

TECHNICAL SPECIFICATION



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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 07.120

ISBN 978-2-8322-8561-9

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CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	7
3.1 General terms	8
3.2 Key control characteristics	8
3.3 Terms related to measurements.....	8
4 Sample preparation	10
5 Measurement of volume resistivity of graphene pellet.....	10
5.1 Description of the measurement apparatus	10
5.2 Determination of sample amount.....	12
5.3 The measurement procedures.....	12
6 Data analysis and interpretation of results	12
6.1 General.....	12
6.2 Analysis of volume resistivity as a function of the applied pressures	13
6.3 Calculation of volume conductivity of a pellet.....	13
6.4 Analysis of volume resistivity (or volume conductivity) as a function of the volume density of graphene pellet.....	13
7 Report	14
Annex A (informative) Case studies	15
A.1 Graphene (reduced graphene oxide (rGO) and graphene nanopowder (GNP)).....	15
A.2 Morphology change of rGO flakes before and after pressurization.....	15
A.3 Raman spectroscopy measurement of graphene powder before and after pressurization up to 52 MPa.....	16
A.4 Results on powder resistivity measurements.....	17
A.4.1 Powder resistivity measurement of rGO-A (company 1) with various amounts	17
A.4.2 Powder resistivity measurement of 1,0 g of rGO-B (company 2).....	19
A.4.3 Powder resistivity measurement of GNP	22
A.4.4 Powder resistivity measurement of graphene oxides with different amounts of oxygen	26
Bibliography.....	32
Figure 1 – Measurement system	11
Figure A.1 – FE-SEM images of rGO flakes of (A) Company 1 (rGO-A), (B) Company 2 (rGO-B) and (C) graphene nanopowder (GNP) before (left) and after (right) pressurization	15
Figure A.2 – Raman spectra of (A) rGO-A, (B) rGO-B and (C) GNP before (black line) and after (red line) pressurization	16
Figure A.3 – Comparison data for I_D/I_G of rGO-A (short-dash line), rGO-B (solid line) and GNP (long-dash line) before and after pressurization	16
Figure A.4 – Correlation plots of (A) thickness, (B) volume resistivity (ρ_V), and (C) volume conductivity (σ_V) as a function of the applied pressure: (1) 0,1 g and (2) 0,2 g of rGO-A.....	18

Figure A.5 – Correlation plots of (A) volume resistivity (ρ_V) and (B) volume conductivity (σ_V) as a function of the volume density (d_V) of a graphene pellet: 0,1 g (filled symbol) and 0,2 g (unfilled symbol) of rGO-A	19
Figure A.6 – Correlation plots of (A) thickness (t), (B) volume resistivity (ρ_V), and (C) volume conductivity (σ_V) of rGO-B (1,0 g) as a function of the applied pressure	19
Figure A.7 – Correlation plots of (A) volume resistivity (ρ_V) and (B) volume conductivity (σ_V) of rGO-B (1,0 g) as a function of the volume density (d_V) of the graphene pellet	20
Figure A.8 – Correlation plots of (A) volume resistivity (ρ_V) and (B) volume conductivity (σ_V) as a function of the volume density (d_V) of graphene pellets: 0,1 g (filled symbol), 0,2 g (unfilled symbol) of rGO-A and 1,0 g (lined symbol) of rGO-B	20
Figure A.9 – Correlation plots of (A) thickness (t), (B) volume resistivity (ρ_V), and (C) volume conductivity (σ_V) as a function of the applied pressure: (1) 0,1 g and (2) 0,2 g of GNP.....	22
Figure A.10 – Correlation plots of (A) volume resistivity (ρ_V) and (B) volume conductivity (σ_V) as a function of the volume density (d_V) of a graphene pellet: 0,1 g (filled symbol) and 0,2 g (unfilled symbol) of GNP	23
Figure A.11 – Comparison plots of (A) volume resistivity (ρ_V) and (B) volume conductivity (σ_V) as a function of the volume density (d_V) of graphene pellets: rGO-A (filled symbol) and GNP (unfilled symbol).....	23
Figure A.12 – XPS survey spectra of as-received (A) rGO-A, (B) rGO-B and (C) GNP	24
Figure A.13 – Correlation plots of thickness (t) as a function of the applied pressure: 0,3 g samples of four types of graphene oxide (G-a, G-b, G-c, and G-d)	26
Figure A.14 – Correlation plots of volume resistivity (ρ_V) as a function of the applied pressure: 0,3 g samples of four types of graphene oxide (G-a, G-b, G-c, and G-d)	27
Figure A.15 – Correlation plots of volume conductivity (σ_V) as a function of the applied pressure: 0,3 g samples of four types of graphene oxide (G-a, G-b, G-c, and G-d)	28
Figure A.16 – Correlation plots of volume resistivity (ρ_V) as a function of the volume density (d_V) of graphene oxide pellet (G-a, G-b, G-c, and G-d).....	29
Figure A.17 – Correlation plots of volume conductivity (σ_V) as a function of the volume density (d_V) of graphene oxide pellet (G-a, G-b, G-c, and G-d).....	30
Figure A.18 – Comparison plots of (A) volume resistivity (ρ_V) and (B) volume conductivity (σ_V) as a function of the volume density (d_V) of graphene oxide pellet (G-a, G-b, G-c, and G-d).....	30
Table 1 – Minimum thickness of the pellet vs amount of the used sample at the maximum applied pressure	12
Table A.1 – An example of the measurement parameters for rGO-A (0,2 g)	17
Table A.2 – Volume resistivity and volume conductivity of rGO pellets	21
Table A.3 – Volume resistivity and volume conductivity of GNP pellets	23
Table A.4 – Summary of XPS data of three graphene samples in a powder form.....	24
Table A.5 – Volume resistivity (ρ_V) and volume conductivity (σ_V) of graphene pellets	25
Table A.6 – Volume resistivity (ρ_V) and volume conductivity (σ_V) of four graphene oxide pellets.....	31

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**NANOMANUFACTURING –
KEY CONTROL CHARACTERISTICS –****Part 6-1: Graphene-based material –
Volume resistivity: four probe method**

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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.

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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.

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.