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Nanomanufacturing – Key control characteristics –
Part 6-7: Graphene – Sheet resistance: van der Pauw method

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IEC TS 62607-6-7 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
113/682/DTS	113/713/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/publications.

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 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- withdrawn,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 is a single layer of carbon atoms arranged in a honeycomb lattice. Graphene has shown many outstanding properties, among which is a high electrical conductivity. Nowadays graphene can be easily grown and transferred on large area (cm^2 to even m^2) and even roll-to-roll supports using chemical vapour deposition (CVD) techniques. This is already enabling its commercial applications in electrotechnical products.

Electrical conductivity of graphene samples can depend on many factors: structural quality, contamination, coupling with the physical support used for a given application to name a few. On practical grounds, sheet resistance is a quantity which can be used as global measure of the local conductivity of a sample with finite geometrical dimensions. In order to check the reproducibility of the electrical properties of graphene, the sheet resistance is clearly a key control characteristic for this material.

The van der Pauw method [1][1] allows the measurement of the sheet resistance of samples of arbitrary shape, with isotropic conductivity and uniform carrier density by performing a pair of four-terminal resistance measurements with electrical contacts placed at arbitrary positions on the sample's perimeter. The method is fast (it takes a few minutes) and easy to implement, since many commercial fixtures are available.

The four-terminal resistance measurements required to apply the method allow to minimize the effect of the contact resistance that appears between graphene and the measurement probes.

The van der Pauw method does not provide any spatial resolution in principle, but considerations about real samples' conductivity uniformity can be made.

In this document it is explained how to specifically apply the van der Pauw method on chemical vapour deposited graphene on rigid insulating support and perform a reliable estimation of the sample sheet resistance also considering the non-ideal nature of commercial graphene.

1 Numbers in square brackets refer to the Bibliography.

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 6-7: Graphene – Sheet resistance: van der Pauw method

1 Scope

This part of IEC TS 62607 establishes a method to determine the key control characteristics

- sheet resistance R_S [measured in ohm per square (Ω/sq)],

by the

- van der Pauw method, vdP.

The sheet resistance R_S is derived by measurements of four-terminal electrical resistance performed on four electrical contacts placed on the boundary of the planar sample and calculated with a mathematical expression involving the two resistance measurements.

- The measurement range for R_S of the graphene samples with the method described in this document goes from 10^{-2} Ω/sq to 10^4 Ω/sq.
- The method is applicable for CVD graphene provided it is transferred to quartz substrates or other insulating materials (quartz, SiO_2 on Si), as well as graphene grown from silicon carbide.
- The method is complementary to the in-line four-point-probe method (4PP, IEC 62607-6-8) for what concerns the measurement of the sheet resistance and can be applied when it is possible to reliably place contacts on the sample boundary, avoiding the sample being scratched by the 4PP.
- The outcome of the van der Pauw method is independent of the contact position provided the sample is uniform, which is typically not true for graphene at this stage. This document considers the case of samples with non-strictly uniform conductivity distribution and suggests a way to consider the sample inhomogeneity as a component of the uncertainty on R_S.

2 Normative references

There are no normative references in this document.