INTERNATIONAL
STANDARD

ISO
11952

First edition
2014-05-15

Surface chemical analysis — Scanning-probe microscopy — Determination of geometric quantities using SPM: Calibration of measuring systems

Analyse chimique des surfaces — Microscopie à sonde à balayage — Détermination des quantités géométriques en utilisant des microscopes à sonde à balayage: Étalonnage des systèmes de mesure

Reference number
ISO 11952:2014(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 201, *Surface chemical analysis*, Subcommittee SC 9, *Scanning probe microscopy*.

Introduction

The progress of miniaturization in semiconductor structuring, together with the rapid advance of many diverse applications of nanotechnology in industrial processes, calls for reliable and comparable quantitative dimensional measurements in the micro- and submicrometre range.[9] Currently, a measurement resolution, in or below the nanometre region, is frequently required. Conventional optical or stylus measurement methods or coordinate measuring systems are not able to offer this level of resolution.

For this reason, scanning-probe microscopes (SPMs) are increasingly employed as quantitative measuring instruments. Their use is no longer confined only to research and development, but has also been extended to include industrial production and inspection.

For this category of measuring instrument, standardized calibration procedures need to be developed, for example, as have been established already long ago for contact stylus instruments (see ISO 12179). For efficient and reliable calibration of SPMs to be carried out, the properties of the measurement standards used need to be documented and be accounted for in the calibration (see Figure 1) and, at the same time, the procedure for the calibration should be clearly defined.

Only if this prerequisite is satisfied, will it be possible to perform traceable measurements of geometrical quantities.

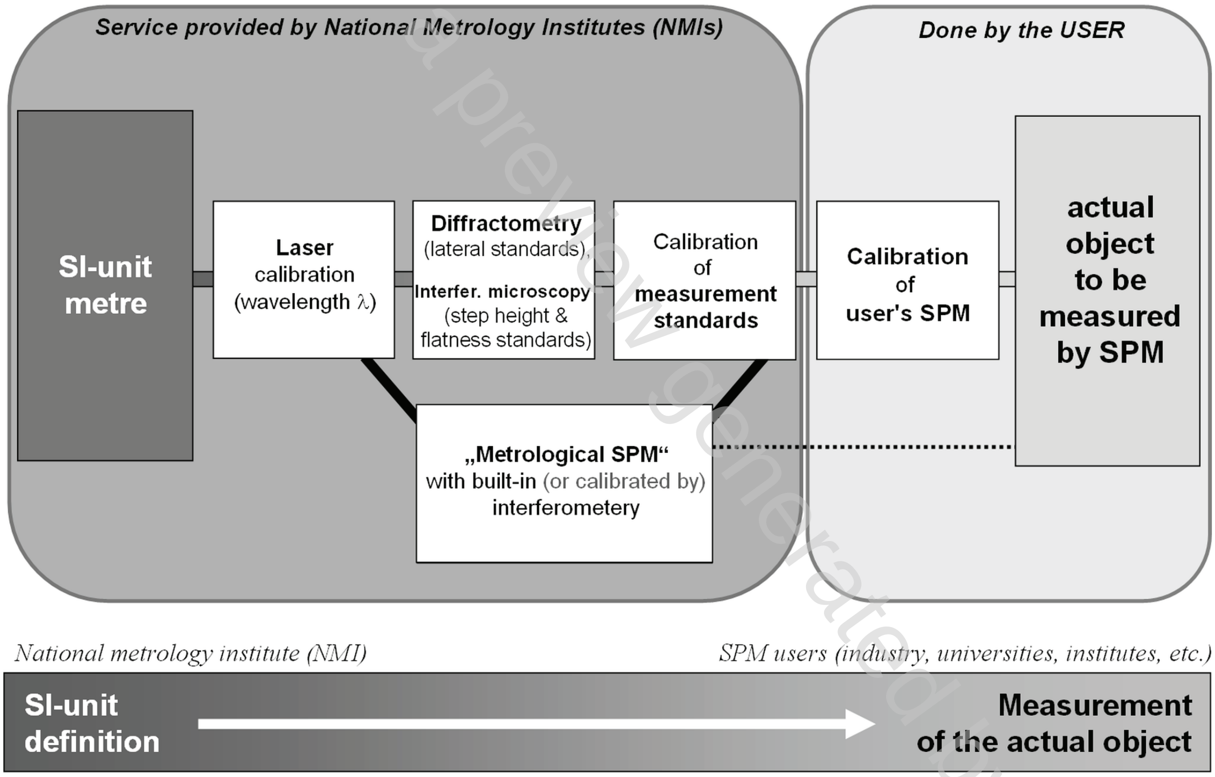


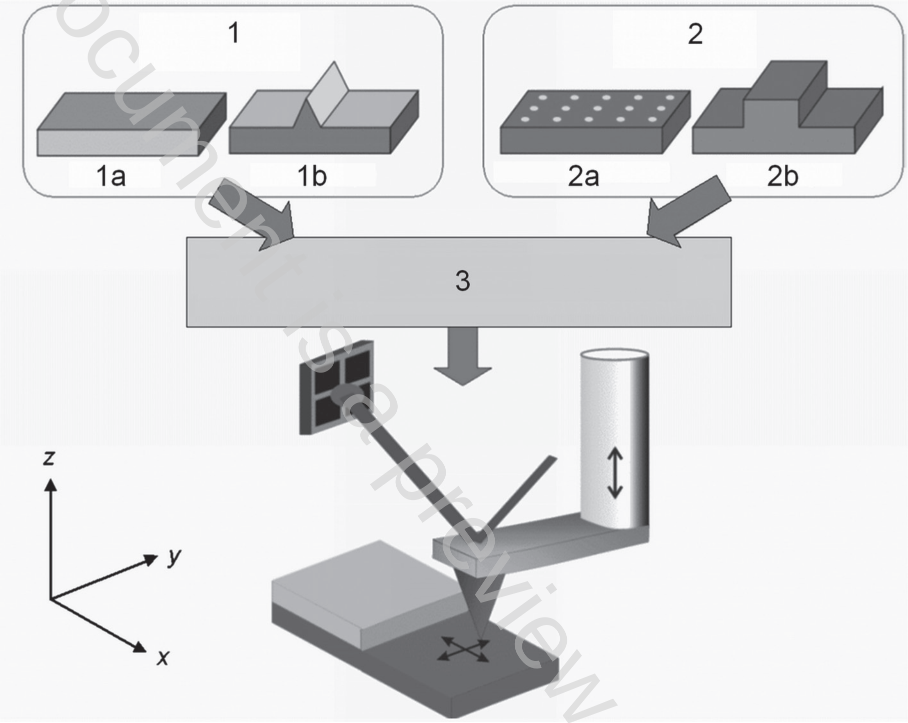
Figure 1 — Traceability chain for scanning-probe microscopes

NOTE The calibration of a user's SPM by means of traceably calibrated measurement standards is the object of this International Standard (done by the user).

A scanning-probe microscope is a serially operating measuring device which uses a probe with a tip of adequate fineness to trace the surface of the object to be measured by exploitation of a local physical interaction (such as the quantum-mechanical tunnel effect, interatomic or intermolecular forces, or evanescent modes of the electromagnetic field). The probe and the object to be measured are being displaced in relation to one another in a plane (hereinafter referred to as the *x*-*y*-plane) according to a defined pattern,[10] while the signal of the interaction is recorded and can be used to control the distance between probe and object. In this International Standard, signals are considered which are used for the determination of the topography (hereinafter called the “*z*-signal”).

This International Standard covers the verification of the device characteristics necessary for the measurement of geometrical measurands and the calibration of the axes of motion (*x*, *y*, *z*),[11] i.e. the traceability to the unit of length via measurement on traceable lateral, step height, and 3D measurement standards (see Figure 2).

While this International Standard aims at axis calibrations at the highest level and is thereby intended primarily for high-stability SPMs, a lower level of calibration might be required for general industry use.



Key

1	measurement standards for verification purposes
1a	flatness
1b	probe shape
2	measurement standards for calibration purposes
2a	1D and 2D lateral
2b	step height
3	calibration of the measurement standards by reference instruments (certified calibration, measurement value including uncertainty)

Figure 2 — Verification and calibration of scanning-probe microscopes with test specimens and measurement standards

This International Standard is mainly based on the guideline VDI/VDE 2656, Part 1, drafted by a guideline committee of the VDI (Verein Deutscher Ingenieure/Association of German Engineers) in the years 2004 to 2008, with the final whiteprint of that guideline being released in June 2008.

Surface chemical analysis — Scanning-probe microscopy — Determination of geometric quantities using SPM: Calibration of measuring systems

1 Scope

This International Standard specifies methods for characterizing and calibrating the scan axes of scanning-probe microscopes for measuring geometric quantities at the highest level. It is applicable to those providing further calibrations and is not intended for general industry use, where a lower level of calibration might be required.

This International Standard has the following objectives:

- to increase the comparability of measurements of geometrical quantities made using scanning-probe microscopes by traceability to the unit of length;
- to define the minimum requirements for the calibration process and the conditions of acceptance;
- to ascertain the instrument’s ability to be calibrated (assignment of a “calibrate-ability” category to the instrument);
- to define the scope of the calibration (conditions of measurement and environments, ranges of measurement, temporal stability, transferability);
- to provide a model, in accordance with ISO/IEC Guide 98-3, to calculate the uncertainty for simple geometrical quantities in measurements using a scanning-probe microscope;
- to define the requirements for reporting results.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11039, *Surface chemical analysis — Scanning-probe microscopy — Measurement of drift rate*

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

IEC/TS 62622, *Artificial gratings used in nanotechnology — Description and measurement of dimensional quality parameters*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18115-2 and IEC/TS 62622 and the following apply.

3.1

scanner bow

additional deflection in the z-direction when the scanner is displaced in the x-y-direction

Note 1 to entry: Scanner bow is also known as out-of-plane motion (see also xtz, ytz in Clause 4).