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Surface chemical analysis — Secondary ion mass spectrometry — Correction method for saturated intensity in single ion counting dynamic secondary ion mass spectrometry

Analyse chimique des surfaces — Spectrométrie de masse des ions secondaires — Méthode de correction de l'intensité de saturation en SIMS dynamique à comptage d'ions individuel

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 201, *Surface chemical analysis*, Subcommittee SC 6, *Secondary ion mass spectrometry*.

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Introduction

For the quantitative analysis of materials using secondary ion mass spectrometry (SIMS), the abundance of a species should be a linear function of its measured signal intensity. However, this relationship can become nonlinear as the count rates rise because of saturation of the detector, which uses a pulse counting system. This causes underestimation of an abundance of high-count-rate species. The nonlinearity of the counting system can be corrected using the relevant method, so that the corrected count rate gives a wider linear range.

This document explains how to assess the linearity in the high-count-rate region. The document also provides a correction method for the saturated intensity in a certain situation. It uses a test based on depth profile analysis of two isotopes in a reference material which has a gradual concentration change between low and high concentration regimes. The correction method is based on the approximate intermediate extended dead time model.

This document should be used when characterizing a new spectrometer so that it may be operated in an appropriate intensity range or when applying a new analysis condition. It should then be repeated after any substantive modification to the detection circuits, such as the multiplier voltage or the threshold, after replacement of their multiplier, or at approximately 6-monthly intervals.

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Surface chemical analysis — Secondary ion mass spectrometry — Correction method for saturated intensity in single ion counting dynamic secondary ion mass spectrometry

1 Scope

This document specifies a method for determining the maximum count rate for an acceptable limit of divergence from linearity of the intensity scale in pulse counting magnetic sector-type secondary ion mass spectrometers or quadrupole secondary ion mass spectrometers. It uses a test based on depth profile analysis of two isotopes in a reference material which has a gradual concentration change between low and high concentration regimes. It also includes a correction method for saturated intensity caused by the dead time of the detector. The correction can increase the intensity range for 95 % linearity so that a higher maximum count rate can be employed for those spectrometers for which the relevant correction equations have been shown to be valid.

This document does not apply to time of flight mass spectrometers.

This document is only applicable to elements with minor isotopes. It is not applicable if the element is monoisotopic or contains isotopes with equal abundances.

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 18115-1, *Surface chemical analysis — Vocabulary — Part 1: General terms and terms used in spectroscopy*

ISO 18115-2, *Surface chemical analysis — Vocabulary — Part 2: Terms used in scanning-probe microscopy*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18115-1 and ISO 18115-2 and the following 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
major isotope
isotope whose abundance is more than others of the same element

3.2
minor isotope
isotope whose abundance is less than a *major isotope* (3.1)

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3.3
pulse counting system
ion detector system which counts an ion as a single pulse

Note 1 to entry: When an ion reaches the detector it generates some electrons, which are multiplied whenever they collide with the multiplier or channeltron. Sufficient current is then produced so that the ion can be counted as a single pulse.

3.4
medium intensity region
intensity region where the major isotope intensity is still linear and the minor isotope intensity is sufficiently higher than background

3.5
saturation
phenomenon when too many ions reach the detector at the same time, their pulses are overlapped and the detector cannot separate individual pulses

3.6
approximate intermediate extended dead time model
a-IED
model for detector *saturation* (3.5)

4 Symbols and abbreviated terms

The term "intensity" is used below and elsewhere. This refers to a measurement of count rate in the depth profiles.

$I_M(t)$	measured intensity at the time t, expressed in counts per second ($cts \cdot s^{-1}$)
I_{Max}	maximum measured intensity, expressed in counts per second ($cts \cdot s^{-1}$)
$I_{M\text{-}J}(t)$	measured intensity of the major isotope at time t, expressed in counts per second ($cts \cdot s^{-1}$)
$I_{M\text{-}N}(t)$	measured intensity of the minor isotope at time t, expressed in counts per second ($cts \cdot s^{-1}$)
$I_{M\text{-}N\text{-}P}(t')$	$I_{M\text{-}N}(t)$ interpolated at the measurement time of $I_{M\text{-}J}(t')$, expressed in counts per second ($cts \cdot s^{-1}$)
$I_{M\text{-}Max}$	maximum reliable intensity without saturated intensity correction, expressed in counts per second ($cts \cdot s^{-1}$)
$I_C(t)$	corrected intensity at time t, expressed in counts per second ($cts \cdot s^{-1}$)
$I_{C\text{-}J}(t)$	corrected intensity of the major isotope at time t, expressed in counts per second ($cts \cdot s^{-1}$)
$I_{C\text{-}N}(t)$	corrected intensity of the minor isotope at time t, expressed in counts per second ($cts \cdot s^{-1}$)
$I_{C\text{-}N\text{-}P}(t')$	$I_{C\text{-}N}(t)$ which is interpolated at the measurement time of $I_{C\text{-}J}(t')$, expressed in counts per second ($cts \cdot s^{-1}$)
$I_{C\text{-}Max}$	maximum reliable intensity after saturated intensity correction, expressed in counts per second ($cts \cdot s^{-1}$)
$I_{C\text{-}m\text{-}Max}$	maximum reliable measured intensity without intensity correction at $I_{C\text{-}Max}$, expressed in counts per second ($cts \cdot s^{-1}$)
R_J	natural abundance of the major isotope
R_N	natural abundance of the minor isotope
R	practical isotope ratio; isotope ratio (R_J/R_N) multiplied by the transmittance differential efficiency, also known as isotope ratio corrected for mass-fractionation
t_{MM}	maximum time within the medium intensity region, expressed in seconds (s)
t_{ML}	minimum time within the medium intensity region, expressed in seconds (s)
t_{CM}	time at $I_{C\text{-}Max}$, expressed in seconds (s)
N_{Mid}	number of data points in the medium intensity region
N_{Cor}	number of data points for the intensity from the $I_{M\text{-}Max}$ up to the $I_{C\text{-}Max}$
ρ	parameter corresponding to the degree of dead time extension; extension parameter

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