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Use of UV-Vis absorption spectroscopy in the characterization of cadmium chalcogenide colloidal quantum dots

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Use of UV-Vis absorption spectroscopy in the characterization of cadmium chalcogenide colloidal quantum dots

Utilisation de la spectroscopie d'absorption dans l'UV-visible pour la caractérisation des points quantiques colloïdaux des chalcogénures de cadmium

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Foreword

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The committee responsible for this is document is ISO/TC 229, *Nanotechnologies*.

Introduction

Engineered nanoparticles of semiconductor materials with sizes down to the extent where the behaviour of electrons and holes are affected by the quantum confinement often possess unique electronic and optical properties intermediate between those of bulk semiconductors and those of discrete molecules. This normally refers to a nanoparticle diameter comparable to the Bohr radius of the exciton for the particular semiconductor material. Such nanoparticles are generally called quantum dots (QDs). A significant feature of these nanoparticles resulting from quantum confinement of charge carriers is size dependence of their electronic structure and, consequently, the excitonic absorption and emission wavelengths. Particularly, the transition energy from the valence band to the conduction band, and consequently the onset of absorption and the first excitonic transition (referred to here as first absorption peak position), is a function of the diameter of the particle (see Reference [1]).

Quantum dots commonly present sophisticated core-shell structures with a ligand shell controlling solubility and subsequent chemical functionalization. They are typically synthesized by chemical methods, with large-scale production and their size, shape, composition, and structure control capabilities. Commercially available quantum dots are mainly made from cadmium chalcogenide (CdTe, CdSe, CdS) materials. The size dependence of emission maximum, narrow emission band width, and good photostability make these engineered nanoparticles appealing in biological labelling and opto-electronics applications (see Reference [2]).

Ultraviolet-visible (UV-Vis) absorption spectroscopy has become a routine method to characterize QDs in a colloidal dispersion, by utilizing the relationship between the wavelength of the first excitonic absorption peak and the particle size that has been established after extensive photophysics research in the past, and using analytical methods for high-quality cadmium chalcogenide (CdTe, CdSe, CdS) materials of narrow size distribution. Key properties, such as average nanoparticle size and number concentration, can be approximately calculated from the measured absorption spectra. This Technical Specification intends to facilitate the use of UV-Vis spectroscopy for the characterization of quantum dot colloidal dispersions.

Use of UV-Vis absorption spectroscopy in the characterization of cadmium chalcogenide colloidal quantum dots

1 Scope

This Technical Specification provides guidelines for estimating the diameter and the number concentration of monodisperse cadmium chalcogenide (CdTe, CdSe, CdS) quantum dots (QDs) with a narrow size distribution in a colloidal dispersion using Ultraviolet-visible (UV-Vis) absorption spectroscopy.

The analysis of the spheroidal particle size is applicable to the diameter range of 3,5 nm to 9 nm for CdTe, 1 nm to 8 nm for CdSe, and 1 nm to 5,5 nm for CdS and is recommended for samples with narrow size distributions.

2 Terms, definitions, and abbreviated terms

2.1 Terms and definitions

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

2.1.1
quantum dot
QD
crystalline nanoparticle that exhibits size-dependent properties due to quantum confinement effects on the electronic states

[SOURCE: ISO/TS 27687:2008, definition 4.7]

2.1.2
quantum confinement
boundary condition resulting in phenomena when electrons and holes in a material are confined by a potential well in one dimension (quantum well), in two dimensions (quantum wire), or in three dimensions (quantum dot)

[SOURCE: ISO/IEC DTS 80004-12, definition 2.5]

2.1.3
first excitonic absorption
light absorption in quantum dots originating from the electronic transition from ground state to first excitonic excited state

2.2 Abbreviated terms

QD	quantum dot
TEM	transmission electron microscopy
TOPO	trioctylphosphine oxide
OPA	n-octylphosphonate
HDA	hexadecylamine