
**Surface chemical analysis — Scanning-
probe microscopy — Definition and
calibration of the lateral resolution of a
near-field optical microscope**

*Analyse chimique des surfaces — Microscopie à sonde à balayage —
Définition et étalonnage de la résolution latérale d'un microscope
optique en champ proche*





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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.

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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 27911 was prepared by Technical Committee ISO/TC 201, *Surface chemical analysis*, Subcommittee SC 9, *Scanning probe microscopy*.

Introduction

The near-field scanning optical microscope (NSOM or SNOM) is a form of scanning-probe microscope (SPM) that uses an optical source but achieves, through the use of the near field, a spatial resolution significantly superior to that defined by the Abbe diffraction limit. NSOM instruments are mainly either apertured, when the resolution is governed by the aperture size, or apertureless, when the resolution is more complex. In apertureless NSOMs, a very sharp scannable tip is used to probe the surface, or molecules on the surface, through local scattering of light from the test specimen surface or the tip apex. The spatial resolution for scattering NSOMs is a complex phenomenon and is less easily characterized in terms of an instrumental property, and so this International Standard focuses on, and is limited to, the lateral spatial resolution of apertured NSOM instruments.

Although the term spatial resolution has a clear meaning, it is often characterized in different ways. In this International Standard, one convenient and effective method for measuring the spatial resolution of an apertured NSOM instrument is presented, suitable for use by non-expert operators.

Surface chemical analysis — Scanning-probe microscopy — Definition and calibration of the lateral resolution of a near-field optical microscope

1 Scope

This International Standard describes a method for determining the spatial (lateral) resolution of an apertured near-field scanning optical microscope (NSOM) by imaging an object with a size much smaller than the expected resolution. It is applicable to aperture-type NSOMs operated in the transmission, reflection, collection or illumination/collection mode.

2 Normative references

The following referenced documents are indispensable for the application 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 18115-2, *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 18115-2 and the following apply.

3.1

far field

electromagnetic field at a distance from a light source significantly greater than the wavelength of the light

3.2

point spread function

response of an imaging system to a point source or point object

4 Symbols and abbreviated terms

APD avalanche photodiode

FWHM full width at half maximum

NA numerical aperture

PMT photomultiplier tube

PSF point spread function

QD quantum dot

δ FWHM of the PSF of the NSOM, i.e. the lateral resolution of the NSOM instrument

5 General information

5.1 Background information

The NSOM is a form of scanning-probe microscope with a probe that has an optical aperture that can illuminate, and/or collect the light from, the surface of a test specimen in the distance within a fraction of the wavelength of the light, this region being called the near field. A two-dimensional NSOM image consists of pixels that contain optical information (normally, the light intensity or photon counts obtained at each pixel position). For an apertured NSOM, an open optical aperture of subwavelength diameter is located at the apex of a sharp probe, and light is emitted and/or collected by it. The NSOM probe is scanned over the specimen surface in the near field. Because the aperture is so close to the surface, the size of the spot illuminated on the surface (or from which light is collected) is determined not by the light wavelength but mostly by the aperture size. Since the aperture size can be made as small as a few tens of nanometres, spatial resolution far better than the theoretical resolution limit of the conventional far-field optical microscope can be achieved by an NSOM. The spatial resolution achievable by reducing the size of the aperture is limited by the skin depth of the metal coating of the NSOM probe, which defines the aperture, and by the fact that optical throughput decreases rapidly with decreasing aperture diameter, going beyond the limits of practical detection.

5.2 Types of NSOM operation

5.2.1 General

Below we describe different modes of NSOM operation. This International Standard is concerned with apertured NSOMs operated in the illumination, collection or illumination/collection mode. Control of the gap between the specimen and the probe is achieved by shear-force detection using optical or electrical transduction for a straight-fibre probe, and by cantilever deflection using optical transduction for a bent or cantilevered probe.

5.2.2 Classification

5.2.2.1 NSOMs can be classified on the basis of how the light is transmitted to/collected from the specimen:

- a) Illumination mode: The light emanates from the aperture and is collected with a lens in the far field.
- b) Collection mode: The specimen is illuminated by light from a far-field source or excited to emit light by another means and light is detected (collected) using the NSOM aperture.
- c) Illumination/collection mode: The NSOM aperture is used for both illumination and collection.

5.2.2.2 NSOMs can also be classified on the basis of the position of the collection optics with respect to the illumination optics:

- a) Reflection mode: Both illumination and collection are carried out on the same side of the specimen in any of the three modes defined above.
- b) Transmission mode: The collection and the illumination optics are located on opposite sides of the specimen. In most cases, including the reflection mode a) above, a high-NA lens is used for high collection efficiency.