IEC TS 62607-8-2

Edition 1.0 2021-01

TECHNICAL SPECIFICATION

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Nanomanufacturing – Key control characteristics – Part 8-2: Nano-enabled metal-oxide interfacial devices – Test method for the polarization properties by thermally stimulated depolarization current

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IEC TS 62607-8-2:2021-01(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 07.120; 07.030

ISBN 978-2-8322-9219-8

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CONTENTS

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NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 8-2: Nano-enabled metal-oxide interfacial devices – Test method for the polarization properties by thermally stimulated depolarization current

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- 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 62607-8-2, which is a Technical Specification, has been prepared by IEC technical committee 113: Nanotechnology standardization for electrical and electronic products and systems.

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

Draft TS	Report on voting
113/539/DTS	113/562/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- withdrawn,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.

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INTRODUCTION

Thermally stimulated depolarization current (TSDC) measurement has been a widely used method for acquiring information about electric polarization phenomena of various materials such as dielectrics, ferroelectrics, semiconductors, ceramics, plastics, and other organic materials for the past several decades. Recently, TSDC measurement became recognized as a powerful tool to evaluate polarization and depolarization, relaxation time, charge-storage and activation energy in advanced electronic materials including nano-enabled materials and devices. Accordingly, a standardized protocol for TSDC measurement will be useful to add validity to the experimental data for the purposes of productization of nano-enabled materials and devices. The reference sample for the reproducible TSDC measurement is also important.

This document offers a measurement method to be developed for determining polarization properties of metal-oxide interfacial devices using TSDC.

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NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 8-2: Nano-enabled metal-oxide interfacial devices – Test method for the polarization properties by thermally stimulated depolarization 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. The latter is frequently called thermally stimulated depolarization current (TSDC). This part of IEC 62607 focuses on the latter method, and specifies the measurement procedures to be developed for determining polarization properties of metal-oxide interfacial devices.

This document includes:

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

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2 Normative references

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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
sample on which to evaluate a specific physical property such as electrical resistance or *I-V* behaviour

[SOURCE: IEC 62607-2-1]

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

3.1.3
thermally stimulated depolarization current
TSDC
current flowing through an external circuit connecting to DUT, originated from the release of stored dielectric polarization due to raising temperature

3.2 Abbreviated terms

DUT device under test

TSC thermally stimulated current

TSDC thermally stimulated depolarization current

$SrTiO_3$ strontium titanium trioxide, strontium titanate

4 Measurement of TSDC

4.1 General

4.1.1 Measurement system

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An accurate and reproducible test protocol of TSDC is standardized. Examples of an accurate and reproducible standardized test protocol of TSDC are shown in Figure 1. In the diagrams, each sample is attached to the sample holder with (a) upper and lower electrodes or (b) contact probes. The photos of these sample holders are shown in Figure 2 a) and b), respectively.

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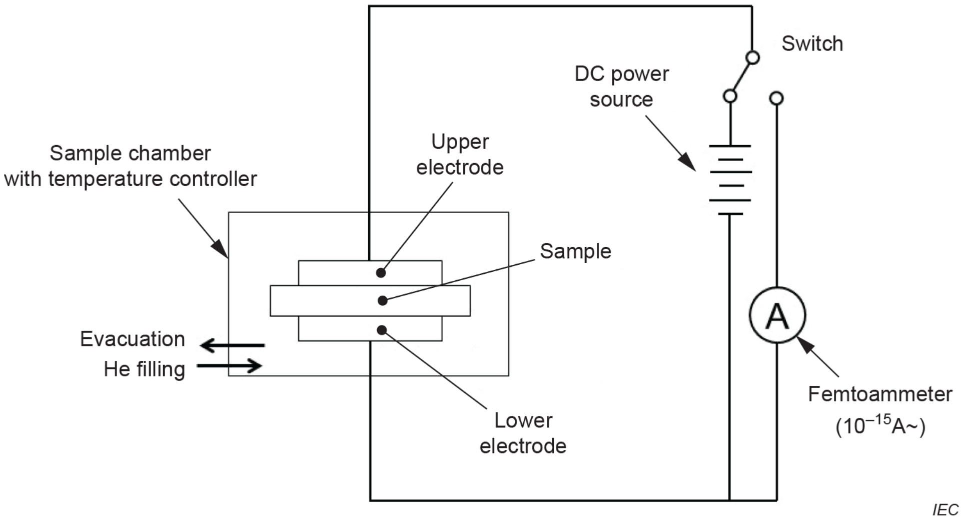
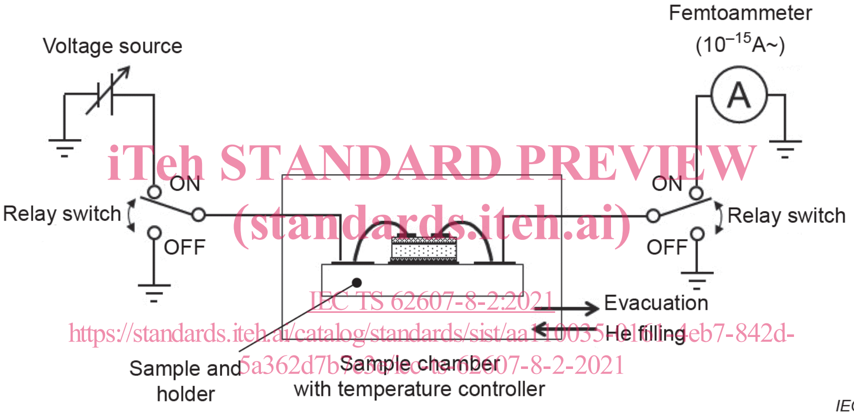


a) **Sample is attached to the sample holder with upper and lower electrodes**



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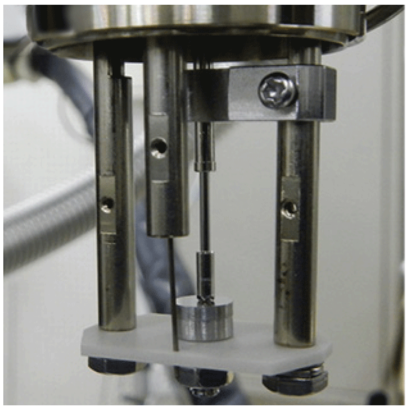
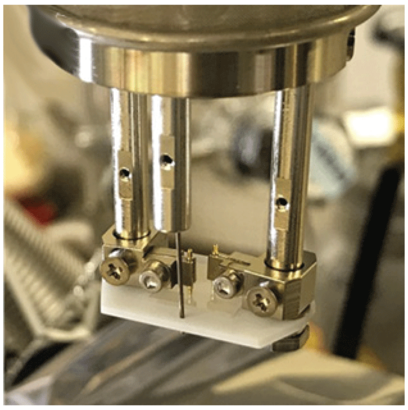
b) **Sample is attached to the sample holder with contact probes**

Figure 1 – Examples of the experimental schematic diagram of TSDC



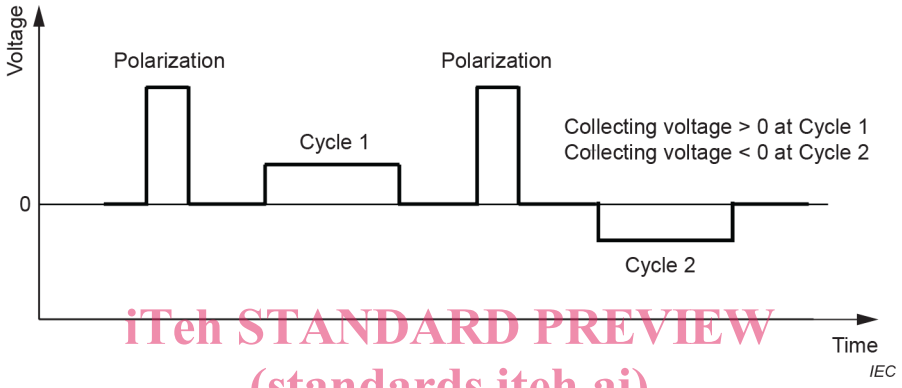


a) **upper and lower electrodes** b) **contact probes**

Figure 2 – Photos of sample holders

4.1.2 TSDC measurement sequence

Examples of temperature control sequence for TSDC measurements are shown in Figure 3 a) In the case that the polarization is produced by the voltage, the sign of the current depends on that of the polarization voltage. On the other hand, the sign of the collecting voltage is considered not to affect the polarity of the polarization current. Therefore, the current of the depolarization process is obtained by subtracting the detrapped current from the observed current as shown in Figure 3 b). When the collecting voltage is applied in Cycles 2 and 4, the background current of the system can be obtained. If difference is evidenced between the currents of Cycles 2 and 4, it is recommended to check the status of the TSDC measurement setup to determine the origin of the background current. Furthermore, because the polarity of the pyroelectric current depends on that of the temperature slope, the difference between currents at Cycles 3 and 4 is assumed to be the pyroelectric current; in case that the pyroelectric current is evidenced, the contribution should be subtracted from the measured current [1].



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Detrapping process: $i_{\text{cycle 1}} - i_{\text{cycle 2}} = 2 \times i_{\text{detrap}}$

Depolarization process: $i_{\text{cycle 1}} = i_{\text{cycle 2}} = 0$

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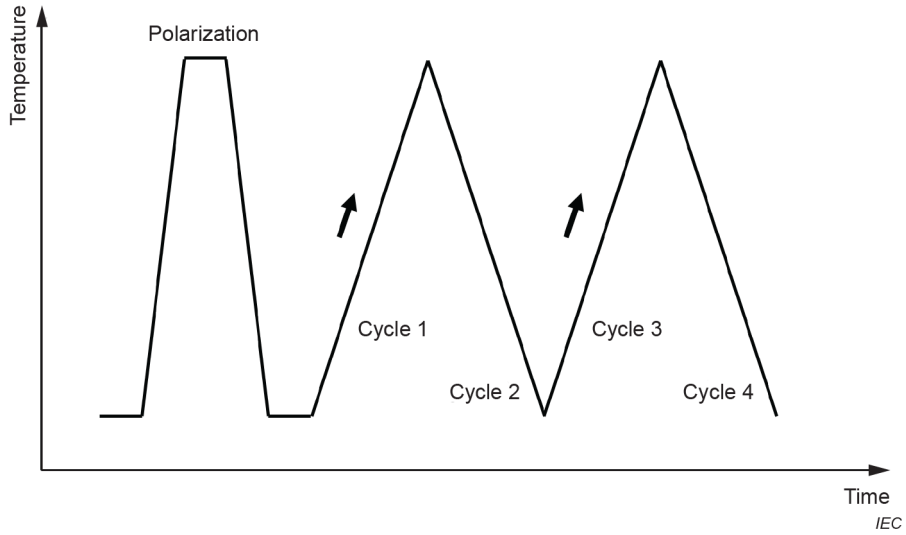
The depolarization current does not depend on the sign of the collecting voltage.

a)



b)

Figure 3 – Visualization of TSDC measurement sequence