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Surface chemical analysis — Vocabulary —

Part 3: Terms used in optical interface analysis

Analyse chimique des surfaces — Vocabulaire —

Partie 3: Termes utilisés dans l'analyse des interfaces optiques

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Foreword

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This document was prepared by Technical Committee ISO/TC 201, *Surface chemical analysis*, Subcommittee SC 1, *Terminology*.

A list of all parts in the ISO 18115 series can be found on the ISO website.

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.

Introduction

Optical spectroscopies and surface chemical analysis, in general, are important areas which involve interactions between people with different backgrounds and from different fields. Those conducting optical spectroscopy on surfaces can be materials scientists, chemists, physicists or biologists and might have a background that is primarily experimental or primarily theoretical. Those making use of the data and results extend beyond this group into other disciplines.

ISO 18115-1 extend from the techniques of electron spectroscopy and mass spectrometry to general spectrometry terms and X-ray analysis. The terms covered in ISO 18115-2 relate to scanning-probe microscopy.

This document covers terms used in optical spectroscopies. This includes terms related to general terms, properties of light and optical properties of materials. In terms of techniques, there is a focus on terms related to Raman spectroscopy, ellipsometry and nonlinear optical techniques.

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 are given in alphabetical order, classified under 3.1 general terms, 3.2 properties of light, 3.3 optical properties of materials, 3.4 ellipsometry terms, 3.5 Raman spectroscopy terms and 3.6 nonlinear optical technique terms. The terms in each clause are not always mutually exclusive and some terms placed in one clause can equally belong in another.

Surface chemical analysis — Vocabulary —

Part 3:
Terms used in optical interface analysis

1 Scope

This document defines terms for surface chemical analysis in the area of optical interface analysis including ellipsometry, Raman spectroscopy and nonlinear optical techniques as well as general optical terms.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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 https://www.electropedia.org/

3.1 General terms

3.1.1
background signal
signal present at a particular position, energy, mass or wavelength due to processes or sources other than those of primary interest

3.1.2
CCD detector
semiconductor device that converts light into an electrical signal

Note 1 to entry: When a photon is absorbed by the detector, a single electron is released. Electrodes covering the chip surface hold these electrons in place in an array of wells, or pixels, such that during exposure to light, a pattern of charge builds up that corresponds to the pattern of light.

3.1.3
compensator
retardation plate of fixed or variable optical path length difference used for introducing a light path difference between two beams or to compensate the optical path length that can cause unwanted dispersion or time-delay

Note 1 to entry: See also *retardation plate/wave plate* (3.1.34).

[SOURCE: ISO 10934:2020, 3.1.27, adapted]

3.1.4
confocal optical microscopy
optical microscopy in which, light is suppressed from out-of-focus planes using one or more pinholes such that only light from a confocal volume is detected

Note 1 to entry: An image of an extended area is formed via scanning.

Note 2 to entry: The confocal principle leads to improved contrast and axial resolution by suppression of light from out-of-focus planes.

3.1.5
confocal volume
effective volume that is in focus around a point in the object which gives rise to the detected signal or image in confocal microscopy

[SOURCE: ISO 10934:2020, 3.3.10.8, modified — The phrase “detected signal or” has been added.]

3.1.6
depth of field
region where the sharpness of the edges of the images reaches a pre-set optimum

[SOURCE: ISO 26824:2013, 8.16, modified — "the" has been replaced by "a" prior to "pre-set optimum".]

3.1.7
depth of focus
axial depth of the space on both sides of the focal plane, within which the image or signal appears acceptably sharp, while the positions of the object plane and of the objective are maintained

Note 1 to entry: The method to determine when the image or signal is acceptably sharp depends on the microscopy or spectroscopy method. For example, in confocal Raman microscopy, the depth of focus can be determined as when the signal does not decrease by more than 87 % ($1/e^2$) compared to the maximum signal exactly at the object position.

[SOURCE: ISO 19262:2015, 3.68, modified — Note 1 to entry has been added.]

3.1.8
diffraction grating
set of regularly repeating structures which, when illuminated, produce, by reflection or transmission, maxima and minima of intensity as a consequence of interference

Note 1 to entry: These maxima and minima vary in position according to wavelength. Radiation of any given wavelength may thus be selected from interference pattern allowing the grating to be used for producing monochromatic light.

[SOURCE: ISO 10934:2020(en), 3.1.42, modified — "diffraction" has been deleted as a consequence and Note 1 has been reworded slightly.]

3.1.9
dipole moment
vector quantity describing the separation of electric charges where the direction is from negative to positive charge

Note 1 to entry: When an atom or molecule interacts with an electromagnetic wave, it can undergo a transition from an initial to a final state of energy difference through the coupling of the electromagnetic field to the transition dipole moment. When this transition is from a lower energy state to a higher energy state, this results in the absorption of a photon. A transition from a higher energy state to a lower energy state results in the emission of a photon.

3.1.10
edge filter
optical filter that rejects light above or below a specific wavelength but transmits light outside that criterion

Note 1 to entry: Depending on whether the transmitted part contains the longer or shorter wavelengths, the edge filter is called a long wave pass (LWP) or a short-wave pass (SWP) filter, respectively.

Note 2 to entry: In Raman spectroscopy, an edge filter is used to reject *Rayleigh scattering* (3.3.38) but permit measurement of either *Stokes* (3.5.25) or *anti-Stokes* (3.5.1) Raman scattering.

Note 3 to entry: In reality, edge filters have a narrow transition width. Edge filters with a very narrow transition width are also available and are known as razor edge filters.

3.1.11
fluorophore
molecular entity that emits fluorescent light when excited by a specific range of wavelengths of light

3.1.12
goniometer
instrument that either measures an angle or allows an object to be rotated to a precise angular position

3.1.13
half-wave plate
half-wave compensator
optical device which alters the polarization state of light travelling through the device by π

3.1.14
Jones matrix
two by two matrix that is used to represent the operation of an optical element such as a polarizer on the polarization state of light

Note 1 to entry: Fully polarized light is represented by a *Jones vector* (3.2.17).

3.1.15
lock in amplifier
type of amplifier that extracts a signal from a complex waveform at the same frequency as that of a second carrier wave

3.1.16
monochromator
optical device that transmits a light beam with a certain wavelength within a wider range of wavelengths available at the input

Note 1 to entry: The bandwidth is defined by the *spectral purity* (3.1.33)

3.1.17
neutral density filter
filter having uniform absorption throughout the range from near ultraviolet to near infrared radiation, thus reducing the light intensity without altering spectral distribution

[SOURCE: ISO 6196-6:1992, 06.01.13]

3.1.18
notch filter
optical filter that attenuates light with a specific narrow frequency range while passing all other frequencies unaltered

Note 1 to entry: In Raman spectroscopy, a narrow notch is used to reject *Rayleigh scattering* (3.3.38) but permit measurement of both *Stokes* (3.5.25) and *anti-Stokes Raman scattering* (3.5.1).

3.1.19
numerical aperture
NA
product of the refractive index of the medium in which the lens is working, n, and the sine of one-half of the angular aperture of the lens, θ

Note 1 to entry: The numerical aperture is given by NA = $n\sin\theta$, where 2θ is the full angular aperture of the lens.

[SOURCE: ISO 18115-2:2021, 5.93, modified — Note 2 has been deleted.]

3.1.20
objective lens
combination of several lenses in a common mounting which, together with the focusing lens, projects a real reversed image of the object in the image plane

[SOURCE: ISO 9849:2017, 3.2.20]

3.1.21
optical modulator
optical device that imposes modulation on a light beam

Note 1 to entry: This modulation can be for example in phase, frequency or amplitude.

Note 2 to entry: Examples include electro-optical modulator or photo acoustical modulator.

3.1.22
peak height
distance between the peak maximum and the background

Note 1 to entry: The method used to determine the background should be carefully considered and specified.

[SOURCE: ISO 7941:1988, 4.3.2, modified — Reworded slightly.]

3.1.23
peak shape
form of a spectral feature that can typically be described by a mathematical function and parameters such as spectral position, height, and width

Note 1 to entry: Examples of the mathematical function include Gaussian, Lorentzian, PearsonVII and Voigt functions.

3.1.24
peak width
width of a peak at a defined fraction of the peak height

Note 1 to entry: Any background subtraction method used should be specified.

Note 2 to entry: The most common measure of peak width is the full width of the peak at half maximum (FWHM) intensity.

Note 3 to entry: For asymmetrical peaks, convenient measures of peak width are the half-widths of each side of the peak at half maximum intensity. Other parameters that can be measured are skewness, the amount and direction of skew or departure from horizontal symmetry and kurtosis which is a measure of how tall and sharp a peak is.

3.1.25
photobleaching
loss of optical *fluorescence* (3.2.15) in a fluorescent molecule due to overexposure with irradiating light

3.1.26
photodetector
device that converts light into an electrical signal

Note 1 to entry: Examples include photodiode, photomultiplier, CCD and CMOS.

3.1.27
photomultiplier tubes
photomultipliers
PMTs
electronic device for amplifying and converting light pulses into measurable electrical signals

Note 1 to entry: They can be used for the collection of, for example, confocal Raman, *CARS* (3.5.3), two photon fluorescence, TPEF *(two photon excitation fluorescence)* (3.2.46) and *second harmonic generation* (3.6.27).

[SOURCE: ISO 772:2011(en), 1.163, modified — Note 1 has been added.]

3.1.28
polarizer
material which only transmits the component of a light wave which is oscillating in a particular direction

[SOURCE: ISO 23713:2005, 3.2, modified]

3.1.29
quarter-wave plate
optical device which changes the polarization state of light travelling through the device by $\pi/2$

3.1.30
selection rules
set of restrictions governing the allowedness of transitions of a system from one quantum state to another

Note 1 to entry: The selection rules may differ according to the technique used to observe the transition for example between infrared spectroscopy and Raman spectroscopy.

3.1.31
silicon diode detector
photodiode that converts the light into electrical current

Note 1 to entry: These types of detectors can be used for *SRS* (3.5.24) and it is a type of *photodetector* (3.1.26).

3.1.32
solid angle
$\Omega = A/r^2$

where

A is the area of the included surface of a sphere in a cone with its apex at the centre of the sphere;

r is the radius of the sphere

Note 1 to entry: The solid angle is the three-dimensional angle, e.g. the cone of light from a point source.

Note 2 to entry: Solid angles are expressed in steradians (sr).

[SOURCE: ISO 80000-3:2006, 3-6 and notes adapted from ISO 4007:2018, 3.4.13

3.1.33
spectral purity
indication of the monochromaticity of a given light sample

3.1.34
wave plate
retardation plate
optical device generally consisting of a piece, or pieces, of optically anisotropic material with plane faces, to produce a specific polarization state change of the light when travelling through the device

Note 1 to entry: Waveplates are constructed out of a birefringent material (for example quartz, mica, or certain polymers), for which the index of refraction is different for light linearly polarized along one or the other of two certain perpendicular crystal axes.

3.2 Terms related to properties of light

3.2.1
airy disc
central spot of light in the diffraction pattern of a point light source

3.2.2
bandwidth
range of frequencies within a given band

Note 1 to entry: A common way to calculate bandwidth is to use the full width at half maximum. It is typically measured in hertz.

3.2.3
beam diameter
diameter of an electromagnetic beam along any specified line that is perpendicular to the beam axis and intersects it.

Note 1 to entry: The beam diameter can be defined in several ways, such as full-width at half-maximum (FWHM), 1/e, $1/e^2$ or 4σ based on the measured intensity as a function of lateral distance.

Note 2 to entry: This usually refers to a beam of circular cross section, but not necessarily so it can be, for example, elliptical in which case the orientation of the major and minor axis needs to be specified.

3.2.4
beam divergence
angular measure of the increase in beam diameter or radius with distance from the optical aperture or antenna aperture from which the beam emerges

Note 1 to entry: As the *wavevector, k* (3.2.49) is a vector it is dependent on both the spectral purity and angular divergence of a source.

3.2.5
candela
luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of 1/683 W per steradian (a unit of solid angle)

Note 1 to entry: Candela (cd) is the unit of luminous intensity in the International System of Units (SI).

3.2.6
chromaticity
property of a colour stimulus defined by its chromaticity coordinates, or by its dominant or complementary wavelength and purity taken together

Note 1 to entry: Chromaticity coordinates specifies a colour regardless of its luminance.

[SOURCE: ISO 9241-302:2008(en), 3.3.9, modified — Note 1 to entry has been added.]

3.2.7
circular polarization
polarization state in which, at each point, the electric field of the wave has a constant magnitude, but its direction rotates with time at a steady rate in a plane perpendicular to the direction of the wave

Note 1 to entry: Circularly polarized light can be produced by passing linearly polarized light through a quarter-wave plate at an angle of 45° to the optical axis of the plate.

Note 2 to entry: As the electric field can rotate clockwise or anti-clockwise as it propagates, circularly polarized waves exhibit chirality.

3.2.8
coherence
characteristic of a beam of electromagnetic radiation where there is a deterministic (not random) phase relationship between each pair of points in the beam

Note 1 to entry: There are two types of coherence; *spatial coherence* (3.2.40) and *temporal coherence* (3.2.45)

[SOURCE: ISO 11145:2018, 3.11.1, modified — Note 1 has been added.]

3.2.9
coherence length
propagation distance in a dispersive medium over which an electromagnetic wave maintains a specified degree of coherence

Note 1 to entry: Practically, it is used for quantifying the degree of *temporal coherence* (3.2.45) as the propagation length (and thus propagation time) over which coherence degrades significantly.

3.2.10
colour temperature
temperature of a Planckian radiator whose radiation has the same chromaticity as that of a given stimulus

[SOURCE: ISO 9241-6:1999, 3.5]

3.2.11
depolarization
act of randomizing the polarization of an electromagnetic wave

Note 1 to entry: A depolarizer is the device used to depolarise light regardless of the input wave. In reality a depolariser will produce a pseudo-random output.

3.2.12
diffraction limit
maximum spatial resolution achievable for an optical system, governed by diffraction phenomena

Note 1 to entry: The Abbe diffraction limit, is defined as $\lambda / (2\ \mathrm{NA})$ in which λ is the wavelength of the illuminating light and NA is the *numerical aperture* (3.1.19).

3.2.13
elliptical polarization
polarization state in which, the electric field vector describes an ellipse in any fixed plane intersecting, and normal to, the direction of propagation

Note 1 to entry: An elliptically polarized wave may be resolved into two linearly polarized waves in phase quadrature, with their polarization planes at right angles to each other. Circular and linear polarization can be considered to be special cases of elliptical polarization.

Note 2 to entry: As the electric field can rotate clockwise or anti-clockwise as it propagates, elliptically polarized waves exhibit chirality.

3.2.14
extinction coefficient
imaginary part of a complex refractive index of a material which describes the amount of attenuation when the electromagnetic wave propagates through the material

3.2.15
fluorescence
phenomenon in which absorption of light of a given frequency by a substance is followed by the emission of light at a lower frequency (longer wavelength) from the excited states with the same degeneracy

Note 1 to entry: Generally, the emission is from singlet excited state to singlet ground state.

Note 2 to entry: In the case of multiphoton fluorescence, the emitted light may be of a shorter wavelength.

3.2.16
frequency
reciprocal of the period

Note 1 to entry: The unit of frequency is the hertz (Hz), which corresponds to one cycle of periodic motion per second.

[SOURCE: ISO 2041:2018, 3.3.33]