TECHNICAL SPECIFICATION

ISO/TS 80004-4

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Nanotechnologies — Vocabulary —

Part 4: Nanostructured materials

Nanotechnologies — Vocabulaire —

Partie 4: Matériaux nanostructurés

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of document:

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ISO/TS 80004-4 was prepared by Technical Committee ISO/TC 229, *Nanotechnologies*.

ISO/TS 80004 consists of the following parts, under the general title *Nanotechnologies — Vocabulary*:

— *Part 1: Core terms*

— *Part 3: Carbon nano-objects*

— *Part 4: Nanostructured materials*

— *Part 5: Nano/bio interface*

— *Part 7: Diagnostics and therapeutics for healthcare*

The following parts are under preparation:

— *Part 2: Nano-objects: Nanoparticle, nanofibre and nanoplate*[1)]

— *Part 6: Nanoscale measurement and instrumentation*

— *Part 8: Nanomanufacturing processes*

1) ISO/TS 27687:2008, *Nanotechnologies — Terminology and definitions for nano-objects — Nanoparticle, nanofibre and nanoplate,* will be revised as ISO 80004-2.

Introduction

With increasing scientific knowledge and a growing number of technical terms in this field, the purpose of this Technical Specification is to define important terms for nanostructured materials.

Nanostructured materials are characterized by internal structures or surface structures at the nanoscale. Nano-objects (material with one, two or three external dimensions in the nanoscale) can be nanostructured.

A material should not be classified as nanostructured based solely on its crystalline properties (three-dimensional arrangements of atoms or molecules forming a crystallite, short range order of atoms in amorphous or quasi-amorphous phases, grain boundaries, intragranular interfaces, dislocations, etc.). In contrast, materials with a grain size distribution having a significant fraction of grains in the nanoscale (nanocrystalline), voids and pores in the nanoscale, or precipitations in the nanoscale (i.e. nano-objects in a solid matrix) are sufficient features for materials to be classified as "nanostructured" (see ISO/TS 80004-1:2010, 2.4, nanomaterial). Similarly, almost all materials always have surfaces with morphological and chemical heterogeneities in the nanoscale. Only surfaces that have been intentionally modified or textured to have morphological or chemical heterogeneities in the nanoscale identify materials as "nanostructured".

Five categories of nanostructured materials are covered in this Technical Specification (see Figure 1):

1) nanostructured powder;

2) nanocomposite;

3) solid nanofoam;

4) nanoporous material;

5) fluid nanodispersion.

For some of these five categories, a number of subcategory terms are also defined. The category and subcategory terms are not comprehensive; additional categories and subcategories will be added in later revisions of this Technical Specification.

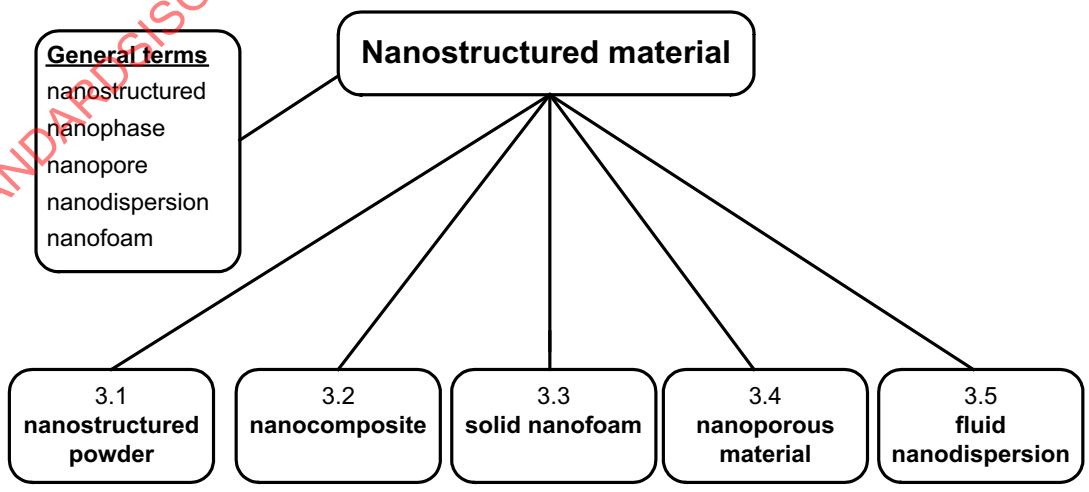

Figure 1 — Categories of nanostructured materials defined in this Technical Specification

In both nanopowders and fluid nanodispersions, the nano-objects (or their aggregates or agglomerates) are arranged in a non-random distribution (generating a short-range order, i.e. a structure). Also, it is recognized that in many cases the nano-objects (or their aggregates or agglomerates) will interact with the molecules of the liquid (particularly in polar liquids) in a thin boundary layer on the surface of each particle. The homogeneity of properties in the liquid is modified in terms of a “nanostructure”. The effects can be revealed by physico-chemical measurements.

If, on the other hand, the liquid medium serves as a background and there is no particular interrelation among the nano-objects contained within it, then such a nanosuspension is not considered “nanostructured” as a whole but rather just as an ensemble of nano-objects. In this sense, the term “nanosuspension” as defined here recognizes a grey zone between nanostructured material and a material consisting of nano-objects. Overall, the conclusion was that the term “nanosuspension” should be included in this Technical Specification because of its current and expanding usage to describe materials in the field.

Nanotechnologies — Vocabulary —

Part 4:
Nanostructured materials

1 Scope

This Technical Specification gives terms and definitions for materials in the field of nanotechnologies where one or more components are nanoscale regions and the materials exhibit properties attributable to the presence of those nanoscale regions. It is intended to facilitate communications between organizations and individuals in industry and those who interact with them.

Materials have topographical or compositional features at the nanoscale, but this is not sufficient to classify the material as nanostructured. Materials classified as nanostructured have an internal or surface structure with a significant fraction of features, grains, voids or precipitates in the nanoscale. Articles that contain nano-objects or nanostructured materials are not necessarily nanostructured materials themselves.

This Technical Specification includes nanodispersion.

2 Basic terms used in the description of nanostructured material

2.1
nanoscale
size range from approximately 1 nm to 100 nm

NOTE 1 Properties that are not extrapolations from a larger size will typically, but not exclusively, be exhibited in this size range. For such properties the size limits are considered approximate.

NOTE 2 The lower limit in this definition (approximately 1 nm) is introduced to avoid single and small groups of atoms from being designated as nano-objects or elements of nanostructures, which might be implied by the absence of a lower limit.

[ISO/TS 80004-1:2010, definition 2.1]

2.2
nano-object
material with one, two or three external dimensions in the **nanoscale** (2.1)

NOTE Generic term for all discrete nanoscale objects.

[ISO/TS 80004-1:2010, definition 2.5]

2.3
nanomaterial
material with any external dimension in the **nanoscale** (2.1) or having internal structure or surface structure in the nanoscale

NOTE This generic term is inclusive of **nano-object** (2.2) and **nanostructured material** (2.11).

[ISO/TS 80004-1:2010, definition 2.4]

2.4
nanoparticle
nano-object (2.2) with all three external dimensions in the **nanoscale** (2.1)

NOTE If the lengths of the longest to the shortest axes of the nano-object differ significantly (typically by more than three times), the terms **nanofibre** (2.5) or **nanoplate** (2.6) are intended to be used instead of the term nanoparticle.

[ISO/TS 27687:2008, definition 4.1]

2.5
nanofibre
nano-object (2.2) with two similar external dimensions in the **nanoscale** (2.1) and the third dimension significantly larger

NOTE Adapted from ISO/TS 27687:2008, definition 4.3.

2.6
nanoplate
nano-object (2.2) with one external dimension in the **nanoscale** (2.1) and the two other external dimensions significantly larger

NOTE 1 The smallest external dimension is the thickness of the nanoplate.

NOTE 2 The two significantly larger dimensions are considered to differ from the nanoscale dimension by more than three times.

NOTE 3 The larger external dimensions are not necessarily in the nanoscale.

[ISO/TS 27687:2008, definition 4.2]

2.7
aggregate
particle comprising strongly bonded or fused particles where the resulting external surface area may be significantly smaller than the sum of calculated surface areas of the individual components

NOTE 1 The forces holding an aggregate together are strong forces, for example covalent bonds, or those resulting from sintering or complex physical entanglement.

NOTE 2 Aggregates are also termed secondary particles and the original source particles are termed primary particles.

[ISO/TS 27687:2008, definition 3.3]

2.8
agglomerate
collection of weakly bound particles or aggregates or mixtures of the two where the resulting external surface area is similar to the sum of the surface areas of the individual components

NOTE 1 The forces holding an agglomerate together are weak forces, for example van der Waals forces, or simple physical entanglement.

NOTE 2 Agglomerates are also termed secondary particles and the original source particles are termed primary particles.

[ISO/TS 27687:2008, definition 3.2]

2.9
nanostructure
composition of inter-related constituent parts in which one or more of those parts is a **nanoscale** (2.1) region

NOTE A region is defined by a boundary representing a discontinuity in properties.

[ISO/TS 80004-1:2010, definition 2.6]

2.10
nanostructured
having internal or surface structure in the **nanoscale** (2.1)

NOTE If external dimensions are in the nanoscale, the term **nano-object** (2.2) is recommended.

2.11
nanostructured material
material having internal or surface structure in the **nanoscale** (2.1)

NOTE 1 If external dimensions are in the nanoscale, the term **nano-object** (2.2) is recommended.

NOTE 2 Adapted from ISO/TS 80004-1:2010, definition 2.7.

2.12
nanophase
physically or chemically distinct region or collective term for physically distinct regions of the same kind in a material with the discrete regions having one, two or three dimensions in the **nanoscale** (2.1)

NOTE **Nano-object**s (2.2) embedded in another phase constitute a nanophase.

2.13
nanopore
cavity with at least one dimension in the **nanoscale** (2.1), which may contain a gas or liquid

NOTE 1 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 15901-3:2007.

NOTE 2 When nanopores are appropriately interconnected they may allow for transport through the material (permeability).

2.14
nanodispersion
material in which **nano-object**s (2.2) or a **nanophase** (2.12) are dispersed in a continuous phase of a different composition

2.15
nanofoam
liquid or solid matrix, filled with a second, gaseous phase, typically resulting in a material of much lower density with a **nanostructured** (2.10) matrix, for example having **nanoscale** (2.1) struts and walls, or a gaseous **nanophase** (2.12) consisting of nanoscale bubbles (closed nanofoam), or both

3 Terms describing categories of nanostructured material

3.1
nanostructured powder
powder comprising **nanostructured agglomerate**s (3.1.2), **nanostructured aggregate**s (3.1.1), or other particles of **nanostructured material** (2.11)

NOTE The term “powder” is used in the sense of an assembly of discrete particles, usually less than 1 mm in size (see ISO 3252:1999, definition 1001).

3.1.1
nanostructured aggregate
aggregate (2.7) formed from **nano-object**s (2.2)

NOTE By definition, aggregates cannot easily release nano-objects.

3.1.2
nanostructured agglomerate
agglomerate (2.7) of **nano-object**s (2.2), or agglomerate of **nanostructured** (2.10) **aggregate**s (2.7)

3.1.3
nanostructured core-shell particle
particle consisting of a core and shell(s), where the diameter of the core or the thickness of the shell is in the **nanoscale** (2.1)

NOTE If at least one external dimension is at the nanoscale, the term **nano-object** (2.2) is preferred.

3.1.4
nanostructured capsule
shell with **nanoscale** (2.1) thickness, which can enclose, fix, transport or release substances

3.2
nanocomposite
solid comprising a mixture of two or more phase-separated materials, one or more being **nanophase** (2.12)

NOTE 1 Gaseous nanophases are excluded [they are covered by **nanoporous material** (3.4)].

NOTE 2 Materials with **nanoscale** (2.1) phases formed by precipitation alone are not considered to be nanocomposite materials.

3.2.1
polymer matrix nanocomposite
nanocomposite (3.2) with at least one major polymeric phase

3.2.1.1
polymer clay nanocomposite
polymer matrix nanocomposite (3.2.1) with a **nanostructured** (2.10) clay phase

3.2.2
metal matrix nanocomposite
nanocomposite (3.2) with at least one major metallic phase

3.2.3
ceramic matrix nanocomposite
nanocomposite (3.2) with at least one major ceramic phase

3.3
solid nanofoam
solid matrix filled with a second, gaseous phase, typically resulting in a material of much lower density, with a **nanostructured** (2.10) matrix, for example having **nanoscale** (2.1) struts and walls, or gaseous **nanophase** (2.12) consisting of nanoscale bubbles [closed **nanofoam** (2.15)], or both

3.4
nanoporous material
solid material with **nanopore**s (2.13)

NOTE 1 The solid may be either amorphous, crystalline, or a mixture of both.

NOTE 2 The definitions of **solid nanofoam** (3.3) (where most of the volume is occupied by pores) and nanoporous material (also materials with a small fraction of pores covered) are overlapping.

3.5
fluid nanodispersion
heterogeneous material in which **nano-object**s (2.2) or a **nanophase** (2.12) are dispersed in a continuous fluid phase of a different composition

3.5.1
nanosuspension
fluid nanodispersion (3.5) where the dispersed phase is a solid

NOTE The use of the term "nanosuspension" carries no implication regarding thermodynamic stability.

3.5.2
nano-emulsion
fluid nanodispersion (3.5) with at least one liquid **nanophase** (2.12)

3.5.3
liquid nanofoam
fluid nanodispersion (3.5) filled with a second, gaseous **nanophase** (2.12), typically resulting in a material of much lower density

3.5.4
nano-aerosol
fluid nanodispersion (3.5) with gaseous matrix and at least one liquid or solid **nanophase** (2.12) [including **nano-object**s (2.2)]