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Nanomanufacturing – Reliability assessment – Part 3-1: Graphene-based material – Stability: Temperature and humidity test

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NANOMANUFACTURING – RELIABILITY ASSESSMENT –

Part 3-1: Graphene-based material – Stability: Temperature and humidity test

FOREWORD

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IEC TS 62876-3-1 has been prepared by IEC technical committee 113: Nanotechnology for electrotechnical products and systems. It is a Technical Specification.

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

Draft	Report on voting
113/592/DTS	113/616/RVDTS

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 Technical Specification 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 TS 62876 series, published under the general title *Nanomanufacturing – Reliability assessment*, 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- withdrawn,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.

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INTRODUCTION

Graphene, a single-layer of carbon atoms arranged in a honeycomb lattice, has a high potential for future nanotechnology applications due to the excellent conductivity, transparency and flexibility of the material. Many research organizations and industrial companies are developing fabrication technologies for graphene films on substrates, as dry powders or graphene in liquid dispersions for a wide variety of applications. Therefore, the need for a system of standardized tests for the key control characteristics to benchmark graphene material in its different physical and chemical modifications remains critical. The absence of such a system slows down the development process and hinders companies to be commercially successful. To improve this situation, IEC TC 113 is developing a comprehensive system of material specifications (IEC 62565-3-X series) which list application relevant key control characteristics (KCCs) and the related measurement standards (IEC 62607-6-X series) for graphene materials in general. That includes graphene, few-layer graphene and multilayer graphene, graphene oxide and other graphene-related materials.

In addition to the KCCs to qualify graphene material after fabrication, it is also important to obtain information on its long-term stability. This document defines the conditions for a set of stress tests to qualify graphene material for an acceptable level of reliability and durability in its performance category and operating service environment.

These tests are performed using samples with graphene material layers on the same substrate as is used in the final product. If the graphene material layer in the final product is embedded between other materials, the test samples are prepared in the same way. The basic idea is to prepare test samples which are representative for the application, so that the results of the reliability screening allow the prediction of the reliability of the layer in the final product. The results of these tests will help to establish acceptance criteria for the graphene material including its manufacturing process. This document does not address the quantitative reliability measures and life predictions of the product, which would involve further testing based on the knowledge of failure mechanisms.

The objectives of this document are to:

– specify the requirements for a general reliability stress screening (RSS) standard for nano-enabled electrotechnical products using graphene and other graphene-based materials;

– give direction to the supplier and to the end user on the production and purchase of nano-enabled electrotechnical products to meet and verify reliability qualification standards for certain specified service environments;

– provide a list of reliability qualification stress tests and conditions;

– establish guidance for selection of appropriate measurements and pass/fail criteria.

– give relevant references; and

– establish the minimum reporting requirements.

This document is meant to be a general document that can be applied to all modifications of graphene materials. Even if this document focuses on graphene materials, an analogue systematics might be useable for other 2D materials. Nevertheless, as it is expected that failure mechanisms are material dependent, a direct comparison of time-to-failure values is not recommended.

As such, the results of this reliability screening test give guidance to optimize graphene material fabrication processes and the use of graphene materials in a product design.

In some cases, it may be required that prior to the tests the environmental chamber be evacuated to vacuum so the intrinsic KCCs are measured (without influence from other environmental contaminants).

It is the intent of this document to be compatible with and work in conjunction with the performance standards defined in the IEC 62607 series.

NANOMANUFACTURING – RELIABILITY ASSESSMENT –

Part 3-1: Graphene-based material – Stability: Temperature and humidity test

1 Scope

This part of IEC TS 62876 establishes a standardized method to determine the

- stability

of films of graphene-based material by a

- temperature and humidity test.

It establishes a general methodology for reliability stress screening (RSS) to qualify the use of graphene-based material in its subsequent product value stage. The intention is to prepare test samples undergoing the same or similar failure mechanisms as the graphene-based material in the final product.

- Selected stress factors in this test to drive the failure mechanisms are low temperature, high temperature, change of temperature and damp heat with respect to test severity, test sequence, sample quantities and acceptance criteria.
- The RSS test procedure defined here supports reliability assessment in the design phase of a product by providing guidelines for selecting appropriate measurement methods and how to define specific pass/fail criteria.
- The described methodology does not replace traditional reliability tests on the final product level and will not provide full reliability data which allow the estimation of product lifetimes. If the samples pass the test, the design is called qualified in accordance with IEC 62876-3-1.

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.

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*