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Surface chemical analysis — Determination of lateral resolution and sharpness in beam based methods with a range from nanometres to micrometres

Analyse chimique des surfaces — Détermination de la résolution latérale et de la netteté par des méthodes à base de faisceau utilisant une gamme allant des nanomètres aux micromètres

Reference number
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Contents

Page

Foreword ..... **v**

Introduction ..... **vi**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Symbols and abbreviated terms **3**

5 General information **4**
5.1 Background 4
5.2 Survey on principal methods to characterize lateral resolution in imaging surface chemical analysis 5
5.3 Measurement of lateral resolution in imaging surface chemical analysis 6
5.4 Dependence of lateral resolution on scan direction 6
5.5 Reporting results 7

6 Measurement of lateral resolution using the straight edge method **8**
6.1 Introduction 8
6.2 Model functions and sharpness parameters 8
6.3 Requirements for a test sample 9
6.4 Cleaning the straight-edge specimen 10
6.5 Mounting the straight-edge specimen 10
6.6 Operating the instrument 10
6.7 Data acquisition requirements 10
6.8 Determination of D_{12-88} 11
6.9 Determination of line spread function 11
6.10 Reporting 11

7 Measurement of lateral resolution using the narrow line method **13**
7.1 Introduction 13
7.2 Requirements for a test sample 13
7.3 Cleaning the narrow stripe specimen 13
7.4 Mounting the narrow stripe specimen 14
7.5 Operating the instrument 14
7.6 Data acquisition requirements 14
7.7 Determination of w_{LSF} 14
7.8 Reporting 15

8 Measurement of lateral resolution using the grating method **17**
8.1 Introduction 17
8.2 Requirements for a test sample 17
8.3 Cleaning the grating specimen 19
8.4 Mounting the grating specimen 19
8.5 Operating the instrument 20
8.6 Data acquisition 20
8.7 Estimation of effective lateral resolution r_e by visual inspection of an image or a line scan 20
8.8 Determination of effective lateral resolution r_e by numerical analysis of a line profile 23
8.8.1 General 23
8.8.2 Consideration of noise and determination of reduced noise σ_{Nr} 23
8.8.3 Determination of dip D 24
8.8.4 Resolution criterion 25
8.9 Determination of the effective lateral resolution r_e using graded gratings 26
8.9.1 Estimation of effective lateral resolution r_e by using the resolution criterion in Formula (17) 26

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8.9.2 Determination of effective lateral resolution r_e by using Formula (17) and an interpolation–extrapolation method 27
8.10 Reporting 29
Annex A (informative) **The relation between sharpness parameters and effective lateral resolution** **31**
Annex B (informative) **Straight edge method: systematic underestimation of D_{12-88} caused by insufficient plateau length L_{pl}** **33**
Annex C (informative) **Straight edge method: required length ranges for L_{ESF}** **35**
Annex D (informative) **Straight edge method: the uncertainty of D_{12-88}** **36**
Annex E (informative) **Narrow stripe method: systematic overestimation of w_{LSF} caused by inappropriately large widths w_s of the imaged stripe** **37**
Annex F (informative) **Narrow line method: the uncertainty of w_{LSF}** **39**
Annex G (informative) **Imaging of square gratings: reduction of image period for three-stripe gratings** **40**
Annex H (informative) **Imaging of square gratings: relation between signal-to-noise ratio and effective lateral resolution** **43**
Annex I (informative) **Imaging of square gratings: minimum number of sampling points per period** **46**
Annex J (informative) **Imaging of square gratings: uncertainty of r_e determined by visual inspection of an image or line scan over a series of gratings** **47**
Annex K (informative) **Imaging of square gratings: Uncertainty of r_e determined by interpolation–extrapolation** **48**
Annex L (informative) **Determination of lateral resolution by imaging of square wave gratings — practical example for SIMS** **50**
Bibliography **53**

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 201, *Surface chemical analysis*, Subcommittee SC 2, *General procedures*.

This second edition cancels and replaces the first edition, ISO 18516:2006, which has been technically revised as follows:

1. content related to straight edge method expanded;
2. new content addressing the narrow stripe method added;
3. new content addressing the use of gratings in the determination of lateral resolution added;
4. implementation of concepts developed in ISO/TR 19319:2013(E);
5. title and scope changed to address nanotechnology following the recommendations of TC 201/SG 1.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

Secondary ion mass spectrometry (SIMS), Auger electron spectroscopy (AES) and X-ray photoelectron spectroscopy (XPS) are surface-analytical techniques that are used to generate chemical maps of surfaces and line scans across surfaces. These techniques can have lateral resolutions for instance as good as 10 nm for AES, 50 nm for SIMS and 5 μm for laboratory XPS and can cover areas as large as many square millimetres by using stitching techniques. Different instruments generate images with different lateral resolutions. Moreover, an analyst needs to have a suitable method to measure the lateral resolution of an instrument for any given settings. In this way, analysts can obtain the optimum lateral resolution from a given instrument, appropriate to the analytical requirements, in a consistent and clear way. The ability of the analyst to realize these resolutions in an effective way will, of course, also depend on the quality of the signal levels obtained and the level of noise. Resolution is a quality parameter of images and line scans and describes the performance of imaging instruments used to deliver them. This document is based on ISO/TR 19319:2013, which explains theoretical backgrounds of a determination of resolution and sharpness parameters used to express the performance of imaging instruments[1].

This document describes different methods for the determination of lateral resolution in beam-based methods as AES, SIMS and XPS. These are (a) the straight edge method, (b) the narrow line method and (c) the grating method. The method to be chosen for use depends on the expected value of the lateral resolution and the specific needs to be addressed. The standard is targeted at the needs of different communities: the manufacturers for specifying or benchmarking an instrument, the analysts in a laboratory for their day-to-day running of instruments to match the needs of good laboratory practice (GLP) and the analysts in testing laboratories operating under a formal accreditation scheme, for example ISO 17025, who must prepare and run standard operation protocols (SOP) for regular function control of instruments.

The annexes provide forthcoming information on how to find appropriate measurement parameters, considerations of the uncertainty of measurement and one practical example, the determination of effective lateral resolution by evaluation of a secondary ion image of a grating.

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Surface chemical analysis — Determination of lateral resolution and sharpness in beam based methods with a range from nanometres to micrometres

1 Scope

This document describes methods for measuring lateral resolution and sharpness in imaging surface chemical analysis. It applies to all methods of surface analysis which use a beam to analyse the chemical composition of surfaces under defined settings of an instrument. It applies to scanning instruments, where a finely focused beam is scanned over the sample in a preselected field of view, as well as to full field imaging instruments, where the field of view is simultaneously imaged by a broad beam, an imaging lens system and a pixelated detector. The methods for measuring lateral resolution and sharpness are

— the straight edge method;

— the narrow line method;

— the grating method.

This document applies to instruments and methods that provide information on layers with nanometre thicknesses and to surfaces with nanometre-sized structures and individual nano-objects.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 16242:2011, *Surface chemical analysis — Recording and reporting data in Auger electron spectroscopy (AES)*

ISO 16243:2011, *Surface chemical analysis — Recording and reporting data in X-ray photoelectron spectroscopy (XPS)*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
edge spread function
ESF
normalized spatial signal distribution in the linearized output of an imaging system resulting from imaging a theoretical infinitely sharp edge

[SOURCE: ISO 12231:2012, 3.43, modified — note removed]

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3.2
effective lateral resolution
r_e
minimum spacing at which two features of the image can be recognised as distinct and separate

Note 1 to entry: For the analytical methods in the scope of this document the image is formed from chemical composition data.

Note 2 to entry: "effective" has been added because the lateral resolution characteristic of an image is not only defined by the instrument used for taking it but also by the noise in the image data (see Reference [2] and ISO/TR 19319:2013). Effective lateral resolution r_e as introduced in this document takes account of that noise.

Note 3 to entry: The said minimum spacing can be determined as that distance between two stripes of a square-wave grating at which the dip of signal intensity between two maxima of the measured grating profile is at least four times the reduced noise.

Note 4 to entry: In microbeam analysis [ISO 22493:2008, 7.2] the term "image resolution" is defined in a similar way.

3.3
line spread function
LSF
normalized spatial signal distribution in the linearized output of an imaging system resulting from imaging a theoretical infinitely thin line

[SOURCE: ISO 12231:2012, 3.94]

3.4
noise
time-varying disturbances superimposed on the analytical signal with fluctuations leading to uncertainty in the signal intensity

Note 1 to entry: An accurate measure of noise can be determined from the standard deviation of the fluctuations.

[SOURCE: ISO 18115-1:2013, 4.315, modified — Note 2 to entry removed.]

3.5
reduced noise
standard deviation of noise σ_N multiplied by $(5/S_{pp})^{1/2}$, where S_{pp} is the number of sampling points per period in the measured grating profile

3.6
sharpness
property of an image or line scan to show a sharp line of demarcation between two adjacent areas of different signal intensities

Note 1 to entry: For the analytical methods in the scope of this document the signal intensities in images and line scans relate to chemical composition.

Note 2 to entry: In practical laterally resolved surface analysis objective measures of sharpness are realized as the distance $D_{12–88}$ between the 12 % and 88 % intensity points in a line scan across a part of the sample containing a well-defined step function for the signal relating to the property being resolved.

[SOURCE: ISO 6196-5:1987, 05.04, modified]

3.7
signal-to-noise ratio
$R_{S/N}$
ratio of the signal intensity to a measure of the total noise in determining that signal

[SOURCE: ISO 18115-1:2013, 4.427, modified — Notes to entry removed.]

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