taking the sample out from the sample chamber.

Documents
Document Sharing Hub
Full document details: PD IEC TS 62607-8-1:2020