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Nanomanufacturing – Key control characteristics – Part 6-21: Graphene-based material – Elemental composition, C/O ratio: X-ray photoelectron spectroscopy

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IEC TS 62607-6-21 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
113/607/DTS	113/630/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 www.iec.ch/standardsdev/publications.

A list of all parts of 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- withdrawn,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.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Graphene has unique electrical, thermal and mechanical properties and has wide potential industrial application, especially in the electronics industry: batteries, integrated circuits, high-frequency electronics, displays, etc. [1], [2], [3], [4], [5][1]. The content of main elements, especially oxygen element and the ratio of carbon to oxygen are the significant parameters influencing the electronic and thermal application performance of graphene materials [3]. The main elements in graphene materials include carbon (C), oxygen (O), nitrogen (N), sulfur (S), chloride (Cl), and silicon (Si). The C/O ratio is a key parameter to identify the type of graphene or graphene-oxide (GO), and reflects directly the degree of reduction and product quality of reduced graphene oxide (rGO). Because of multiple different production processes and manufacturers for graphene powder, the main elemental composition and C/O ratio are also different. For the development of industrial application, a standard measurement method with reliability, accuracy and reproducibility needs to be established. The X-ray photoelectron spectroscopy (XPS) technique can measure multiple elements simultaneously and obtain accurately the relative abundance of each element in a test sample [6], [7].

The purpose of this document is to provide an optimized preparation, measurement and analysis procedure for graphene powder, to enable accurate and quantitative determination of the C, O, N, S, Cl, Si elements and C/O ratio using the XPS technique.

This document has been developed based on study in VAMAS Technical Working Area 41 (TWA 41).

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1 Numbers in square brackets refer to the Bibliography.

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 6-21: Graphene-based material – Elemental composition, C/O ratio: X-ray photoelectron spectroscopy

1 Scope

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

– elemental composition, and
– C/O ratio

for powders of graphene-based materials by

– X-ray photoelectron spectroscopy (XPS).

The elemental composition (species and relative abundance) is derived by the elemental binding energy and integral peak area at corresponding portion of XPS spectrum.

– The elemental composition refers to main elements in graphene powders, typically including carbon (C), oxygen (O), nitrogen (N), sulfur (S) , chloride (Cl) and silicon (Si).
– This document is applicable to graphene powders consisting of graphene, bilayer graphene (2LG), trilayer graphene (3LG), few-layer graphene (FLG), graphene nanoplate (GNP), reduced graphene oxide (rGO), graphene oxide (GO), and functionalized graphene powders.
– Typical application areas are the microelectronics and thermal management industries, e.g. batteries, integrated circuits, high-frequency electronics. This document can be used by manufacturers in research and development and by downstream users for product selection.

2 Normative references

There are no normative references in this document.