BSI Standards Publication

Nanomanufacturing — Key control characteristics

Part 6-1: Graphene-based material — Volume resistivity: four probe method

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee NTI/1, Nanotechnologies.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Nanomanufacturing – Key control characteristics – Part 6-1: Graphene-based material – Volume resistivity: four probe method

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FOREWORD

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- 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 62607-6-1, 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:

Draft TS	Report on voting
113/454/DTS	113/511/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 of the IEC TS 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- withdrawn,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

Graphene has attracted great interest as a next generation electronic material due to its extremely high mobility and ballistic transport of electrons [1][1]. The unique properties of graphene enable it to be an effective candidate used in electronic products such as transparent conducting films, sensors, field emitters, supercapacitors, etc.

Characterization of the electrical properties of graphene itself is essential to both manufacturers and users in order to develop innovative electronic devices or to improve existing electronic devices using it.

Commercialized graphene products can be categorized by their manufacturing methods as follows: (i) graphene flakes and/or nanoplatelets in powder form (hereinafter called GNP), (ii) graphene sheets suspended in liquids or (iii) graphene films grown by chemical vapour deposition (CVD).

Many electrical properties of a powder-type graphene product are significantly affected by its geometric and electronic parameters [2]. First, it is required to select the parameter that best represents the quality of the graphene products. Second, a suitable sample preparation for the purpose of electrical measurements is also elucidated and described. Finally, measurement conditions are also crucial factors to determine the representative value of the powder product in terms of its electrical properties.

Among the measurands in determining electronic properties of powder-type graphene – sheet resistance (or conductance), resistivity (or conductivity), volume resistivity (or volume conductivity), and so on – this document selects volume resistivity (or volume conductivity) for the representative measurand which reveals the electrical properties of powder-type graphene through a series of experiments.

This document describes a simple method to evaluate the volume resistivity (or volume conductivity) of powder-type graphene, which includes preparation of its pellet and a measurement method.

Case studies illustrating the application of the standard are provided in Annex A.

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1 Numbers in square brackets refer to the Bibliography.

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 6-1: Graphene-based material – Volume resistivity: four probe method

1 Scope

This part of IEC TS 62607 establishes a standardized method to determine the electrical key control characteristic

– volume resistivity

for powder consisting of graphene-based material like flakes of graphene, few layer graphene and/or reduced graphene oxide after preparation of a sample in pellet form by

– four probe method

using powder resistivity measurement system.

The volume resistivity is a measure of the quality of powder-type graphene products in terms of electrical property and reflects the density-dependency shown in a pellet of powder-type graphene.

The volume conductivity can directly be derived from the volume resistivity.

Typical application areas are industries that use powder-type graphene products for graphene manufacture, potential developers, and users who produce graphene-based products. As the volume resistivity measured according to this document requires the preparation of a sample in the form of a pellet, this document describes in detail

– an apparatus to prepare consistently a test sample, the pellet,
– the preparation of the pellet starting from powder-type graphene,
– the measurement procedure to measure the volume resistivity (or volume conductivity) of the pellet, and
– the data analysis, the interpretation and reporting of the results.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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

NOTE A comprehensive nanotechnology vocabulary is under ongoing development in IEC TC 113 and ISO/TC 229, in cooperation with ISO/TC 229. The vocabulary is being published as different parts of IEC TS 80004 and ISO/TS 80004. The terms and definitions in this document are harmonized with the terms and definitions of IEC 80004 (all parts) and ISO 80004 (all parts). They will remain harmonized during the maintenance of the document. Definitions not yet specified are taken from scientific literature.