PD IEC/TS 62607-6-4:2016

BSI Standards Publication

Nanomanufacturing — Key control characteristics

Part 6-4: Graphene — Surface conductance measurement using resonant cavity

Documents
Document Sharing Hub

Full document details: PD IEC/TS 62607-6-4:2016

National foreword

This Published Document is the UK implementation of IEC/TS 62607-6-4:2016.

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 secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2016.
Published by BSI Standards Limited 2016

ISBN 978 0 580 91019 7
ICS 07.030

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 October 2016.

Amendments/corrigenda issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: PD IEC/TS 62607-6-4:2016

IEC TS 62607-6-4

Edition 1.0 2016-09

TECHNICAL SPECIFICATION

colour inside

Nanomanufacturing – Key control characteristics – Part 6-4: Graphene – Surface conductance measurement using resonant cavity

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 07.030

ISBN 978-2-8322-3667-3

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

® Registered trademark of the International Electrotechnical Commission

Documents
Document Sharing Hub

Full document details: PD IEC/TS 62607-6-4:2016

CONTENTS

FOREWORD 3
INTRODUCTION 5
1 Scope 6
2 Normative references 6
3 Terms and definitions 6
3.1 Graphene layers 6
3.2 Measurement terminology 8
4 Microwave cavity test fixture 9
5 Test specimen 10
6 Measurement procedure 10
6.1 Apparatus 10
6.2 Calibration 11
6.3 Measurements 11
6.3.1 General 11
6.3.2 Empty cavity 11
6.3.3 Specimen 11
6.3.4 Repeated procedure 12
6.3.5 Substrate 12
7 Calculations of surface conductance 12
8 Report 12
9 Accuracy consideration 13
Annex A (informative) Case study of surface conductance measurement of single-layer and few-layer graphene 14
A.1 General 14
A.2 Cavity perturbation procedure 14
A.3 Experimental procedure 15
A.4 Results 15
A.5 Surface conductance of single-layer graphene and few-layer graphene 16
A.6 Summary 17
Bibliography 18

Figure 1 – Microwave cavity test fixture 10
Figure A.1 – S_{21} magnitude of the resonant peak TE_{103} as a function of frequency at several specimen insertions (h_x) 16
Figure A.2 – Plots of $1/Q_x - 1/Q_0$ as a function of the normalized specimen area ($w h_x$). 16

Documents
Document Sharing Hub
Full document details: PD IEC/TS 62607-6-4:2016

INTERNATIONAL ELECTROTECHNICAL COMMISSION

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 6-4: Graphene – Surface conductance measurement using resonant cavity

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 62607-6-4, which is a Technical Specification, has been prepared by IEC technical committee 113: Nanotechnology for electrotechnical products and systems.

Documents
Document Sharing Hub

Full document details: PD IEC/TS 62607-6-4:2016

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

Enquiry draft	Report on voting
113/295/DTS	113/324/RVC

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

- transformed into an International Standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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.

Documents
Document Sharing Hub

Full document details: PD IEC/TS 62607-6-4:2016

INTRODUCTION

The microwave resonant cavity test method for surface conductance is non-contact, fast, sensitive and accurate. It is well suited for standards, research and development (R&D), and for quality control in the manufacturing of two-dimensional (2D) nano-carbon materials. These sheet-like or flake-like carbon forms can be assembled into atomically-thin monolayer or multilayer graphene materials, which can be stacked, folded, crumpled or pillared into a variety of nano-carbon architectures with the lateral dimension limited to a few tenths of a nanometre. Many of these materials are new and exhibit extraordinary physical and electrical properties such as optical transparency, anisotropic heat diffusivity and charge transport that are of significant interest to science, technology and commercial applications [1, 2][1].

Depending on particular morphologies, density of states and structural perfection, the surface conductance of these materials may vary from 1 S to about 10^{-4} S. Conventional direct current (DC) surface conductance measurement techniques require a complex test vehicle and interconnections for making electrical contacts, which affect and alter the measurement, making it difficult to decouple the intrinsic properties of the material.

In comparison, the resonant cavity measurement method is fast and non-contact. Thus, it is well suited for use in R&D and manufacturing environments where the surface conductance is a critical functional parameter. Moreover, it can be employed to measure electrical characteristics of other nano-size structures.

[1] Numbers in square brackets refer to the Bibliography

Documents
Document Sharing Hub
Full document details: PD IEC/TS 62607-6-4:2016