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Microbeam analysis — Analytical electron microscopy — Vocabulary

Analyse par microfaisceaux — Microscopie électronique analytique — Vocabulaire

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

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ISO 15932 was prepared by Technical Committee ISO/TC 202, *Microbeam Analysis*, Subcommittee SC 1, *Terminology*.

Introduction

Analytical electron microscopy (AEM) is a technique used to qualitatively determine and quantitatively measure the elemental composition and examine the electronic state of the small area of solid material observed by TEM/STEM. AEM is based on the physical mechanism of electron-stimulated X-ray spectrometry and electron energy loss spectrometry. AEM also provides structure information from small regions by micro-diffraction technique using small electron probe.

As a major sub-field of microbeam analysis (MBA), AEM is widely applied in diverse business sectors (high－tech industries, basic industries, metallurgy and geology, biology and medicine, environmental protection, trade. etc.) and has a wide business environment for standardization.

Standardization of terminology in a technical field is one of the basic prerequisites for development of standards on other aspects of that field.

This International Standard is relevant to the international scientific and engineering communities that require an AEM vocabulary that contains consistent definitions of terms as they are used in the practice of microbeam analysis combined with transmission electron microscopy and scanning transmission electron microscopy.

This International Standard is one developed in a package of standards on scanning electron microscopy (SEM), Electron probe X-ray microanalysis (EPMA), energy－dispersive spectroscopy (EDS) etc. which have been already developed and are to be developed by ISO/TC202, *Microbeam analysis*, Subcommittee SC1, *Terminology*, to cover the complete field of MBA.

Microbeam analysis — Analytical electron microscopy — Vocabulary

1 Scope

This International Standard defines terms used in the practices of analytical electron microscopy (AEM). It covers both general and specific concepts classified according to their hierarchy in a systematic order.

This International Standard is applicable to all standardization documents relevant to the practice of AEM. In addition, some parts of this International Standard are applicable to those documents relevant to the practice of related fields (e.g. TEM,STEM,SEM, EPMA, EDX) for definition of those terms common to them.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 704, *Terminology work—Principles and methods*

ISO 1087-1, *Terminology work— Vocabulary — Part 1: Theory and application*

ISO 10241, *International terminology standards — Preparation and layout*

ISO 22493, *Microbeam analysis—Scanning electron microscopy—Vocabulary*

ISO 23833, *Microbeam analysis—Electron probe microanalysis(EPMA)—Vocabulary*

3 Abbreviations

AEM analytical electron microscopy/microscope

CBED convergent beam electron diffraction

CRT cathode ray tube

EDS energy dispersive X-ray spectroscope/spectroscopy

EDX energy dispersive X-ray spectroscope/spectroscopy

EELS electron energy loss spectroscope/spectroscopy

FFT fast Fourier transformation

FIB focused ion milling

FWHM full width at half maximum

HAADF high angle annular dark field

HREM high-resolution transmission electron microscope/microscopy

SE secondary electron

STEM scanning transmission electron microscope/microscopy

TEM transmission electron microscope/microscopy

4 Definitions of terms used in the physical basis of AEM

4.1
electron optics
science that deals with the trajectory of electrons as they pass through electrostatic and/or electromagnetic fields

4.1.1
electron source
device that generates electrons necessary for forming an electron beam in the electron optical system

4.1.1.1
energy spread
diversity of energy of electrons in the incident beam

4.1.1.2
effective source size
effective dimension of the electron source typically measured at the beam crossover

4.1.2
electron emission
ejection of electrons from the surface of a material under certain conditions

4.1.2.1
thermionic emission
electron emission caused by the application of a electrostatic field, which relies on the use of high temperature to enable electrons in the cathode to overcome the work function energy barrier and escape into the vacuum

4.1.2.2
field emission
electron emission caused by the strong electric field on and near the surface of the material

4.1.2.2.1
cold field emission
field emission in which the emission process relies purely on the applied electric field to extract electrons from the cathode operating at ambient temperature

4.1.2.2.2
thermal field emission
field emission in which the emission process relies on both the elevated temperature of the cathode tip and an applied electric field of high voltage in a high vacuum environment

4.1.3
electron lens
basic component of an electron optical system, using an electrostatic and/or electromagnetic field to change the trajectories of the electrons passing through it

4.1.3.1
electrostatic lens
electron lens employing an electrostatic field formed by a specific configuration of electrodes

4.1.3.2
electromagnetic lens
electron lens employing an electromagnetic field formed by a specific configuration of electromagnetic coil (or permanent magnet) and polepiece

4.1.4
focusing
converging an electron beam to a specific point using an electron lens

4.1.5
demagnification
numerical value by which the diameter of the electron beam exiting a lens is reduced in comparison to the diameter of the electron beam entering the lens

4.2
electron scattering
electron deflection with or without the loss of kinetic energy as a result of collision(s) with target atom(s) or electron(s)

4.2.1
elastic scattering
electron scattering in which energy and momentum are conserved in the collision

4.2.1.1
zero-loss
unscattered and elastically scattered electrons (with only minimal loss of energy due to phonon excitation), giving rise to an intensity peak or the position of which defines zero in the electron energy loss spectrum

4.2.2
inelastic scattering
electron scattering in which energy and/or momentum are not conserved in the collision system

NOTE For inelastic scattering, the electron trajectory is modified by plasmon loss, core loss and other multiple scatterings

4.2.2.1
thermal diffuse scattering
electron scattering which is caused by electron-phonon scattering due to thermal vibration of the lattice

4.2.2.2
plasmon loss
type of energy loss in EELS in which the incident electron is affected by the collective oscillations of free electrons in the specimen and loses kinetic energy as a result

4.2.2.3
inner-shell ionization
excitation of an electron bound in an inner-shell(nonvalence) orbital to an unbound state in the continuum above the Fermi level

4.2.2.4
core-loss
energy loss of an electron in the beam caused by excitation of an of an inner shell electron

4.2.3
scattering cross-section
hypothetical area normal to the incident radiation that would geometrically intercept the total amount of radiation actually scattered by a scattering atom

NOTE Scattering cross-section is usually expressed only as area (m^2).

4.3
Bloch wave
wave function of an electron in a periodic crystal potential which is written as the product of a plane wave envelope function and a periodic function that has the same periodicity as the crystal poteritial

4.3.1
anomalous absorption
absorption of Bloch wave in the crystalline material when the wave is symmetric and forms its antinodes at the nuclei

4.3.2
anomalous transmission
absorption of Bloch wave in the crystalline material when the wave is antisymmetric and forms its nodes at the nuclei

4.4
coherence
wave property exhibited by electron beams in which two waves share the same frequency and are in phase.

NOTE Phase shifts between two coherent beams result in interference and generate diffraction patterns.

4.5
TEM
microscopy technique where images of an ultra thin specimen are obtained by a electron beam that transmits the specimen

4.5.1
HREM
method for obtaining lattice and crystal structure image by interfering a transmitted electron wave and diffracted electron waves using the electromagnetic lens with small spherical aberration

4.5.2
STEM
type of transmission electron microscope which rasters the focused electron beam scanned over the specimen

4.5.3
HAADF-STEM
imaging mode in a scanning transmission electron microscope (STEM) in which images are formed by collecting very high angle, incoherently scattered electrons with an annular dark-field detector

4.6
electron holography
application of holography techniques to electron waves in which the coherent beam is split into at least two beams by using an electron biprism

4.6.1
electron prism
device which splits the coherent electron beam into several beams in order to obtain interferogram, hologram