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Surface chemical analysis — Vocabulary —

Part 2:
Terms used in scanning-probe microscopy

Analyse chimique des surfaces — Vocabulaire —

Partie 2: Termes utilisés en microscopie à sonde à balayage

Reference number
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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.

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.

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.

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

Together with Part 1 (see below), it cancels and replaces ISO 18115:2001, which has been split into two parts and at the same time technically revised. The two parts also incorporate the Amendments ISO 18115:2001/Amd.1:2006 and ISO 18115:2001/Amd.2:2007.

ISO 18115 consists of the following parts, under the general title *Surface chemical analysis — Vocabulary*:

- *Part 1: General terms and terms used in spectroscopy*

- *Part 2: Terms used in scanning-probe microscopy*

Introduction

Surface chemical analysis is an important area which involves interactions between people with different backgrounds and from different fields. Those conducting surface chemical analysis might be materials scientists, chemists or physicists and might have a background that is primarily experimental or primarily theoretical. Those making use of the surface chemical data extend beyond this group into other disciplines.

With the present techniques of surface chemical analysis, compositional information is obtained for regions close to a surface (generally within 20 nm) and composition-versus-depth information is obtained with surface analytical techniques as surface layers are removed. The terms covered in this part of ISO 18115 relate to scanning-probe microscopy. The surface analytical terms covered in Part 1 extend from the techniques of electron spectroscopy and mass spectrometry to optical spectrometry and X-ray analysis. Concepts for these techniques derive from disciplines as widely ranging as nuclear physics and radiation science to physical chemistry and optics.

The wide range of disciplines and the individualities of national usages have led to different meanings being attributed to particular terms and, again, different terms being used to describe the same concept. To avoid the consequent misunderstandings and to facilitate the exchange of information, it is essential to clarify the concepts, to establish the correct terms for use and to establish their definitions.

The terms and definitions in the two parts of ISO 18115 have been prepared in conformance with the principles and style defined in ISO 1087-1:2000, *Terminology work — Vocabulary — Part 1: Theory and application*, and ISO 10241:1992, *International terminology standards — Preparation and layout*. Essential aspects of these standards appear in Subclauses 3.1 to 3.3. The terms are given in alphabetical order, classified under three headings:

Clause 4: Definitions of the scanning-probe microscopy methods.

Clause 5: Acronyms and terms for contact mechanics models.

Clause 6: Definitions of terms for scanning-probe methods.

A single alphabetical index to this part of ISO 18115 is given after the Bibliography. To help users, a second index is provided for the terms in Part 1 covering the general terms and terms used in spectroscopy. To assist retrieval, compound terms can be found in the indexes in both natural and reverse word order.

This part of ISO 18115 contains new terms in addition to those terms, previously published in ISO 18115:2001/Amd.2, that involve scanning-probe microscopy. All other terms now appear in ISO 18115-1.

INTERNATIONAL STANDARD **ISO 18115-2:2010(E)**

Surface chemical analysis — Vocabulary —

Part 1:
Terms used in scanning-probe microscopy

1 Scope

ISO 18115 defines terms for surface chemical analysis. Part 1 covers general terms and those used in spectroscopy while this part covers terms used in scanning-probe microscopy.

2 Abbreviations

In the list below, note that the final “M”, given as “microscopy”, may be taken equally as “microscope”, depending on the context. References to the entries where the abbreviations, or key words in the abbreviations, are defined are given in brackets.

AFM	atomic-force microscopy (see 4.3)
ANSOM	apertureless near-field scanning optical microscopy (deprecated) (see 4.37)
ASNOM	apertureless scanning near-field optical microscopy (deprecated) (see 4.37)
BEEM	ballistic-electron emission microscopy (cf. 6.8)
BEES	ballistic-electron emission spectroscopy (cf. 6.8)
CPAFM	conductive-probe atomic-force microscopy (see 4.5)
CFM	chemical-force microscopy (see 4.4)
CITS	current-imaging tunnelling spectroscopy (see 4.6)
DFM	dynamic-force microscopy (see 4.7)
DMM	displacement modulation microscopy
DTM	differential-tunnelling microscopy
EC-AFM	electrochemical atomic-force microscopy (see 4.9)
ECFM	electrochemical-force microscopy
EC-SPM	electrochemical scanning-probe microscopy
EC-STM	electrochemical scanning tunnelling microscopy (see 4.10)
EFM	electrostatic-force microscopy (see 4.8)

FFM	frictional-force microscopy (see 4.12)
FM-AFM	frequency modulation atomic-force microscopy (see 4.11)
FMM	force modulation microscopy (cf. 6.60)
FRET	fluorescent resonance energy transfer (see 6.54)
FS	force spectroscopy (see 6.58)
HFM	heterodyne force microscopy
IC	intermittent contact (see 6.73)
IETS	inelastic electron tunnelling spectroscopy
IFM	interfacial-force microscopy
KFM	Kelvin force microscopy (deprecated) (see 4.13)
KPM	Kelvin probe microscopy (cf. 6.76)
KPFM	Kelvin-probe force microscopy (see 4.13)
LFM	lateral-force microscopy (see 4.14)
LFMM	lateral-force modulation microscopy (cf. 6.77)
MDFM	magnetic dynamic-force microscopy (see 4.15)
MDM	microwave dielectric microscopy
MFM	magnetic-force microscopy (see 4.16)
MOKE	magneto-optic Kerr effect
MRFM	magnetic-resonance force microscopy (see 4.17)
MTA	micro-thermal analysis
NC-AFM	non-contact atomic-force microscopy (see 4.19)
NIS	nano-impedance spectroscopy
NSOM	near-field scanning optical microscopy (see 4.18)
PF-AFM	pulsed-force atomic-force microscopy (cf. 6.125)
PFM	piezoresponse force microscopy (cf. 6.100)
PSTM	photon scanning tunnelling microscopy
PTMS	photothermal micro-spectroscopy (see 4.20)
RNSOM	reflection near-field scanning optical microscopy (see 6.133)
RSNOM	reflection scanning near-field optical microscopy (cf. 6.133)
SCM	scanning capacitance microscopy (see 4.21)

SCPM	scanning chemical-potential microscopy (see 4.22)
SECM	scanning electrochemical microscopy (see 4.23)
SERRS	surface-enhanced resonant Raman spectroscopy (see 6.154)
SERS	surface-enhanced Raman scattering (see 6.151)
SFM	scanning force microscopy (deprecated) (see 4.3)
SGM	scanning gate microscopy
ShFM	shear-force microscopy (see 4.38)
SHG	second harmonic generation
SHPFM	second harmonic piezo force microscopy
SHPM	scanning Hall probe microscopy (see 4.24)
SICM	scanning ion conductance microscopy (see 4.25)
SIM	scanning impedance microscopy
SKPM	scanning Kelvin probe microscopy (cf. 6.76)
SMRM	scanning magneto-resistance microscopy (see 4.26)
SMSM	scanning Maxwell stress microscopy (see 4.27)

NOTE 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.

SNDM	scanning non-linear dielectric microscopy (see 4.30)
SNFUH	scanning near-field ultrasound holography (see 4.29)
SNOM	scanning near-field optical microscopy (see 4.18)
SNTM	scanning near-field thermal microscopy (see 4.28)
SPM	scanning-probe microscopy (see 4.31)
SP-STM	spin-polarized scanning tunnelling microscopy (see 4.39)
SP-STS	spin-polarized scanning tunnelling spectroscopy (see 4.40)
SRTM	spin-resolved tunnelling microscopy (deprecated) (see 4.39)
SSM	scanning superconducting interference device (SQUID) microscopy
s-NSOM	scattering near-field scanning optical microscopy (see 4.37)
s-SNOM	scattering scanning near-field optical microscopy (see 4.37)
SSPM	scanning surface potential microscopy (see 4.33)
SSRM	scanning spreading-resistance microscopy (see 4.32)

STM	scanning tunnelling microscopy (see 4.35)
SThM	scanning thermal microscopy (see 4.34)
STS	scanning tunnelling spectroscopy (see 4.36)
SVM	scanning voltage microscopy
TECARS	tip-enhanced coherent anti-Stokes Raman scattering
TEFS	tip-enhanced fluorescence spectroscopy (see 4.42)
TEOS	tip-enhanced optical spectroscopy
TERS	tip-enhanced Raman scattering (see 4.43)
TNSOM	transmission near-field scanning optical microscopy
TSM	thermal-scanning microscopy (deprecated, see 4.34, Note 2)
TSNOM	transmission scanning near-field optical microscopy
UFM	ultrasonic force microscopy (see 4.44)

3 Format

3.1 Use of terms printed boldface in definitions

A term printed boldface in a definition or a note is defined in another entry in either part of this International Standard. However, the term is printed boldface only the first time it occurs in each entry.

3.2 Non-preferred and deprecated terms

A term listed lightface is non-preferred or deprecated. The preferred term is listed boldface.

3.3 Subject fields

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.

4 Definitions of the scanning-probe microscopy methods

4.1 The following are the definitions of scanned probe microscopy methods. In the list below, note that the final “M” and final “S” in the acronyms, given as “microscopy” or “spectroscopy”, may also mean “microscope” or “spectrometer”, respectively, depending on the context. For the definition relating to the microscope or spectrometer, replace the words “a method” by the words “an instrument” where that appears.

4.2
apertureless Raman microscopy
⟨NSOM, SNOM⟩ a method of microscopy involving the acquisition of Raman spectroscopic data utilizing a **near-field** optical source and based upon a metal **tip** in close proximity to the sample surface illuminated with suitably polarized light

4.3
atomic-force microscopy
AFM

scanning force microscopy (deprecated)

SFM (deprecated)

a method for imaging surfaces by mechanically scanning their surface contours, in which the deflection of a sharp **tip** sensing the surface forces, mounted on a compliant **cantilever**, is monitored

NOTE 1 AFM can provide a quantitative height **image** of both insulating and conducting surfaces.

NOTE 2 Some AFM instruments move the sample in the x-, y- and z-directions whilst keeping the tip position constant and others move the tip whilst keeping the sample position constant.

NOTE 3 AFM can be conducted in vacuum, a liquid, a controlled atmosphere or air. Atomic resolution may be attainable with suitable samples, with sharp tips and by using an appropriate imaging mode.

NOTE 4 Many types of force can be measured, such as the **normal forces** or the **lateral, friction or shear force**. When the latter is measured, the technique is referred to as **lateral**, **frictional** or **shear force microscopy**. This generic term encompasses all of the types of force microscopy listed in Clause 2.

NOTE 5 AFMs can be used to measure surface **normal forces** at individual points in the pixel array used for imaging.

NOTE 6 For typical AFM tips with radii <100 nm, the normal force should be less than about 0,1 µN, depending on the sample material, or irreversible surface deformation and excessive tip wear occurs.

4.4
chemical-force microscopy
CFM

an **LFM** or **AFM** mode in which the deflection of a sharp **probe tip**, functionalized to provide interaction forces with specific molecules, is monitored

NOTE LFM is the most popularly used mode.

4.5
conductive-probe atomic-force microscopy
CPAFM

CAFM (deprecated)

C-AFM (deprecated)

⟨AFM⟩ an **AFM** mode in which a conductive **probe** is used to measure both topography and electric current between the **tip** and the sample

NOTE CPAFM is a secondary imaging mode derived from contact AFM that characterizes conductivity variations across medium- to low-conducting and semiconducting materials. Typically, a DC bias is applied to the tip, and the sample is held at ground potential. While the z feedback signal is used to generate a normal-contact AFM topography **image**, the current passing between the tip and sample is measured to generate the conductive AFM image.

4.6
current-imaging tunnelling spectroscopy
CITS

⟨STM⟩ a method in which the **STM tip** is held at a constant height above the surface, while the bias voltage, V, is scanned and the tunnelling current, I, is measured and mapped

NOTE The constant height is usually maintained by gating the feedback loop so that it is only active for some proportion of the time; during the remaining time, the feedback loop is switched off and the applied **tip bias** is ramped and the current is measured.

cf. **I-V spectroscopy**

4.7
dynamic-mode AFM
dynamic-force microscopy
DFM
⟨AFM⟩ an **AFM** mode in which the relative positions of the **probe tip** and sample vary in a sinusoidal manner at each point in the **image**

NOTE 1 The sinusoidal oscillation is usually in the form of a vibration in the z-direction and is often driven at a frequency close to, and sometimes equal to, the **cantilever resonance frequency**.

NOTE 2 The signal measured can be the amplitude, the phase shift or the resonance frequency shift of the cantilever.

4.8
electrostatic-force microscopy
electric-force microscopy (deprecated)
EFM
⟨AFM⟩ an **AFM** mode in which a conductive **probe** is used to map both topography and electrostatic force between the **tip** and the sample surface

4.9
electrochemical atomic-force microscopy
EC-AFM
⟨AFM⟩ an **AFM** mode in which a conductive **probe** is used in an electrolyte solution to measure both topography and electrochemical current

4.10
electrochemical scanning tunnelling microscopy
EC-STM
⟨STM⟩ an **STM** mode in which a coated **tip** is used in an electrolyte solution to measure both topography and electrochemical current

4.11
frequency modulation atomic-force microscopy
FM-AFM
dynamic-mode AFM in which the shift in **resonance frequency** of the **probe assembly** is monitored and is adjusted to a setpoint using a feedback circuit

4.12
frictional-force microscopy
FFM
an **SPM** mode in which the **friction force** is monitored

NOTE The friction force can be detected in a static or frequency-modulated mode. Information on the tilt azimuthal variation of the frictional force needs the static mode.

4.13
Kelvin-probe force microscopy
KPFM
KFM (deprecated)
dynamic-mode AFM using a conducting **probe tip** to measure spatial or temporal changes in the relative electric potentials of the tip and the surface

NOTE Changes in the relative potentials reflect changes in the surface **work function**.

4.14
lateral-force microscopy
LFM
an **SPM** mode in which surface contours are scanned with a **probe assembly** whilst monitoring the lateral forces exerted on the **probe tip** by observation of the torsion of the **cantilever** arising as a result of those forces

NOTE The lateral forces can be detected in a static or frequency-modulated mode. Information on the tilt azimuth of surface molecules needs the static mode.

4.15
magnetic dynamic-force microscopy
MDFM
magnetic AC mode (deprecated)
MAC mode (deprecated)
⟨AFM⟩ an **AFM** mode in which the **probe** is oscillated by using a **magnetic force**

4.16
magnetic-force microscopy
MFM
an **AFM** mode employing a **probe assembly** that monitors both atomic forces and magnetic interactions between the **probe tip** and a surface

4.17
magnetic-resonance force microscopy
MRFM
⟨AFM⟩ an **AFM** imaging mode in which magnetic signals are mechanically detected by using a **cantilever** at resonance and the force arising from nuclear or electronic spin in the sample is sensitively measured

4.18
near-field scanning optical microscopy
NSOM
scanning near-field optical microscopy
SNOM
a method of imaging surfaces optically in transmission or reflection by mechanically scanning an optically active **probe** much smaller than the wavelength of light over the surface whilst monitoring the transmitted or reflected light or an associated signal in the **near-field** regime

cf. **scattering NSOM**, **scattering SNOM**

NOTE 1 Topography is important and the probe is scanned at constant height. Usually the probe is oscillated in the shear mode to detect and set the height.

NOTE 2 Where the extent of the optical probe is defined by an **aperture**, the aperture size is typically in the range 10 nm to 100 nm, and this largely defines the resolution. This form of instrument is often called an aperture NSOM or aperture SNOM to distinguish it from a **scattering NSOM** or **scattering SNOM** (previously called **apertureless NSOM** or **apertureless SNOM**) although, generally, the adjective “aperture” is omitted. In the apertureless form, the extent of the optically active probe is defined by an illuminated sharp metal or metal-coated **tip** with a radius typically in the range 10 nm to 100 nm, and this largely defines the resolution.

NOTE 3 In addition to the optical **image**, NSOM can provide a quantitative image of the surface contours similar to that available in **AFM** and allied scanning-probe techniques.

NOTE 4 This generic term encompasses all of the types of near-field microscopy listed in Clause 2.

4.19
non-contact atomic-force microscopy
NC-AFM
dynamic-mode AFM in which the **probe tip** is operated at such a distance from the surface that it samples the weak, attractive, van der Waals or other forces

NOTE Forces in this mode are very low and are best for studying soft materials or avoiding cross-contamination of the tip and the surface.

4.20
photothermal micro-spectroscopy
PTMS
an **SThM** mode in which the **probe** detects the photothermal response of a sample exposed to infrared light to obtain an absorption spectrum

NOTE The infrared light can be either from a tuneable monochromatic source or from a broadband source set up as part of a Fourier transform infrared spectrometer. In the latter case, the photothermal temperature fluctuations can be measured as a function of time to provide an interferogram which is Fourier-transformed to give the spectrum of sub-micron-sized regions of the sample.

4.21
scanning capacitance microscopy
SCM
an **SPM** mode in which a conductive **probe** is used to measure both topography and capacitance between the **tip** and sample

4.22
scanning chemical-potential microscopy
SCPM
an **SPM** mode in which spatial variations in the thermoelectric voltage signal, created by a constant temperature gradient normal to the sample surface, are measured and related to spatial variations in the chemical-potential gradient

4.23
scanning electrochemical microscopy
SECM
an **SPM** mode in which imaging occurs in an electrolyte solution with an electrochemically active **tip**

NOTE In most cases, the SECM tip is an ultra-microelectrode and the tip signal is a Faradaic current from electrolysis of solution species.

4.24
scanning Hall probe microscopy
SHPM
an **SPM** mode in which a Hall probe is used as the scanning sensor to measure and map the magnetic field from a sample surface

4.25
scanning ion conductance microscopy
SICM
an **SPM** mode in which an electrolyte-filled micropipette is used as a local **probe** for insulating samples immersed in an electrolytic solution

NOTE The distance dependence of the ion conductance provides the key to performing non-contact surface profiling.

4.26
scanning magneto-resistance microscopy
SMRM
an **SPM** mode in which a magneto-resistive sensor **probe** on a **cantilever** is scanned in the **contact mode** over a magnetic sample surface to measure two-dimensional magnetic **images** by acquiring magneto-resistive voltage

4.27
scanning Maxwell stress microscopy
SMSM
an **SPM** mode in which a conductive **probe** is used to measure both topography and surface potential by utilizing the Maxwell stress

4.28
scanning near-field thermal microscopy
SNTM
a SNOM method in which an infrared-sensing thermometer is used to detect the local emission collected by an optical **probe** to measure both the topography and thermal properties

4.29
scanning near-field ultrasound holography
SNFUH
a method for imaging surfaces and the subsurface regimes by mechanically scanning their surface contours and detecting the results of the interference of a high-frequency acoustic wave (of the order of MHz or higher and substantially greater than the **resonance frequency** of the **cantilever**) applied to the bottom of the sample while another wave is applied to the cantilever at a slightly different frequency

4.30
scanning non-linear dielectric microscopy
SNDM
an **SPM** mode in which a conductive **probe** is used to measure both topography and dielectric constant (capacitance)

4.31
scanning-probe microscopy
SPM
a method of imaging surfaces by mechanically scanning a **probe** over the surface under study, in which the concomitant response of a detector is measured

NOTE 1 This generic term encompasses **AFM**, **CFM**, **CITS**, **FFM**, **LFM**, SFM, **SNOM**, **STM**, TSM, etc., listed in Clause 2.

NOTE 2 The resolution varies from that of STM, where individual atoms can be resolved, to **SThM** in which the resolution is generally limited to around 1 µm.

4.32
scanning spreading-resistance microscopy
SSRM
an **SPM** mode in which a conductive **tip** is used to measure both topography and spreading resistance

NOTE Whilst full-diamond or diamond-coated **probes** are almost always used for the SSRM of Si samples, it is possible to perform SSRM with other conductive tips when (in cases such as the imaging of InP, which is soft) the use of a diamond tip could damage the sample.

4.33
scanning surface potential microscopy
SSPM
an **SPM** mode in which a conductive **probe** is used to measure both topography and surface potential

NOTE **KPFM** is SSPM conducted using an **AFM** as defined in 4.13. Where this is appropriate, KPFM should be used to describe the method rather than the more generic term, SSPM.

4.34
scanning thermal microscopy
SThM
an **SPM** method in which a thermal sensor is integrated into the **probe** to measure both topography and thermal properties

NOTE 1 Examples of such thermal properties are temperature and thermal conductivity.

NOTE 2 This method is sometimes known as thermal-scanning microscopy or TSM. This expression and acronym are deprecated.