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Nanomanufacturing – Key control characteristics – Part 6-2: Graphene – Number of layers: atomic force microscopy, optical transmission, Raman spectroscopy

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IEC TS 62607-6-2 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
113/676/DTS	113/727/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 http://www.iec.ch/standardsdev/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

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- withdrawn,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

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INTRODUCTION

Graphene has attracted significant interest as a next-generation electronic material due to its good conductivity and mobility. It has been regarded as more advantageous than carbon nanotube (CNT) because of its isotropic and homogeneous electronic properties. For these reasons and many more, a Nobel prize in physics was awarded to A. Geim and C. Novoselov in 2010 for their efforts in discovering graphene when they isolated a single layer of graphene using clear adhesive tape.

Graphene has been widely studied by researchers from academic institutions, research institutes, and industries due to its unique and interesting properties such as conductivity [1][1], mechanical strength and flexibility [2], which are better than other metals or semiconductors. These properties are influenced by the number of layers of graphene and disappear as the number of layers increases. Graphene also shows an unusual reduction in optical transparency even considering a single atomic layer [3]. Therefore, graphene applications need to investigate the precise number of layers of graphene.

Many companies are now providing graphene samples to industries and research communities. These are prepared (or manufactured) by various methods such as CVD or mechanical exfoliation. Defining and evaluating the number of layers of this fabricated graphene is critical both from research and industrial points of view. Unfortunately, there are no commonly accepted standards for this purpose, hindering the reliable production and expansion of graphene applications.

The number of layers of graphene is usually observed by atomic force microscopy (AFM), light transmittance, Raman spectroscopy, transmission electron microscopy (TEM), and ellipsometry. Every analytical method has its own limitations in terms of precisely measuring the number of graphene layers and can also cause ambiguity for providing reliable information. For these reasons, developing an easy, fast, and reliable method for counting the number of graphene layers is needed.

This document describes a combined method to evaluate accurate number of layers of graphene, which includes measurement method.

Description of combined method and case studies illustrating the application of the standard are provided in Annex A and Annex B, respectively.

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1 Numbers in square brackets refer to the Bibliography.

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 6-2: Graphene – Number of layers: atomic force microscopy, optical transmission, Raman spectroscopy

1 Scope

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

– number of layers

for graphene flakes by a combination of

– atomic force microscopy,
– optical transmission, and
– Raman spectroscopy

2 Normative references

There are no normative references in this document.