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NATIONAL STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

GB/T 47182-2026

Microbeam analysis - Analytical electron microscopy - Method for determining the shell thickness of core-shell particles

微束分析 分析电子显微术 核壳颗粒壳壁厚度的测量方法

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Foreword

This document complies with the provisions of GB/T 1.1-2020 "Standardization Work Guidelines Part

1.Structure and Drafting Rules of Standardization Documents". Drafting. Please note that some content in this document may involve patents. The issuing organization of this document assumes no responsibility for identifying patents. This document was proposed and is under the jurisdiction of the National Technical Committee on Standardization of Microbeam Analysis (SAC/TC38). This document was drafted by: Beijing University of Science and Technology, National Standard (Beijing) Testing and Certification Co., Ltd., Baotou Rare Earth Research Institute, and Beijing University of Chemical Technology. The main drafters of this document are. Quan Maohua, Liu Delu, Jia Rongguang, Ren Xudong, Hong Song, and Ma Tongda.

Core-shell nanomaterials are a new type of nanomaterial that has emerged in recent years. Their unique structure integrates the properties of both the inner and outer layers of the material, allowing them to interact and complement each other. This supplements materials

and imparts new properties. Currently, multi-layered core-shell materials are constantly emerging, finding applications in energy storage, catalysis, medicine, batteries, gas storage and separation, etc. It has wide applications and significant economic benefits. The shell thickness of core-shell materials is one of the key technical indicators determining the performance of these materials. To keep pace with my country's scientific and technological development trends, the development of core-shell materials... The development of well-designed and high-performance micro/nano-scale core-shell materials necessitates precise measurement of the micro/nano-shell thickness. This document aims to standardize the use of transmission electron microscopy (TEM) for this purpose. A method for measuring the shell thickness of micro/nano-scale core-shell particles using micromicroscopy/scanning transmission electron microscopy. Microbeam analysis analysis electron microscopy Methods for measuring the shell wall thickness of core-shell particles

1 Scope

GB/T 47182-2026 is the Chinese national standard covering measuring the shell on a core-shell nanoparticle - a few nanometres of one material over another, resolved in the electron microscope, which is the dimension that governs the catalytic, optical or magnetic behaviour of the particle. First edition, in force since 1 September 2026. It was issued on 27 February 2026 and has been in force since 1 September 2026, as a first edition. The document is under the responsibility of the Standardization Administration of China. This page is published from the official record of the 2026 edition; the clause text of a standard this recent is not yet in circulation, and the figures, limits and tables it contains are those of the document itself, delivered in full with the English translation.

This document describes the acquisition of nanoscale core-shell materials using transmission electron microscopy/scanning transmission electron microscopy (TEM/STEM). A method for projecting patterns and measuring their shell thickness (10nm~100nm). This document applies to digital images of micro/nano particles recorded by TEM/STEM and those equipped with energy-dispersive X-ray spectrometers (EDS) or electronic spectrometers. The elemental distribution map recorded by the energy loss sub-elemental spectrometer (EELS) is used to measure the shell thickness. It is applicable to measuring particle core diameters ranging from 10 nm. 1μm. This document does not apply to particles with horizontally projected shapes where the Z-direction is greater than the X-direction or Y-direction, or particles with complex geometric horizontally projected shapes. Particles, such as sea urchin-like nanoparticles.

Note. The main reason is that when the measured shell thickness fluctuates by more than 20% of the minimum cross-sectional diameter, the uncertainty of this document will increase significantly.

2 Normative references

The contents of the following documents, through normative references within the text, constitute essential provisions of this document. Dated citations are not included. For references to documents, only the version corresponding to that date applies to this document; for undated references, the latest version (including all amendments) applies. This document.

GB/T 27418 Evaluation and Expression of Measurement Uncertainty

GB/T 34002 Method for calibrating image magnification using periodic structure standard materials in microbeam analysis transmission electron microscopy

3 Terms and Definitions

The following terms and definitions apply to this document.

3.1 Core-shell material Materials whose basic structure is formed by one material forming a micro- or nano-hollow shell or by encapsulating another nanomaterial inside.

Note. Hollow shell refers to a structure with a certain wall thickness and an internal cavity.

3.2 The geometric shape projected onto a horizontal plane after the electron beam penetrates the sample vertically.

3.3 Contrast The difference in signal strength between two arbitrary selected points (P1, P2) of interest on the image, expressed as the maximum signal strength obtained under specific operating conditions. The intensity of the signal is normalized.

Note. Contrast is expressed by formula (1). C =|S2-S1|/Smax(0< C < 1) (1) In the formula.