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Nanomanufacturing — Key control characteristics

Part 6-16: Two-dimensional materials — Carrier
concentration: Field effect transistor method

National foreword

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TECHNICAL SPECIFICATION



**Nanomanufacturing – Key control characteristics –
Part 6-16: Two-dimensional materials – Carrier concentration: Field effect
transistor method**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**NANOMANUFACTURING –
KEY CONTROL CHARACTERISTICS –****Part 6-16: Two-dimensional materials –
Carrier concentration: Field effect transistor method**

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INTRODUCTION

Atomically thin 2D materials are expected to be used for future electrical sub-systems or electronic device applications. For these applications, the materials need to be doped with dopants to generate carriers. In contrast to 3D bulk materials, carrier concentrations in 2D materials are difficult to measure directly due to their limited thickness.

- Different from conventional 3D bulk materials in which doping effect is induced from activation of substitutional dopant atoms, the doping effect in 2D materials is mostly induced by generation of free carriers, for example electrons by using plasma treatment, chemical treatment, etc.
- In the 3D bulk materials, carrier concentration can be obtained by measuring concentration of dopant atoms under the assumption that both concentrations are the same. Therefore, it is possible to measure the doping concentration in 3D bulk materials using secondary ion mass spectroscopy (SIMS), which measures the concentration of dopant atoms, and using I-V or C-V characterization, which measures the concentration of free charge carriers such as electrons and holes [1]¹.
- In contrast, in the 2D materials, carrier concentration needs to be measured for carriers such as electrons and holes which are induced from external means such as plasma treatment or chemical treatment.

For this reason, a standard method to determine the carrier concentration needs to be established for 2D materials.

¹ Numbers in square brackets refer to the Bibliography.