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Nanotehnologija - Slovar - 13. del: Grafen in sorodni dvodimenzionalni (2D) materiali (ISO/TS 80004-13:2017)

Nanotechnologies - Vocabulary - Part 13: Graphene and related two-dimensional (2D) materials (ISO/TS 80004-13:2017)

Nanotechnologien - Fachwörterverzeichnis - Teil 13: Graphen und andere zweidimensionale (2D) Werkstoffe (ISO/TS 80004-13:2017)

Nanotechnologies - Vocabulaire - Partie 13: Graphène et autres matériaux bidimensionnels (ISO/TS 80004-13:2017)

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Part 13: Graphene and related two-dimensional (2D) materials

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Partie 13: Graphène et autres matériaux bidimensionnels

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Foreword

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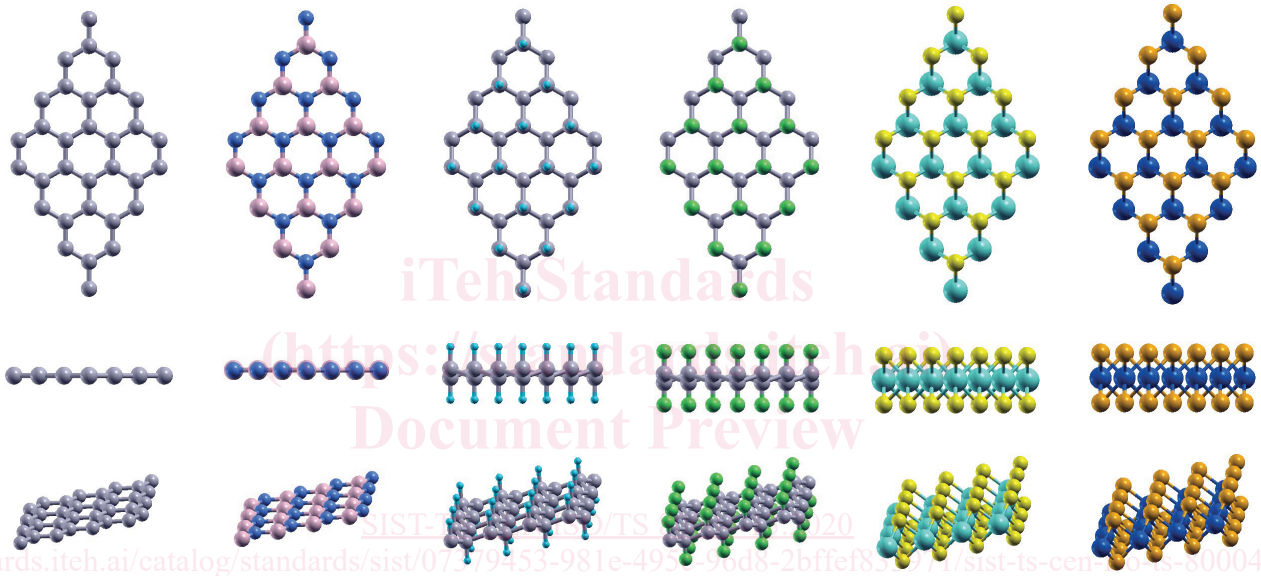
This document was prepared by Technical Committee ISO/TC 229, *Nanotechnologies*, and IEC/TC 113, *Nanotechnology for electrotechnical products and systems*.

A list of all parts in the ISO 80004 series can be found on the ISO website.

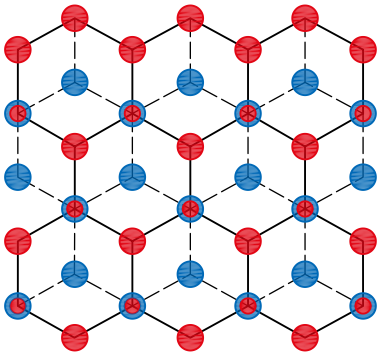
Introduction

Over the last decade, huge interest has arisen in graphene both scientifically and commercially, due to the many exceptional properties associated with this material, properties such as the electrical and thermal conductivity. More recently, other materials with a structure similar to that of graphene have also shown promising properties including monolayer and few-layer versions of hexagonal boron nitride (hBN), molybdenum disulphide (MoS_2), tungsten diselenide (WSe_2), silicene and germanene and layered assemblies of mixtures of these materials. These materials have their thickness constrained within the nanoscale or smaller and consist of between one and several layers. These materials are thus termed two-dimensional (2D) materials as they have one dimension at the nanoscale or smaller, with the other two dimensions generally at scales larger than the nanoscale. A layered material consists of two-dimensional layers weakly stacked or bound to form three-dimensional structures. Examples of 2D materials and the different stacking configurations in graphene are shown in Figure 1. It should be noted that 2D materials are not necessarily topographically flat in reality and can have a buckled structure. They can also form aggregates and agglomerates which can have different morphologies. Two-dimensional materials are an important subset of nanomaterials.

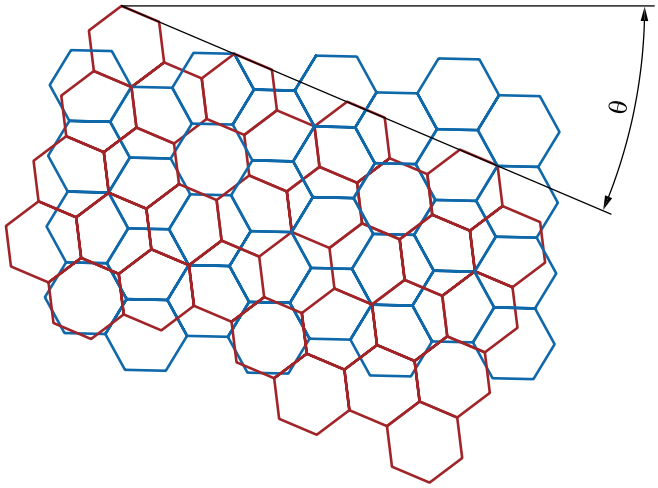


graphene | **hBN** | **graphane** | **perfluoro-graphane** | **MoS_2** | **WSe_2**

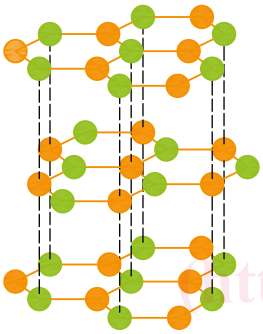
a) Examples of different two-dimensional materials consisting of different elements and structures, as shown by the different coloured orbs and top-down and side views



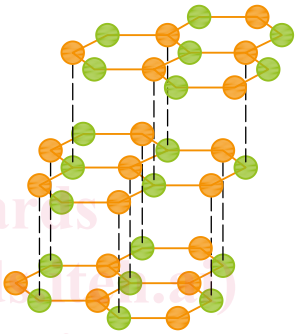
b) Bernal stacked bilayer graphene (3.1.2.6)



c) turbostratic bilayer or twisted bilayer graphene with relative stacking angle, θ, (3.1.2.7)



ABA trilayer



ABC trilayer

d) Bernal stacked (AB) (3.4.1.10) tri-layer graphene (3.1.2.9) and Rhombohedral (ABC) (3.4.1.11) stacked tri-layer graphene (3.1.2.9)

Figure 1 — Examples of 2D materials and the different stacking configurations in graphene layers

It is important to standardize the terminology for graphene, graphene-derived and related 2D materials at the international level, as the number of publications, patents and organizations is increasing rapidly. Thus, these materials need an associated vocabulary as they become commercialized and sold throughout the world.

This document belongs to a multi-part vocabulary covering the different aspects of nanotechnologies. It builds upon ISO/TS 80004-3, ISO/TS 80004-11 and ISO/TS 80004-6 and uses existing definitions where possible.

Nanotechnologies — Vocabulary —

Part 13: Graphene and related two-dimensional (2D) materials

1 Scope

This document lists terms and definitions for graphene and related two-dimensional (2D) materials, and includes related terms naming production methods, properties and their characterization.

It is intended to facilitate communication between organizations and individuals in research, industry and other interested parties and those who interact with them.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms related to materials

3.1.1 General terms related to 2D materials

3.1.1.1
two-dimensional material
2D material
material, consisting of one or several *layers* (3.1.1.5) with the atoms in each layer strongly bonded to neighbouring atoms in the same layer, which has one dimension, its thickness, in the nanoscale or smaller and the other two dimensions generally at larger scales

Note 1 to entry: The number of layers when a two-dimensional material becomes a bulk material varies depending on both the material being measured and its properties. In the case of *graphene layers* (3.1.2.1), it is a two-dimensional material up to 10 layers thick for electrical measurements[10],beyond which the electrical properties of the material are not distinct from those for the bulk [also known as *graphite* (3.1.2.2)].

Note 2 to entry: Interlayer bonding is distinct from and weaker than intralayer bonding.

Note 3 to entry: Each layer may contain more than one element.

Note 4 to entry: A two-dimensional material can be a *nanoplate* (3.1.1.2).

3.1.1.2
nanoplate
nano-object with one external dimension in the nanoscale and the other two external dimensions significantly larger

Note 1 to entry: The larger external dimensions are not necessarily in the nanoscale.

[SOURCE: ISO/TS 80004-2:2015, 4.6]

3.1.1.3
nanofoil
nanosheet
nanoplate (3.1.1.2) with extended lateral dimensions

Note 1 to entry: Nanofoil and nanosheet are used synonymously in specific industrial areas.

Note 2 to entry: Nanofoil and nanosheet extend further with respect to their length and width compared to nanoplate or nanoflake.

[SOURCE: ISO/TS 80004-11:2017, 3.2.1.1]

3.1.1.4
nanoribbon
nanotape
nanoplate (3.1.1.2) with the two larger dimensions significantly different from each other

[SOURCE: ISO/TS 80004-2:2015, 4.10]

3.1.1.5
layer
discrete material restricted in one dimension, within or at the surface of a condensed phase

[SOURCE: ISO/TS 80004-11:2017, 3.1.2]

3.1.1.6
quantum dot
nanoparticle or region which exhibits quantum confinement in all three spatial directions

[SOURCE: ISO/TS 80004-12:2016, 4.1]

3.1.1.7
aggregate
particle comprising strongly bonded or fused particles where the resulting external surface area is significantly smaller than the sum of surface areas of the individual components

Note 1 to entry: The forces holding an aggregate together are strong forces, for example, covalent or ionic bonds or those resulting from sintering or complex physical entanglement or otherwise combined former primary particles.

Note 2 to entry: Aggregates are also termed secondary particles and the original source particles are termed primary particles.

[SOURCE: ISO/TS 80004-2:2015, 3.5, modified – Notes 1 and 2 have been added.]