
**Nanotechnologies — Vocabulary —
Part 11:
Nanolayer, nanocoating, nanofilm, and
related terms**

Nanotechnologies — Vocabulaire —

*Partie 11: Nano-couche, nano-revêtement, nano-film et termes
associés*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see the following URL: www.iso.org/iso/foreword.html.

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

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

Introduction

Nanotechnologies are used in many application areas providing specific functionalities. Ordered structures are beginning to be used increasingly in applications such as layered coatings for protection of surfaces from wear, in which there can be multiple layers with individual layer thicknesses of just a few nanometres. Nanotextured surfaces are being developed where a patterned texture on the surface of a component can have a major influence on the properties of the component.

When discussing these applications of nanotechnologies, a common frame of reference for certain general terms is desirable. In general, a coating is applied to a substrate and is not discrete. In this regard, there is general agreement that a coating which is nanoscale in thickness should not be considered a nanoplate due to the integral relationship of the coating to the substrate. A film is freestanding or applied to a substrate, a layer can be internal or external and be single or multi-layer, a membrane is a film separating two phases.

Many different industries employ terms presented in this document. There are a number of relevant standards committees. In particular, the work of the following ISO committees is acknowledged:

- ISO/TC 35, Paints and varnishes;

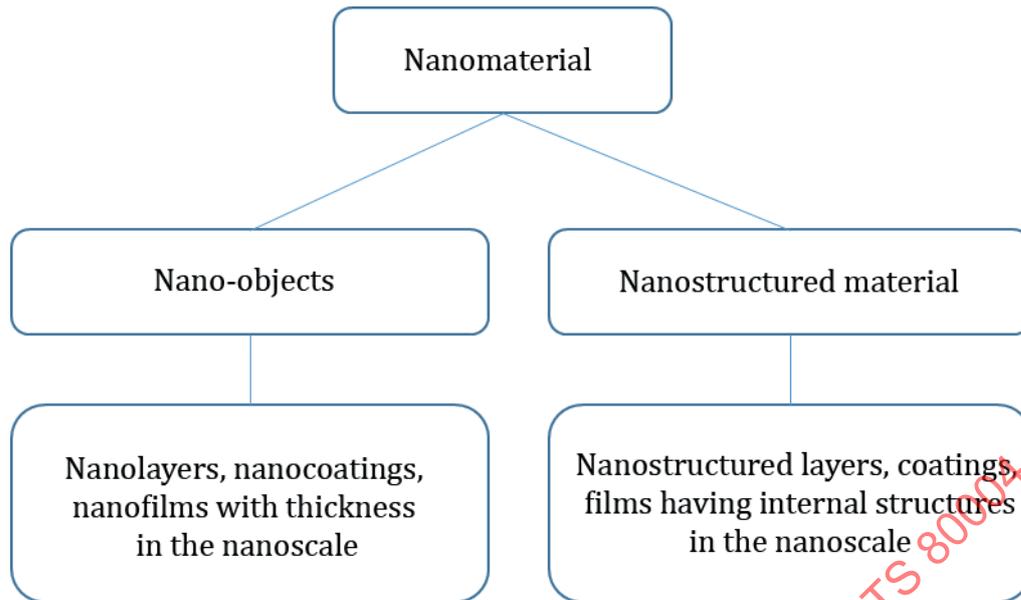
NOTE Specific terms and definitions for paints and varnishes in the field of nanotechnologies are given in ISO 4618.

- ISO/TC 164/SC 3, Hardness testing (e.g. nano-indentation);
- ISO/TC 172/SC 3, Optical materials and components;
- ISO/TC 201, Surface chemical analysis;
- ISO/TC 202, Microbeam analysis;
- ISO/TC 256, Pigments, dyestuffs and extenders.

The terms “coating”, “layer”, “film” and other related terms can be grouped by distinguishing between coatings, layers and films having a thickness in the nanoscale (i.e. external dimension in the nanoscale) and those having internal structures in the nanoscale (e.g. nanostructured coatings, nanocomposite coatings, dispersion coatings with dispersed nano-objects, etc.). For the purposes of classification, following the hierarchy established in ISO/TS 80004-1 (which describes nanomaterial by the two categories “nano-objects” and “nanostructured material”),

- the terms “nanolayer”, “nanocoating”, and “nanofilm” are assigned to “nano-objects”, and
- the terms “nanostructured layers”, “coatings”, and “films” are assigned to nanostructured material.

See [Figure 1](#) for details.



NOTE Assigning the terms “nanolayer”, “nanocoating”, and “nanofilm” to “nano-objects” and the terms “nanostructured layers”, “coatings”, and “films” to “nanostructured material” following the hierarchy of nanomaterial terms in ISO/TS 80004-1.

Figure 1 — Hierarchy of nanomaterial terms

The usage of many terms defined in this document depends on specific sectors. Therefore, there is a specific usage with respect to the deposition techniques used, e.g. coating, ECD (electrochemical deposition), spin coating, PVD (physical vapour deposition), CVD (chemical vapour deposition), sol-gel deposition, ALD (atomic layer deposition), LBL (layer-by-layer deposition), and Langmuir-Blodgett deposition.

Another example is the polymer sector where the terms “film”, “sheet”, or “foil” are often used to describe the same element (i.e. “a thin, flexible, transparent sheet, as of plastic, used in wrapping or packaging”^[9]). In this respect, the terms “foil” or “sheet” might be best suited for freestanding films.

In other areas, the term “film” is used to refer to a foil which might cover the surface of an object. The electroplating and the paint sector uses the terms “coating” and “layer”.

The terms “film”, “coating” and “layer” are often used synonymously. For instance, the vacuum deposition sector uses the terms “thin film” (since ~1960), “film”, “layer”, “multilayer”, but also “coating”, even using the combined term “thin film coating”. Even academic textbooks use these terms synonymously, without any specific definitions^[8]. Nearly all PVD/CVD coatings are nanostructured (i.e. have a structure in the nanoscale).

Some combined terms predominantly use one specific term out of “film”, “coating”, and “layer”:

- “multilayer” (“multi-film” not used);
- “layer-stack” (“film-stack” or “coating-stack” not used);
- “conversion coating” and “diffusion coating” (“conversion film”, “diffusion film” not used);
- “conversion layer” and “layer” (“conversion film”, “diffusion film” not used);
- “boundary layer” (“boundary film” and “boundary coating” not used).

Existing definitions often use self-referencing (or circular referencing), thus film is defined by using coating and layer, layer is defined by using film and coating, and coating is defined by using layer and film.

The following characteristic properties might be helpful to distinguish between the terms “coating” and “film”:

- a coating is applied to “protect” a substrate (e.g. against corrosion, wear) or to change the surface properties (optical, colour, decorative, etc.);
- a film is applied on a substrate to confine the lateral dimensions of the growing film during deposition. The specific film properties (e.g. optical band filter, magnetic storage capacity) are a function of the deposited material and the thickness and structure of the film produced.

The terminology used in the above-mentioned different sectors is already well-established, which sometimes causes inconsistencies and overlaps. This is taken into consideration in this document.

Since the development of nanotechnologies started, terms like “nanocoating”, “nanofilm”, “nanolayer”, etc. are increasingly used but had not yet been defined.

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Nanotechnologies — Vocabulary —

Part 11:

Nanolayer, nanocoating, nanofilm, and related terms

1 Scope

This document lists terms and definitions, and specifies an extensible taxonomic terminology framework for nanolayers, nanocoatings, nanofilms, and related terms in the field of nanotechnologies.

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 Basic terms describing coatings, layers, films, freestanding films and membranes

3.1.1 film

supported or unsupported thin material that is laterally continuously connected

Note 1 to entry: The attribute “thin” is used to emphasize that the thickness of the film is much smaller than the other two dimensions.

Note 2 to entry: A film can be freestanding.

Note 3 to entry: A film can be made of solids or liquids (e.g. liquid film).

Note 4 to entry: A film can be composed of a monomolecular layer (e.g. Langmuir-Blodgett film).

3.1.2 layer

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

3.1.3 multilayer

system of adjacent *layers* (3.1.2) or monolayers

3.1.4 foil

unsupported *film* (3.1.1) with uniform thickness

**3.1.5
membrane**

structure, having lateral dimensions much greater than its thickness, through which transfer can occur under a variety of driving forces

**3.1.6
coating**

adherent surface *layer* ([3.1.2](#))

Note 1 to entry: A coating can consist of multiple layers.

Note 2 to entry: A coating is always attached to a substrate (see ISO 4618:2014, 2.244).

**3.1.7
nanoscale**

length range approximately from 1 nm to 100 nm

Note 1 to entry: Properties that are not extrapolations from a larger size are predominantly exhibited in this length range.

[SOURCE: ISO/TS 80004-1:2015, 2.1]

**3.1.8
nanostructured**

having internal or surface structure in the *nanoscale* ([3.1.7](#))

Note 1 to entry: If external dimensions are in the nanoscale, the term nano-object (see ISO/TS 80004-1:2015, 2.5) is recommended.

[SOURCE: ISO/TS 80004-4:2011, 2.10]

**3.1.9
nanoplate**

nano-object with one external dimension in the *nanoscale* ([3.1.7](#)) and the other two external dimensions significantly larger

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

Note 2 to entry: See ISO/TS 80004-1:2015, 2.5 for the definition of nano-object.

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

**3.1.10
nanopore**

cavity with at least one dimension in the *nanoscale* ([3.1.7](#)), which may contain a gas or liquid

Note 1 to entry: The shape and content of the cavity can vary. The concept of nanopore overlaps with micropore (pore with width of about 2 nm or less), mesopore (pore with width between approximately 2 nm and 50 nm), and macropore (pore with width greater than about 50 nm). See ISO 15901-3.

Note 2 to entry: When nanopores are appropriately interconnected they can allow for transport through the material (permeability).

[SOURCE: ISO/TS 80004-4:2011, 2.13]

**3.1.11
nanoporous material**

solid material with *nanopores* ([3.1.10](#))

Note 1 to entry: The solid can be either amorphous, crystalline, or a mixture of both.

Note 2 to entry: The definitions of solid nanofoam (see ISO/TS 80004-4:2011, 3.3), where most of the volume is occupied by pores, and nanoporous material (also materials where a small fraction of pores are covered) are overlapping.

[SOURCE: ISO/TS 80004-4:2011, 3.4]

3.2 Terms describing elements having thickness in the nanoscale (nanocoatings, nanolayers, nanofilms, and related terms)

3.2.1 Freestanding elements

3.2.1.1

nanofilm

nanosheet

nanoplate (3.1.9) with extended lateral dimensions

Note 1 to entry: Nanofilm and nanosheet are used synonymously in specific industries.

Note 2 to entry: Nanofilm and nanosheet extend further with respect to their length and width compared to nanoplate or *nanoflake* (3.2.1.2).

3.2.1.2

nanoflake

nanoplate (3.1.9) with limited lateral dimensions

3.2.1.3

nanomembrane

membrane (3.1.5) with thickness in the *nanoscale* (3.1.7)

Note 1 to entry: A nanomembrane with pores in the nanoscale is considered as a *nanoporous material* (3.1.11).

3.2.2 Elements on substrates

3.2.2.1

nanolayer

layer (3.1.2) of material with thickness in the *nanoscale* (3.1.7)

3.2.2.2

nanocoating

coating (3.1.6) with thickness in the *nanoscale* (3.1.7)

3.2.2.3

nanofilm

film (3.1.1) with thickness in the *nanoscale* (3.1.7)

Note 1 to entry: A nanofilm is a *nanolayer* (3.2.2.1) which can be freestanding.

Note 2 to entry: A nanofilm can be made of solids or liquids (e.g. liquid film).

Note 3 to entry: A nanofilm can be composed of a monomolecular layer (e.g. Langmuir-Blodgett film).

3.2.2.4

nanomultilayer

multilayer (3.1.3), the total thickness of which is in the *nanoscale* (3.1.7)

3.3 Terms describing elements having internal or surface structures in the nanoscale

3.3.1

nanostuctured layer

layer (3.1.2) having internal structure or surface structure in the *nanoscale* (3.1.7)

3.3.2

nanostuctured coating

coating (3.1.6) having internal structure or surface structure in the *nanoscale* (3.1.7)

3.3.3

nanostructured film

film (3.1.1) having internal structure or surface structure in the *nanoscale* (3.1.7)

3.3.4

nanocomposite film

solid *film* (3.1.1) comprising a mixture of two or more phase-separated materials, with one or more phase in the *nanoscale* (3.1.7)

Note 1 to entry: Materials with nanophases formed by precipitation are included (e.g. a-C:H:Me coatings).

Note 2 to entry: See ISO/TS 80004-4:2011, 3.2 for the definition of nanocomposite.

3.3.5

nanocomposite coating

solid *coating* (3.1.6) comprising a mixture of two or more phase-separated materials, with one or more phase in the *nanoscale* (3.1.7)

Note 1 to entry: Materials with nanophases formed by precipitation are included (e.g. a-C:H:Me coatings).

Note 2 to entry: See ISO/TS 80004-4:2011, 3.2 for the definition of nanocomposite.

3.3.6

nanoporous membrane

membrane (3.1.5) having *nanopores* (3.1.10) allowing the passage of gas and liquid

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