

TECHNICAL SPECIFICATION



**Nanomanufacturing – Key control characteristics –
Part 6-5: Graphene-based materials – Contact resistance and sheet resistance:
transmission line measurement**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –**Part 6-5: Graphene-based materials – Contact resistance and sheet resistance: transmission line measurement**

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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 in 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

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- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

Technical Specifications for contact resistance and sheet resistance of two-dimensional materials provide a proper definition of contact resistance and sheet resistance measurement and an electrical characterization of two-dimensional materials. This document includes recommended conditions for a sample preparation and recommended method to measure contact resistance and sheet resistance of two-dimensional materials under test in the referenced background research results. Here, the transmission line measurement (TLM) is used which had been used to measure both contact resistance and sheet resistance for conventional bulk semiconductor devices including silicon devices. TLM devices are formed with various spacings between contacts from which contact resistance and sheet resistance are determined from voltage measured. Thickness of the atomic thin 2D materials cannot be defined clearly when the layers are ultrathin near monolayer, and therefore it is difficult to express the thickness-dependent electronic resistivities of the devices fabricated by using 2D materials. TLM is used conveniently to determine contact resistance and sheet resistance of 2D materials since it does not require thickness of tested materials to be included in the calculation procedure.

The objectives of this document are to

- a) define the contact resistance and sheet resistance of two-dimensional materials;
- b) specify the methodology for contact resistance and sheet resistance measurements of two-dimensional materials using transmission line measurement (TLM);
- c) provide a contact formation method for two-dimensional materials with ohmic contact property which is an essential prerequisite;
- d) establish units for the quantitative characteristics of contact resistance and sheet resistance for two-dimensional materials;
- e) provide relevant case studies;
- f) provide relevant references.

This document is meant to be a general document that can be applied to two-dimensional materials and their applications. It is the intent of this document to be compatible with and work in conjunction with the performance standards defined in the IEC TS 62607 series.

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 6-5: Graphene-based materials – Contact resistance and sheet resistance: transmission line measurement

1 Scope

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

- contact resistance, and
- sheet resistance

for graphene-based materials and other two-dimensional materials by a

- transmission line measurement.

The method uses test structures applied to the 2D material by photolithographic methods consisting of several metal electrodes with increasing spacing between the electrodes. By a measurement of the voltage drop between different pairs of electrodes, sheet resistance and contact resistance can be calculated.

- The method can be applied to any other two-dimensional materials which are subject to electrical metal contact on top of the materials.
- The method provides accurate and reproducible results, if the electrical contact formed between the two-dimensional material and the metal electrodes provides ohmic contact property.

2 Normative references

There are no normative references in this document.