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

GB/T 47073-2026

**Surface chemical analysis - Depth profiling - Non-destructive
depth profiling of nanoscale heavy metal oxide thin films on Si
substrates with medium energy ion scattering**

表面化学分析 深度剖析 中能离子散射术对硅基底上纳米尺度重金属氧化物薄膜
的无损深度剖析

(English Translation)

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Table of Contents

Preface
Introduction
1 Scope
2 Normative References
3 Terms and Definitions
4 Principles and Recommendations for MEIS Analysis
5 MEIS Analysis
6 MEIS spectral simulations
7 MEIS Spectral Analysis Results Report
Appendix A (Informative) Interlaboratory Test Report
Appendix B (Informative) List of MEIS Spectrum Simulation Program Source Code and Programs for MEIS Spectrum Simulation Using PowerMeis
Appendix C (Informative) Reliability of IAEA Electronic Countermeasures Data
Appendix D (Informative) Fitting parameters A, B, C, and D to the IAEA database
References

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 23170:2022 "Surface chemical analysis - Depth profiling - Medium-energy ion scattering for nanoscale nanoscales on silicon substrates".

Non-destructive depth profiling of heavy metal oxide thin films.

The following minimal editorial changes have been made to this document.

a) The order of footnotes 3 and 4 has been reversed, following the order in which they are cited in the text.

b) Add the following to Figure A.3."Note. The black line represents experimental data, the red line represents simulation results, and the green line is the result obtained by multiplying the red line by a constant C, which is consistent with the black line." A well-matched curve.

c) Based on reference [16] and formula (1) in this document, correct the unit of parameter

"A" in the header of Table A.4 in Appendix A to [missing information].

$eV0.5 \cdot cm^2/1016.5 atoms$.

d) According to reference [16], the formula (A.1) in Appendix A is corrected to $SS=K Ss(E0) \cos\alpha Ss(KE0) \cos\beta$, $SN=K SN(E0) \cos\alpha SN(KE0) \cos\beta$

e) Correct the terms involving the symbol P in formulas (C.1) and (C.2) in Appendix C to the density symbol ρ .

Please note that some content in this document may involve patents. The issuing organization of this document assumes no responsibility for identifying patents.

This document was proposed and is under the jurisdiction of the National Technical Committee on Standardization of Surface Chemical Analysis (SAC/TC608).

Introduction

Medium-energy ion scattering (MEIS), since its invention in the early 1980s, has been considered a technique with single-atom depth resolution.

Quantitative analysis methods for surface and interface composition. MEIS has been widely used in the analysis of ultrathin films, especially nanoscale gate oxides, to determine their composition.

Separation, thickness, and interface. Recently, MEIS has been used for nanoparticle analysis to determine the size and composition of samples with core-shell structures. With...

The development of MEIS technology, besides the early use of toroidal electrostatic energy analyzers, has seen the emergence of different types of energy analyzers such as magnetic fan analyzers and...

Time-of-flight (TOF) energy analyzers have also been applied. Furthermore, as the size of objects being analyzed, such as electronic devices, continues to shrink, sputtering...

Damage leads to a deterioration in the provided depth profiling results, and the requirements for accuracy and reliability in depth profiling have exceeded the limits of sputtering depth profiling.

Limitations. It is necessary to study the relationships between three types of energy analyzers, ion species, and different energy ranges of incident ions used for MEIS analysis.

Consistency was established, and procedures for quantitative analysis of MEIS were developed. Appendix A reports the results of two international interlaboratory tests.

Surface chemical analysis for in-depth profiling of medium-energy ions Scattering techniques for nanoscale on silicon substrates Non-destructive depth profiling of heavy metal oxide thin films

1 Scope

This document describes the quantitative depth determination of amorphous heavy metal oxide ultrathin films on silicon substrates using medium-energy ion scattering (MEIS).

The method of analysis.

2 Normative references

The contents of the following documents, through normative references within the text, constitute essential provisions of this document. Dated citations are not included.

For references to documents, only the version corresponding to that date applies to this document; for undated references, the latest version (including all amendments) applies.

This document.

Note: GB/T 22461.1-2023 Surface Chemical Analysis Vocabulary Part 1: General Terminology and Spectroscopic Terminology (ISO 18115-1:2013, IDT) Vocabulary-Part 2:

Terms used in scanning-probe microscopy) Note. GB/T 22461.2-2023 Surface Chemical Analysis Vocabulary Part 2: Scanning Probe Microscopy Terminology (ISO 18115-2:2013, MOD)

3 Terms and Definitions

The terms and definitions defined in ISO 18115-1 and ISO 18115-2, as well as the following terms and definitions, apply to this document.

The decelerating force experienced by charged particles such as alpha particles and protons when interacting with electrons leads to energy loss in the particles.

4 Principles and Recommendations for MEIS Analysis

4.1

Ultrafilms with a thickness less than 10 nm can be analyzed using MEIS. Analysis is performed using H or He ionomers at 100 keV to 500 keV.

The system precisely measures the energy and angle of scattered ions to compare the measured spectrum with simulated spectra. It can utilize public websites and MEIS expert databases.

Free programs provided by laboratories and manufacturers (such as PowerMeis1 and SIMNRA2) can be used to simulate MEIS spectra. These simulation programs can calculate scattering...

Cross section and electron stopping power. Calculated electron stopping power values are usually quite inaccurate; therefore, it is recommended to use the values listed on the IAEA

website (3).

Electron blocking ability value.

1) <http://tars.if.ufrgs.br>

2) <https://home.mpcdf.mpg.de/~mam/>

3) It can be obtained from the following URL. <http://www-nds.iaea.org/stopping/> (Note. The original number was 4, but it has been changed to 3 in this document according to the sequential numbering principle.)

4.2

If the required electronic blocking capability value is not listed on the IAEA website, users are advised to perform relevant measurements to obtain more reliable results.