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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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CONTENTS

FOREWORD ... 3
INTRODUCTION ... 5
1 Scope ... 6
2 Normative references ... 6
3 Terms and definitions ... 6
3.1 General terms ... 6
3.2 Key control characteristics measured according to this standard ... 7
3.3 Terms related to the measurement method ... 7
4 General ... 8
4.1 Measurement principle ... 8
4.2 Description of the measurement equipment ... 9
4.3 Sample preparation method ... 9
4.3.1 Sample preparation ... 9
4.3.2 Fabrication of FETs with a 2D channel material ... 9
4.4 Description of measurement equipment ... 10
5 Measurement procedure ... 10
6 Data analysis ... 11
Annex A (informative) Worked example – 2PP and 4PP mobility measurements in bottom-contacted WSe_2 FETs ... 13
A.1 Background ... 13
A.2 Results to be reported ... 14
Annex B (informative) Worked example – 2PP and 4PP mobility measurements in an organic FET ... 15
B.1 Background ... 15
B.2 Results to be reported ... 15
Annex C (informative) Worked example – Mobility measurements on WSe_2 FETs ... 17
C.1 Background ... 17
C.2 Results to be reported ... 18
Bibliography ... 19

Figure 1 – Schematic of field-effect transistor where V_g and V_{ds} are the gate voltage and drain voltage applied with respect to source ... 8
Figure 2 – Determination of field-effect mobility using a current–voltage transfer curve of a FET ... 9
Figure 3 – Schematic (left) and optical microscope image (right) of the four-terminal configuration ... 11
Figure 4 – Transfer curve (a) and corresponding transconductance (b) used to obtain field-effect mobility which is extracted from the transconductance of a FET biased in the linear regime ... 11
Figure 5 – Mobilities obtained as a function of gate voltage ... 12
Figure A.1 – Schematic of FET WSe_2 used for 2PP mobility measurement ... 13
Figure A.2 – Cross-sectional schematic ... 13
Figure A.3 – Optical microscopic picture of a FET used for 4PP mobility measurement ... 14
Figure B.1 – Device structure used for 2PP and 4PP measurements ... 15

Figure B.2 – Comparison of the 2PP and 4PP mobility measurements in a rubrene single-crystal organic FET for different gate voltages 16
Figure C.1 – Colour-corrected optical image 17
Figure C.2 – Schematic cross section of the device 17
Figure C.3 – Temperature-dependent transfer characteristics showing the linear region of device operation for V_{GS} < −80 V 18
Figure C.4 – Extracted field-effect mobility at V_{GS} = −95 V at different temperatures 18

Table A.1 – Comparison of 2PP and 4PP mobilities 14

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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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Draft	Report on voting
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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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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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– revised.

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*