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

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Test method for defect states by thermally stimulated current**

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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.

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- withdrawn,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.

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.

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.]

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.

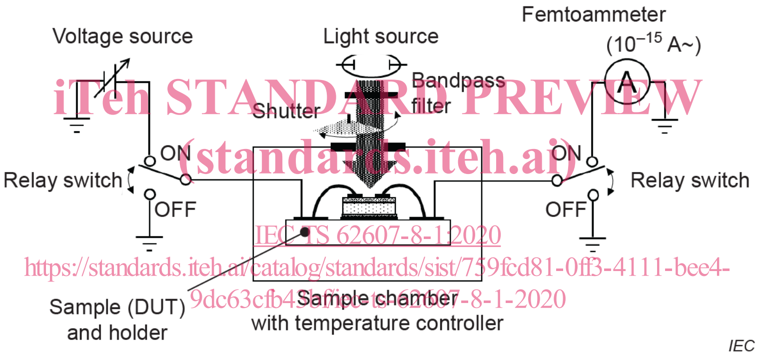

Figure 1 – Structure of TSC measurement device

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.

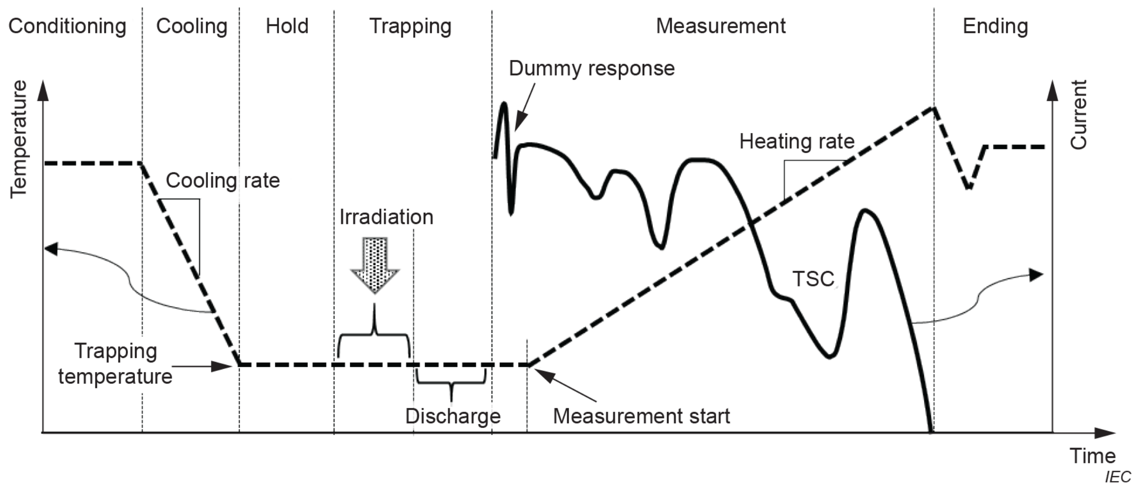

Figure 2 – Visualization of TSC measurement sequence

Table 1 – TSC measurement sequence steps and parameters

Step		Parameter 1	Parameter 2	Parameter 3	Parameter 4
1	Conditioning (Pre-measurement treatment)	Conditioning temperature	Holding time	Releasing voltage	
2	Cooling	Trapping temperature	Cooling rate		
3	Hold	Holding time			
4	Trapping (photoexcitation)	Wavelength (bandpass filter)	Light irradiation time	Holding time	Discharge time
	Trapping (Voltage/Current injection)	Applied voltage	Current	Holding time	Discharge time
5	Measurement	End temperature	Heating rate	Collecting voltage	
6	Ending (Post-measurement treatment)	Target temperature	Heating rate	Holding time	

5 Reporting data

- Measurement parameters shown in Table 1.
- Sample description.
- TSC measurement configuration.
- TSC signal as a function of temperature.

6 Data analysis / interpretation of results

6.1 General

In order to evaluate defect states by using TSC spectra, the temperature dependence is analysed. The possible methods are shown in 6.2, 6.3 and 6.4. The typical example of TSC measurement and the analyses are shown in Annex A. The detailed descriptions of the methods are shown in Annex B.

6.2 Peak method [1][1]

A well-known method to approximate trap energy level, through extracting the slope from an Arrhenius plot.

6.3 T_{start}–T_{stop} method [2] [3]

This method is best effectively used when trap temperature peaks are convoluted and need to be separated (e.g. useful for TSC measurements of organic semiconductors). The method should be applied in the case that the energy distribution is narrow; for example, the single or the deconvoluted TSC peak originated from a single trap level.

NOTE The method is also called fractional TSC measurement or thermal sampling.

6.4 Initial rise method [4]

When considering a small area of the rising slope of a peak in a TSC curve, the approximate trap energy level can be determined from the slope. The method should be applied in the case that the energy distribution is narrow; for example, the single or the deconvoluted TSC peak originated from a single trap level.

NOTE The method is a useful way to apply the TSC method for the quality control, because the data analysis can be performed only by one heating-up step.

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