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**NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA**

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

表面化学分析 扫描探针显微术 采用扫描探针显微镜测定几何量：测量系统校准
(English Translation)

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Foreword

This document complies with the provisions of GB/T 1.1-2020 "Standardization Work Guidelines Part 1: Structure and Drafting Rules of Standardization Documents" Drafting.

This document is equivalent to ISO 11952:2019 "Surface chemical analysis scanning probe microscopy Determination of geometry using scanning probe microscopy" He Quantity. Measurement System Calibration.

Please note that some content in this document may be subject to patents. The publisher of this document assumes no responsibility for identifying patents.

Introduction

The progress of miniaturization of semiconductor device structures, accompanied by the rapid development of many different applications of nanotechnology in industrial manufacturing processes, requires Reliable and comparable quantitative size measurements in the micron and sub-micron range [9]. At present, it is often necessary to reach nanoscale or even higher distinguishing measurement capabilities. Traditional optical, stylus measurement methods or coordinate measurement systems cannot achieve this level of resolution.

Therefore, scanning probe microscopy (SPM) is increasingly used as a quantitative

measurement tool. Its application scope is no longer limited to research development, but covers industrial production and testing.

For this type of measuring instrument, a standardized calibration procedure needs to be developed, such as the established calibration procedure for stylus instruments (see GB/T 33523.701-2017). The characteristics of the measurement standards used for effective and reliable calibration of the SPM are recorded in procedural documents and serve as the basis for calibration (see Figure 1). Also, there are clear calibration steps.

Only when the prerequisites in Figure 1 are met can traceable measurements of geometric quantities be carried out.

NOTE: The purpose of this document is to calibrate the user's SPM using calibrated traceable measurement standards.

Figure 1 Traceability chain of SPM

SPM is a measuring device that works in a point-by-point scanning manner. It uses a probe with a sufficiently sharp tip to Interactions (such as quantum tunneling, forces between atoms or molecules, or near-field modes of electromagnetic waves) are used to describe the surface of the measured object. probe and quilt the measured object moves relatively in a specific way [10] in a plane (hereinafter referred to as the xy plane), and at the same time the interaction signal is collected, and the Used to control the distance between the probe and the object being measured. In this document, signal refers specifically to the signal used to determine the topography (hereinafter referred to as "z Signal").

This document covers the necessary inspection of SPM equipment characteristics required for geometric measurement, as well as the calibration of the motion axes (x, y, z).

Accurate [11], that is, the traceability of length units is achieved by measuring traceable transverse directions, step heights and three-dimensional measurement standards (see Figure 2).

This document is intended for the highest level of axis calibration and is therefore mainly used for high-stability SPMs. General industrial use may require only A slightly lower level of calibration is required.

Indexing serial number description.

- 1 ---Measurement standard sample for inspection;
- 1a---Flatness;
- 1b---Probe shape;
- 2 ---Measurement standards used for calibration;
- 2a---One-dimensional lateral and two-dimensional lateral;

2b---step height;

3 ---Calibrate the measurement standard using a standard device (certified calibration, measurement value and uncertainty).

Figure 2 Verification of calibrated SPM using test samples and standards

Surface chemical analysis scanning probe microscopy Determination of geometric quantities using scanning probe microscopy.

Measurement system calibration

1 Scope

This document describes methods for the characterization and calibration of the scanning axes of scanning probe microscopes (SPM) for the measurement of the highest level geometric quantities, applicable it is used to provide further calibrated measurement systems and is not suitable for general industrial applications with lower calibration level requirements.

This document is intended to.

- Improve the comparability of SPM geometric quantity measurement results by tracing the length unit;
- Clear the minimum requirements for calibration procedures and acceptance conditions;
- Confirm the ability of the instrument being calibrated (give the instrument the category of "calibration capability");
- Specify the scope of calibration (measurement and environmental conditions, measurement range, time stability, versatility);
- According to ISO/IEC Guide98-3, provide a model to calculate the uncertainty of simple geometric quantities in SPM measurements;
- Specifies requirements for reporting results.

2 Normative reference documents

The contents of the following documents constitute essential provisions of this document through normative references in the text. Among them, the dated quotations for undated referenced documents, only the version corresponding to that date applies to this document; for undated referenced documents, the latest version (including all amendments) applies to this document.

ISO 18115-2 Glossary of surface chemical analysis Part 2: Scanning probe microscopy terminology (Surfacechemical Note. GB/T 22461.2-2023 Surface chemical analysis