

INTERNATIONAL STANDARD



**Semiconductor devices – Flexible and stretchable semiconductor devices –
Part 9: Performance testing methods of one transistor and one resistor (1T1R)
resistive memory cells**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.080.99

ISBN 978-2-8322-6222-1

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

CONTENTS

FOREWORD	3
1 Scope	5
2 Normative references	5
3 Terms and definitions	5
4 Device under testing (DUT)	7
5 Test method	8
5.1 General.....	8
5.2 Test equipment and tools	8
5.2.1 General	8
5.2.2 Read	9
5.2.3 Forming	10
5.2.4 SET programming.....	11
5.2.5 RESET programming	12
5.2.6 Endurance	14
5.2.7 Retention	16
5.3 Test report	17
Bibliography.....	18
Figure 1 – 1T1R resistive memory cell	8
Figure 2 – Block diagram of the measurement setup of 1T1R resistive memory cells	9
Figure 3 – Read operation of 1T1R resistive memory cell	9
Figure 4 – Cumulative probability distribution of HRS and LRS of 1T1R resistive memory cells	10
Figure 5 – Forming operation of 1T1R resistive memory cell	11
Figure 6 – Simulation test flow chart of the forming process.....	11
Figure 7 – SET operation of 1T1R resistive memory cell	12
Figure 8 – Simulation test flow chart of the SET operation of 1T1R resistive memory cell	12
Figure 9 – RESET operation of 1T1R resistive memory cell	13
Figure 10 – Simulation test flow chart of the RESET operation of 1T1R resistive memory cell	13
Figure 11 – Cumulative resistance distribution of 1T1R resistive memory	14
Figure 12 – Simulation test flow chart of the endurance test of 1T1R resistive memory cell	15
Figure 13 – Exemplary endurance data of a 1T1R resistive memory cell.....	15
Figure 14 – Simulation test flow chart of retention property of 1T1R resistive memory cells	16
Figure 15 – Exemplary retention characteristics of 1T1R resistive memory cells	16

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SEMICONDUCTOR DEVICES – FLEXIBLE AND
STRETCHABLE SEMICONDUCTOR DEVICES –****Part 9: Performance testing methods of one transistor
and one resistor (1T1R) resistive memory cells**

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.

IEC 62951-9 has been prepared by IEC technical committee 47: Semiconductor devices. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
47/2781/FDIS	47/2791/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 62951 series, published under the general title *Semiconductor devices – Flexible and stretchable semiconductor devices*, 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 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 document 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.

SEMICONDUCTOR DEVICES – FLEXIBLE AND STRETCHABLE SEMICONDUCTOR DEVICES –

Part 9: Performance testing methods of one transistor and one resistor (1T1R) resistive memory cells

1 Scope

This part of IEC 62951 specifies the test methods for evaluating the performance of unipolar-type one transistor one resistor (1T1R) resistive memory cells. The performance test methods in this document include read, forming, SET, RESET, endurance and retention. This document is applicable to flexible devices as well as rigid resistive memory devices without any limitations prone to device technology and size.

2 Normative references

There are no normative references in this document.