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Nanotechnologies — Vocabulary —

Part 12: **Quantum phenomena in nanotechnology**

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Partie 12: Phénomènes quantiques dans les nanotechnologies

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Foreword

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

ISO/TS 80004-12 was prepared jointly by Technical Committee ISO/TC 229, *Nanotechnologies*, and Technical Committee IEC/TC 113, *Nanotechnology standardization for electrical and electronic products and systems*. The draft was circulated for voting to the national bodies of both ISO and IEC.

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

— *Part 1: Core terms*

— *Part 2: Nano-objects*

— *Part 3: Carbon nano-objects*

— *Part 4: Nanostructured materials*

— *Part 5: Nano/bio interface*

— *Part 6: Nano-object characterization*

— *Part 7: Diagnostics and therapeutics for healthcare*

— *Part 8: Nanomanufacturing processes*

— *Part 12: Quantum phenomena in nanotechnology*

The following parts are under preparation:

— *Part 9: Nano-enabled electrotechnical products and systems*

— *Part 10: Nano-enabled photonic components and systems*

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

— *Part 13: Graphene and other two dimensional materials*

Introduction

The unique properties of nano-objects and nanoscale-dependent quantum effects are important aspects of nanotechnology.

As the size of materials decreases to the nanometre range, quantization effects (quantization of energy, quantization of angular momentum, etc.) appear mainly due to the confinement of particles in one, two or three space dimensions (quantum confinement). This leads to the emergence of new size-dependent properties and functionalities which are completely described by quantum mechanics.

It is to be noted that the term “particle” used in this part of ISO/TS 80004 encompasses both the classical and quantum standpoints. In its classical sense, a particle is a discrete portion of matter and is therefore close to the term “particle” as defined in ISO/TS 80004-2 as a “minute piece of matter with defined physical boundaries”. From the perspective of quantum, particles are objects obeying the laws of quantum mechanics. The quantum description includes electrons, atoms, molecules, etc., referred to as particles, and quasi-particles (excitons, phonons, plasmons, magnons, etc.) which are elementary excitations or quanta of collective excitations in strongly interacting systems of particles.

Although quantum effects do not occur exclusively at the nanoscale, the relationship of nanotechnology and quantum effects, or combinations thereof, is important for the identification of nano-enabled products and for the development of nanotechnology.

With regard to the origin of terms, quantum effects terms are often associated with the names of those who discovered them. As such, they are often the subject of controversy about precedence. In addition, quantum phenomena and effects might have different names in different countries.

Nanotechnologies are rapidly evolving fields of technologies and advances in these fields are closely linked to the understanding of quantum effects and phenomena. It is expected that more quantum phenomena-related terms will be added in future revisions of the present document.

This part of ISO/TS 80004 promotes a common language for use by the nanotechnology industry and interdisciplinary research in these areas, organizes features of nanotechnology and contributes to cooperation in the field of nanotechnology and trade in the global market of nano-enabled products.

Some established terms and definitions of quantum mechanics have been gathered in Annex A in order to facilitate the reading of this part of ISO/TS 80004.

Nanotechnologies — Vocabulary —

Part 12:
Quantum phenomena in nanotechnology

1 Scope

This part of ISO/TS 80004 lists terms and definitions relevant to quantum phenomena in nanotechnologies.

All of these terms are important for nanotechnologies, but it is to be noted that many of them are not exclusively relevant to the nanoscale and can also be used to some extent to refer to larger scales.

The list of terms presented does not claim to provide exhaustive coverage of the whole spectrum of quantum concepts and phenomena in nanotechnology. It covers important phenomena as acknowledged by many stakeholders from academia, industry, etc.

This part of ISO/TS 80004 is intended to facilitate communication between organizations and individuals in industry and those who interact with them.

2 Terms describing (or related to) general quantum concepts

2.1
de Broglie wavelength
wavelength of the wave associated with any particle which reflects its wave nature according to de Broglie's formula

Note 1 to entry: de Broglie's formula is $\lambda = h/p$, where λ is the wavelength, h is the Planck's constant and p is the particle momentum.

2.2
quantization
process resulting in quantized physical quantities

2.3
quantized
having discrete values which are multiples of an elementary quantity

Note 1 to entry: The elementary quantity mentioned above is usually called a quantum of the physical quantity in consideration.

2.4
quantum coherence
correlated evolution of wave function phase of a system in a *quantum superposition* (2.9)

Note 1 to entry: Quantum decoherence is the loss of quantum coherence.

2.5
quantum confinement
restriction of a particle's motion in one, two or three space dimensions when the size of a physical system is of the same order of magnitude as the particle's *de Broglie's wavelength* (2.1)

Note 1 to entry: The main characteristic lengths leading to quantum confinement may be their de Broglie wavelength, their Fermi wavelength, their mean free path, their Bohr radius (for excitons) or their coherence length.