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Nanomanufacturing - Key control characteristics -
Part 6-27: Graphene-related products - Field-effect mobility for layers of two-dimensional materials: field-effect transistor method

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Nanomanufacturing - Key control characteristics - Part 6-27: Graphene-related products - Field-effect mobility for layers of two-dimensional materials: field-effect transistor method

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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.

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INTRODUCTION

Atomically thin two-dimensional (2D) materials are expected to be used for future electrical subassemblies or electronic device applications. For these applications, it is obvious that charge carrier mobility will be measured accurately, as an important figure of merit to indicate the electrical operation speed and the efficiency of devices, since the mobility measured from the devices with a 2D material-based channel are subject to errors resulted from large contact resistance.

Two different types of mobility are typically used in semiconductor devices: Hall effect mobility (μ_{H}) and field-effect mobility (μ_{FE}). However, the extraction of the Hall effect mobility requires a specialized structure and an application of magnetic field, which gives rise to difficulties involving small Hall voltage (V_{H}), is not adequate for practical semiconductor devices consisting of field-effect transistors (FETs).

By contrast, field-effect mobility is extracted simply from a transfer curve obtained using a FET in the device operation voltage region; therefore, it is more practical for industrial application of semiconductor devices.

However, typical 2-point probe (2PP) transfer curves involve contact resistance as well as channel resistance in FETs, which results in underestimated values of field-effect mobility. This is critically important for 2D devices because most of 2D material-based devices show Schottky contact property arising at the metal-2D material interface with the van der Waals gap which results in large contact resistance compared to channel resistance.

By using 4-point probe (4PP) transfer curves, the true values of field-effect mobility, which are only dependent on 2D channel, are obtained by excluding contact resistance.

From this reason, a standard method to determine 4PP-based field-effect mobility should be established for 2D materials.

1 Scope

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

- field-effect mobility

for semiconducting two-dimensional (2D) materials by the

- field-effect transistor (FET) method.

For two-dimensional semiconducting materials, the field-effect mobility is determined by fabricating a FET test structure and measuring the transconductance in a four-terminal configuration.

– This method can be applied to layers of semiconducting two-dimensional materials, such as graphene, black phosphorus (BP), molybdenum disulfide (MoS_2), molybdenum ditelluride ($MoTe_2$), tungsten disulfide (WS_2), and tungsten diselenide (WSe_2).

– The four-terminal configuration improves accuracy by eliminating parasitic effects from the probe contacts and cables

2 Normative references

There are no normative references in this document.

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ISO/TS 80004-13, *Nanotechnologies - Vocabulary - Part 13: Graphene and other two-dimensional materials*

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