

TECHNICAL SPECIFICATION



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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 07.120; 07.030

ISBN 978-2-8322-9219-8

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

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 Measurement of TSDC	7
4.1 General.....	7
4.1.1 Measurement system.....	7
4.1.2 TSDC measurement sequence	9
4.1.3 Expression of temperature dependency of TSDC value.....	10
4.2 Sample preparation.....	10
4.3 Experimental procedures	10
5 Reporting data.....	11
6 Data analysis / interpretation of results.....	11
6.1 General.....	11
6.2 Determination of the polarization charge	11
6.3 Peak method.....	11
Annex A (informative) Case study – TSDC measurement of SrTiO ₃	12
A.1 General.....	12
A.2 Estimating activation energy of polarization state by peak method	14
Annex B (informative) Possible methods to analyse TSDC spectra	16
B.1 Determination of the polarization charge	16
B.2 Peak method.....	16
Bibliography.....	17
Figure 1 – Examples of the experimental schematic diagram of TSDC	8
Figure 2 – Photos of sample holders	8
Figure 3 – Visualization of TSDC measurement sequence	9
Figure A.1 – TSDC data comparison by heating rate.....	13
Figure A.2 – Determination of TSDC peak positions using the second derivative curves	15
Figure A.3 – Arrhenius plot of $\ln(T_m^2/\beta)$ versus $1/T_m$	15
Figure B.1 – Peak method	16
Table 1 – TSDC measurement sequence steps and parameters.....	10
Table A.1 – TSDC measurement sequence steps and parameters / case study.....	13
Table A.2 – Activation energies in the first heating for $y = \ln(T_m^2/\beta)$	15

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**NANOMANUFACTURING –
KEY CONTROL CHARACTERISTICS –****Part 8-2: Nano-enabled metal-oxide interfacial devices – Test method for
the polarization properties by thermally stimulated depolarization 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 62607-8-2, 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.

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 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.

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.

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*