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Surface chemical analysis — Vocabulary —

AMENDMENT 2

Analyse chimique des surfaces — Vocabulaire —

AMENDEMENT 2

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Foreword

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Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

Amendment 2 to ISO 18115:2001 was prepared by Technical Committee ISO/TC 201, *Surface chemical analysis*, Subcommittee SC 1, *Terminology*.

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Introduction

In ISO 18115:2001, 350 terms for surface chemical analysis are provided. However, from time to time new terms need to be defined and these will appear in Amendments to ISO 18115. In the first amendment, ISO 18115:2001/Amd.1, five abbreviations and 71 terms were added. Many of these terms covered concepts in glow discharge analysis. None of the previous terms were changed. In this second amendment, a further 87 terms, many for secondary-ion mass spectrometry, elastic peak electron spectroscopy and reflected electron energy loss spectroscopy, 76 acronyms for scanned probes, 33 definitions of techniques, six terms for contact mechanics and 147 terms for concepts in scanned probe analysis are included. Additionally, term 5.24, “attenuation length”, in ISO 18115:2001 has had a sentence added clarifying Note 2 and term 5.25, “attenuation length, effective”, has been revised to make it more general. The previous term 5.25 is still valid as one usage of the revised definition.

This Amendment has been prepared in conformance with the principles and style defined in ISO 1087-1, *Terminology work — Vocabulary — Part 1: Theory and application*, and ISO 10241, *International terminology standards — Preparation and layout*. It should be noted that, as in ISO 18115, a term printed boldface in a definition or a note is defined in another entry. However, the term is printed boldface only the first time it occurs in each entry. A term listed lightface is non-preferred or deprecated. The preferred term is listed boldface. Where a term designates several concepts, it is necessary to indicate the subject field to which each concept belongs. The field is shown lightface, between angle brackets, preceding the definition, on the same line.

The abbreviations given here add to those given in Clause 2 of ISO 18115:2001. The terms given here form new Clauses 7, 8, 9 and 10. An alphabetical index for this Amendment is given after the terms and definitions. The indexes for ISO 18115:2001 and ISO 18115:2001/Amd.1:2006 are given immediately after this for convenience. To assist retrieval, compound terms may be found in these indexes in both natural and reverse word order. It is recommended that users searching for a term start with these indexes.

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Surface chemical analysis — Vocabulary —

AMENDMENT 2

Page 1, following the title to Clause 2

Insert the following subclause title:

2.1 Abbreviations for analytical techniques

Page 2, at the end of the current list of acronyms

Insert the following subclause title and list of abbreviations:

2.2 Abbreviations for scanned probe microscopy

In the list below, note that the final "M" and the final "S", given as "microscopy" and "spectroscopy", may also mean "microscope" or "spectrometer", respectively, depending on the context. Items defined later, or with key words defined, are indicated in brackets.

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AFM atomic force microscopy (see 8.4)

ANSOM apertureless near-field scanning optical microscopy (see 8.2)

ASNOM apertureless scanning near-field optical microscopy (see 8.2)

BEEM ballistic electron emission microscopy (cf. 10.7)

BEES ballistic electron emission spectroscopy (cf. 10.7)

CAFM conductive atomic force microscopy (see 8.5)

CFM chemical force microscopy (cf. 10.17)

CITS current imaging tunnelling spectroscopy (see 8.6)

DFM dynamic force microscopy (see 8.7)

DMM displacement modulation microscopy

DTM differential tunnelling microscopy

EC-AFM electrochemical atomic force microscopy (see 8.9)

ECFM electrochemical force microscopy

EC-SPM electrochemical scanning probe microscopy

EC-STM electrochemical scanning tunnelling microscopy (see 8.10)

EFM electrostatic force microscopy (see 8.8)

FFM frictional force microscopy (cf. 10.49)

FM-AFM frequency modulation atomic force microscopy (cf. 10.43)

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FMM force modulation microscopy (cf. 10.43)

FRET fluorescent resonance energy transfer (see 10.42)

FS force spectroscopy

IC intermittent contact (see 10.58)

IETS inelastic electron tunnelling spectroscopy

IFM interfacial force microscopy

KFM Kelvin force microscopy (cf.10.61)

KPM Kelvin probe microscopy (cf.10.61)

LFM lateral force microscopy (cf.10.62)

LFMM lateral force modulation microscopy (cf.10.62)

MDFM magnetic dynamic force microscopy (see 8.11)

MDM microwave dielectric microscopy

MFM magnetic force microscopy (cf. 10.65)

MOKE magneto-optic Kerr effect

MRFM magnetic resonance force microscopy (see 8.12)

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MTA micro-thermal analysis

NC-AFM non-contact atomic force microscopy (cf. 10.73)

NIS nano-impedance spectroscopy

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NSOM near-field scanning optical microscopy (see 8.13)

PF-AFM pulsed force atomic force microscopy (cf. 10.104)

PFM piezoresponse force microscopy (cf. 10.82)

PSTM photon scanning tunnelling microscopy

PTMS photothermal micro-spectroscopy (see 8.14)

RNSOM reflection near-field scanning optical microscopy

RSNOM reflection scanning near-field optical microscopy (cf. 10.112)

SCM scanning capacitance microscopy (see 8.15)

SCPM scanning chemical potential microscopy (see 8.16)

SECM scanning electrochemical microscopy (see 8.17)

SERRS surface enhanced resonant Raman spectroscopy (see 10.128)

SERS surface enhanced Raman scattering (see 10.126)

SFM scanning force microscopy (see 8.4)

ShFM shear-force microscopy (see 8.29)

SHG second harmonic generation

SHPFM second harmonic piezo force microscopy

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SHPM scanning Hall probe microscopy (see 8.18)

SICM scanning ion conductance microscopy (see 8.19)

SIM scanning impedance microscopy

SKPM scanning Kelvin probe microscopy (cf. 10.61)

SMRM scanning magneto-resistance microscopy (see 8.20)

SMSM scanning Maxwell stress microscopy (see 8.21)

SNDM scanning non-linear dielectric microscopy (see 8.22)

SNOM scanning near-field optical microscopy (see 8.13)

SNTM scanning near-field thermal microscopy

SPM scanning probe microscopy (see 8.23)

SP-STM spin polarized scanning tunnelling microscopy (see 8.30)

SP-STS spin polarized scanning tunnelling spectroscopy (see 8.31)

SRTM spin resolved tunnelling microscopy

SSM scanning superconducting interference device (SQUID) microscopy

SSPM scanning surface potential microscopy (see 8.25)

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SSRM scanning spreading resistance microscopy (see 8.24)

STM scanning tunnelling microscopy (see 8.27)

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SThM scanning thermal microscopy (see 8.26)

STS scanning tunnelling spectroscopy (see 8.28)

TERS tip enhanced Raman scattering (cf. 10.134)

TNSOM transmission near-field scanning optical microscopy

TSM thermal scanning microscopy (deprecated, see 8.26)

TSNOM transmission scanning near-field optical microscopy

UFM ultrasonic force microscopy (see 8.33)

NOTE KFM is sometimes given as KPFM for Kelvin probe force microscopy, but this practice is deprecated. SMSM is sometimes given as SMM, but the latter acronym is also used for scanning microwave microscopy and scanning magnetic microscopy and so should not be used for scanning Maxwell stress microscopy.

Page 7

In Note 2 to term 5.24, **attenuation length**, insert the following sentence between the existing first and second sentences: “Nevertheless, for some measurement conditions in **AES** and **XPS**, the signal intensity may depend approximately exponentially on path length, but the exponential constant (the parameter l) will then normally be different from the corresponding **inelastic mean free path**.” In addition, change “this” to “that” in the following sentence so that Note 2 reads:

> NOTE 2 For electrons in solids, the behaviour only approximates to an exponential decay due to the effects of **elastic scattering**. Nevertheless, for some measurement conditions in **AES** and **XPS**, the signal intensity may depend approximately exponentially on path length, but the exponential constant (the parameter l) will then normally be different from the corresponding **inelastic mean free path**. Where that approximation is valid, the term **effective attenuation length** is used.

Replace term 5.25, **attenuation length, effective**, by

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5.25
attenuation length, effective
⟨AES, XPS⟩ parameter which, when introduced in place of the inelastic mean free path into an expression derived for AES and XPS on the assumption that elastic-scattering effects are negligible for a given quantitative application, will correct that expression for elastic-scattering effects

cf. **attenuation length**

NOTE 1 The effective attenuation length may have different values for different quantitative applications of AES and XPS. However, the most common use of effective attenuation length is the determination of overlayer-film thicknesses from measurement of the changes of substrate Auger-electron or photoelectron signal intensities after deposition of a film or as a function of emission angle. For emission angles of up to about 60° (with respect to the surface normal), it is often satisfactory to use a single value of this parameter. For larger emission angles, the effective attenuation length can depend on this angle.

NOTE 2 Since there are different uses of this term, it is recommended that users specify clearly the particular application and the definition of the parameter for that application (e.g. by giving an equation or by providing a reference to a particular source).

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Add the following new Clauses 7 to 10.

7 Definitions of supplementary terms for surface analysis

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7.1
atomic mass unit (deprecated)
See Note 3 to “unified atomic mass unit”.

cf. **unified atomic mass unit**

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7.2
analyser blanking
⟨SIMS⟩ action to prevent **secondary ions** from travelling through the mass spectrometer and being detected

NOTE This action is usually made by pulsing one of the relevant electrode potentials in **time-of-flight** mass spectrometers to deflect ions of a selected mass range in which intense peaks occur, so that those masses are not detected and thus do not cause unwanted detector saturation.

7.3
angle resolved EPES
AREPES
⟨EPES⟩ a method involving **EPES** measurements as a function of the scattering angle

7.4
aperture, contrast
aperture in an ion or electron optical system designed to reduce unwanted background signal

NOTE This aperture may also govern the spatial resolution and other properties of the system.

7.5
background, metastable
⟨SIMS⟩ intensity in the mass spectrum arising from ions that spontaneously fragment between emission and detection

NOTE In reflectron **time-of-flight** mass spectrometers, the decay of **metastable ions** leads to broad peaks at a mass dependent on the drift energy and **reflector voltage**. Good design minimizes these background signals.

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7.6
beam blanking
electrostatic or electromagnetic process designed to prevent any **beam particles** from impacting the sample

cf. **beam bunching**, **beam chopper**

NOTE For pulsed ion beams, the beam is usually deflected into a beam collector from which no particles can reach the sample and where the process of sputtering causes minimal effect on nearby components of the ion optical system. Typically, in **time-of-flight** static SIMS systems, a beam of between 0,2 pA and 2 pA may be on for between 0,6 ns and 30 ns and off for around 100 µs, with 10 000 repetitions per second.

7.7
beam bunching
⟨SIMS⟩ reduction in the spread of arrival times of an ion pulse by reduction in the speed of the leading ions or acceleration of those at the trailing edge of the pulse

cf. **beam blanking**, **beam chopper**

NOTE This procedure may degrade the optimum focus of the ion beam since different ions experience different fields.

7.8
beam source energy (deprecated)
See ISO 18115:2001, term 5.59, **beam energy**.

7.9
bond cleavage
bond scission
breakage of a molecular bond

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NOTE 1 This breakage may lead to two fragments that may or may not be charged, or to a single rearranged product.

NOTE 2 For α- and β-cleavage, see Reference [7] or [11].

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7.10
cationized ion
positively charged ion resulting from a neutral molecule combining with a cation, usually a metal ion

NOTE 1 Cationization with, for instance, Ag leads to high yields of some positive ion fragments or molecular ions. Each ion has a mass given by the sum of the mass of the parent molecule or fragment and the mass of the added metal atom or atoms. The Ag may be used either as the substrate upon which the molecules are deposited or in the form of a sub-monolayer sputtered onto the molecules already on a surface.

NOTE 2 NH_4^+ may be used as well as metals to cationize molecules.

7.11
charge compensation (deprecated)
charge stabilization (deprecated)
charge neutralization

7.12
chopper, beam
⟨SIMS⟩ electrostatic or electromagnetic device used to generate pulses of ions from a continuous ion beam

cf. **beam blanking**, **beam bunching**

NOTE The beam chopper may be used to define the pulse length and hence the mass resolution in a time-of-flight mass spectrometer and it may also be used to select particular ions in a beam that contains more than one species.

7.13
chromatic aberration
non-ideal focus of an electron or ion optical system for electrons or ions of different energies

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7.14
cluster ion
ion composed of many atoms or chemical species

NOTE 1 The cluster may have a positive or negative charge.

NOTE 2 Cluster ions are used for primary ion sources with enhanced properties over those for monatomic ions. Examples of such sources are: Au_3^+, Au_5^+, Bi_3^+, Bi_5^+, C_{60}^+, $H_3O^+(H_2O)_n$, $[Os_3(CO)_{12}]^+$, SF_5^+.

7.15
cluster SIMS
⟨SIMS⟩ **SIMS** but utilizing a primary beam composed of **cluster ions**

NOTE Cluster ion sources are often used in **static SIMS** to enhance molecular signals and in **dynamic SIMS** to enhance **depth resolution**.

7.16
cross-section, damage
cross-section for the change in the number of particular entities observed as a result of the bombardment by defined ions, electrons or photons

NOTE 1 The observed entities may, for example, be specific molecules on a surface, specific observed ion fragments, atoms in a given chemical state or polymer cross-linking as inferred from spectral data.

NOTE 2 Generally, the larger the entity, the larger the damage cross-section.

NOTE 3 As a result of the break-up of larger entities, the observed entity may increase or decrease in intensity.

NOTE 4 Cross-sections are often expressed as an area per target entity (atom, molecule, etc.) for the relevant process.

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NOTE 5 A cross-section of σ per atom for the removal of entities from a given state on a surface will lead to a reduction $\mathrm{d}N$ in the number of N of entities in that state in a time $\mathrm{d}t$ given by the relation:

$$\mathrm{d}N = NJ\sigma\,\mathrm{d}t$$

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where J is the primary ion or electron dose rate density.

Integration leads to the relation:

$$N = N_0\exp(-J\sigma t)$$

where N_0 is the initial value of N.

The observed value of the number of a given entity may also depend on sources creating that entity as discussed in Note 3.

7.17
cross-section, disappearance
⟨SIMS⟩ **cross-section** for the loss of intensity of an ion signal observed as a result of the bombardment by **primary ions**

cf. **cross-section**, **damage**

NOTE 1 The ion signal used is usually that for a large or characteristic fragment of the molecule such as a cationized, protonated or deprotonated ion from the molecule at a surface.

NOTE 2 Generally, the larger the molecule, the larger the disappearance cross-section.

7.18
damage limit
particle **fluence** above which significant changes in the spectrum or in a stated peak, arising from damage processes, are observed

cf. **static limit**

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7.19
daughter ion
electrically charged product formed from a **parent ion** or neutral entity generally of a larger size

NOTE Formation of the product need not necessarily involve fragmentation. It could, for example, involve a change in the number of charges carried. Thus, all **fragment ions** are daughter ions, but not all daughter ions are necessarily fragment ions.

7.20
dendrimer
molecule comprising a multifunctional core molecule with a dendritic wedge of highly branched monomers regularly attached to each functional site, leading to a monodisperse, tree-like or generational structure

NOTE Dendrimer synthesis occurs in polymer chemistry and involves stepwise reactions in which the dendrimer is built up one monomer layer, or generation, at a time. The core molecule is referred to as "generation 0". Each successive repeat unit along all branches forms the next generation, "generation 1", "generation 2", and so on, until the terminating generation.

7.21
deprotonated ion
parent molecule or fragment from which a proton has been removed to form a negative ion

7.22
differential electron elastic reflection coefficient
⟨EPES⟩ ratio, per solid angle, of the number of electrons backscattered quasi-elastically from a solid surface at a given scattering angle to the number of incident electrons

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NOTE The differential elastic reflection coefficient for electrons depends on the atomic composition of the surface layer of the solid, on the **differential elastic scattering cross-sections** of the different atoms for electrons, on the corresponding **IMFP**, on the energy of the incident electrons and on the scattering geometry.

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7.23
dual beam profiling
⟨SIMS⟩ **sputter depth profiling** involving two ion guns

NOTE 1 Two similar ion guns may be used in opposite azimuths of the sample to reduce the development of topography.

NOTE 2 In **time-of-flight** mass spectrometers, one beam is used with a short on time for the SIMS analysis whilst a second is used during the period when the first is off and the mass analysis has been completed in each cycle. The second gun provides the ions for sputter removal of the sample to form the depth profile. This combination allows practical **sputtering rates** to be achieved and the profiling to be optimized separately from the optimization for the SIMS analysis.

7.24
efficiency
⟨SIMS⟩ quotient of the measured yield of an ion species per **primary ion** and the **disappearance cross-section**

7.25
elastic peak
quasi-elastic peak
peak in the electron spectrum, produced by quasi-elastically scattered electrons detected by an electron spectrometer

cf. **elastic peak electron spectroscopy**, **EPES**, **recoil effect**, **reflected electron energy loss spectroscopy**, **REELS**

NOTE 1 All electrons that are scattered by atoms may be elastically scattered in the centre-of-mass frame, but energy losses that are typically less than 1 eV may be observed in the laboratory frame. These losses are generally significantly less than the measured energy width of the electrons in a primary electron beam. Historically, and more generally, the scattering has been called "elastic"; however, the term quasi-elastic is now often used if the small change in energy that occurs on scattering is important.

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NOTE 2 The energy and the energy broadening of the quasi-elastic peak are influenced by the recoil of the scatterer atoms, the energy distribution of the primary (incident) electrons, the scattering geometry, the acceptance geometry and the response function of the electron spectrometer. The intensity of the elastic peak depends on the electron differential elastic scattering cross-section and on the total cross-section for inelastic electron scattering at the particular primary electron beam energy and in the given scattering geometry, that includes the probability of surface excitations.

7.26
elastic peak electron spectroscopy
EPES
a method in which an **electron spectrometer** is used to measure the energy, intensity and/or energy broadening distribution of quasi-elastically scattered electrons from a solid or liquid **surface**

cf. **recoil effect**, **reflected electron energy loss spectroscopy**, **REELS**

NOTE 1 An electron beam in the energy range 100 eV to 3 keV is often used for this kind of spectroscopy.

NOTE 2 In general, electron sources with energy spreads that are less than 1 eV are required to provide adequate information.

NOTE 3 EPES is often an auxiliary method of **AES** and **REELS**, providing information on the composition of the surface layer. EPES is suitable for experimental determination of the **IMFP**, the electron **differential elastic scattering cross-section** and the **surface excitation parameter**.

7.27
energy acceptance window
range of energies accepted by a spectrometer, leading to a detected signal

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7.28
enhancement factor
$K_{n,1}$
⟨SIMS, sputtering⟩ ratio of the ion or neutral sputtering yield using a primary ion cluster of n similar atoms to n times the ion or neutral sputtering yield using a primary ion of one of those atoms where the primary ion energy per atom is the same in each case

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7.29
excited state
state of a system with energy higher than that of the ground state

NOTE This term is generally used to characterize a molecule in one of its electronically excited states, but can also refer to vibrational and/or rotational excitation in the electronic ground state.

7.30
extraction bias
⟨SIMS⟩ voltage between the electrodes used to define the **extraction field** occurring in the period between ion pulses in the pulsed extraction mode

NOTE 1 This term is used in **time-of-flight** SIMS instruments.

NOTE 2 The extraction bias may be set to zero or it may be set at a particular value to deflect low-energy electrons to the sample for charge neutralization or, in dual ion beam systems for **depth profiling**, to deflect **secondary ions** generated by the **sputter depth profiling** ion gun in order to prevent them from entering the mass spectrometer and generating background counts.

7.31
extraction field
⟨SIMS⟩ electric field above the sample, operational during ion emission from the sample

NOTE The extraction field may be pulsed or constant, depending on the type of instrument.

7.32
extractor voltage
⟨SIMS⟩ voltage, referenced to the sample, of the electrode defining the field above the sample and used to facilitate the introduction of emitted ions into the mass spectrometer

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NOTE 1 In the pulsed extraction mode, the extractor voltage will be pulsed to the high value required to extract ions emitted from the sample by the primary ion pulse for at least the time period necessary for the heaviest ion to pass through the extractor electrode and will then be reduced to the **extraction bias** value until the next pulse is required.

NOTE 2 This voltage, together with the separation distance between the sample and the extractor electrode, defines the **extraction field**.

7.33
FAB-SIMS
⟨SIMS⟩ **SIMS** in which the primary-ion beam is replaced by a fast atom beam

7.34
FIB
focussed ion beam system
ion beam system used for machining small regions with sub-micron precision

NOTE 1 In general, FIBs use an **LMIS** to generate a finely focussed ion beam with diameters typically in the range 7 nm to 300 nm and of sufficient flux, typically 4 pA to 20 nA, to machine small items for study by AES, SIMS or TEM in an economic time. They are also used to manufacture **SPM** tips, those for **AFM** having radii down to 2 nm.

NOTE 2 FIB-machined surfaces may have an ion-damaged surface that needs to be removed.

7.35
fragment ion
charged dissociation product arising from ionic fragmentation

[IUPAC [11]]

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cf. **daughter ion**, **metastable ion**

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NOTE Fragment ions may dissociate further to form other electrically charged molecular or atomic moieties of successively lower mass.

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7.36
fragmentation
breakdown of a molecule or ion to form one or more ions or neutrals of lower mass whilst conserving the total charge

7.37
G-SIMS
variant of **static SIMS** in which two spectra from the same area, recorded with different beam energies or different bombarding ions, are ratioed to each other and the result used to scale one of the spectra to generate a new spectrum

NOTE 1 As with static SIMS, the ion **areic dose** during measurement is restricted to less than 10^{16} ions/m^2 to an extent that depends on both the material of the sample and the size of the molecular fragments being analysed.

NOTE 2 The **G-SIMS** spectrum enables the whole mass of molecules on the surface to be determined more readily than in static SIMS.

7.38
impact energy per ion
kinetic energy of the **beam particles** on impact

cf. **beam impact energy**

7.39
information area
area of a region in the plane of the surface from which useful information is obtained

NOTE 1 The information area can be identified with the minimum surface area from which a specified percentage (e.g. 95 % or 99 %) of the detected signal originates.

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