INTERNATIONAL STANDARD

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Surface chemical analysis — Secondary-ion mass spectrometry — Method for depth profiling of boron in silicon

Analyse chimique des surfaces — Spectrométrie de masse des ions secondaires — Dosage du bore dans le silicium par profilage d'épaisseur

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Contents

Page

Foreword

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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).

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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 6, *Secondary ion mass spectrometry*.

Annex A of this International Standard is for information only.

This second edition cancels and replaces the first edition (ISO 17560:2002), which has been technically revised. The revision also includes editorial correction.

Introduction

This International Standard was prepared for the quantitative depth profiling of boron in silicon by secondary-ion mass spectrometry (SIMS).

For quantitative depth profiling, calibration is necessary both for the concentration and the depth scales of the profile measured. A procedure for the determination of boron in silicon has been established as an International Standard, ISO 14237. Thus, the calibration of boron atomic concentration is performed by following ISO 14237.

This International Standard describes standard procedures for depth profiling of boron in single-crystal, poly-crystal, or amorphous silicon using SIMS and for depth scale calibration using stylus profilometry or optical interferometry.

Surface chemical analysis — Secondary-ion mass spectrometry — Method for depth profiling of boron in silicon

1 Scope

This International Standard specifies a secondary-ion mass spectrometric method using magnetic-sector or quadrupole mass spectrometers for depth profiling of boron in silicon, and using stylus profilometry or optical interferometry for depth scale calibration. This method is applicable to single-crystal, polycrystal, or amorphous silicon specimens with boron atomic concentrations between 1×10^{16} atoms/cm^3 and 1×10^{20} atoms/cm^3, and to crater depths of 50 nm or deeper.

2 Normative reference

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 14237:2010, *Surface chemical analysis — Secondary-ion mass spectrometry — Determination of boron atomic concentration in silicon using uniformly doped materials*

3 Symbols and abbreviations

C_i total boron atomic concentration in measurement cycle i, expressed in atoms per cubic centimetre (atoms/cm^3)

C_i^{10} atomic concentration of the boron isotope with mass number 10 in measurement cycle i, expressed in atoms per cubic centimeter (atoms/cm^3)

C_i^{11} atomic concentration of the boron isotope with mass number 11 in measurement cycle i, expressed in atoms per cubic centimeter (atoms/cm^3)

d_i depth measured in measurement cycle i, expressed in micrometres (µm) or nanometers (nm)

d_t crater depth, expressed in micrometres (µm) or nanometres (nm)

I_i^{10} ion intensity of the boron isotope with mass number 10 in measurement cycle i, expressed in counts per second (counts/s)

I_i^{11} ion intensity of the boron isotope with mass number 11 in measurement cycle i, expressed in counts per second (counts/s)

I_i^{Si} ion intensity of silicon matrix in measurement cycle i, expressed in counts per second (counts/s)

J_i^{10} boron to silicon ion intensity ratio for the boron isotope with mass number 10 in measurement cycle i

J_i^{11} boron to silicon ion intensity ratio for the boron isotope with mass number 11 in measurement cycle i

J_{BG}^{10} mean background boron to silicon ion intensity ratio for the boron isotope with mass number 10 in measurement cycle i

J_{BG}^{11} mean background boron to silicon ion intensity ratio for the boron isotope with mass number 11 in measurement cycle i

N total number of measurement cycles

T total measurement time, expressed in seconds (s)

t_i^{B} starting time of boron-ion acquisition in measurement cycle i, expressed in seconds (s)

Δt_i^{B} duration of boron-ion acquisition in each measurement cycle, expressed in seconds (s)

δ mass discrimination correction factor

λ wavelength of the light for optical interferometry, expressed in micrometres (µm) or nanometres (nm)

$\mathrm{RSF}^{\mathrm{work}}$ working relative-sensitivity factor

SIMS secondary-ion mass spectrometry

4 Principle

An oxygen-ion beam or caesium-ion beam is scanned over the specimen surface and the emitted secondary-ions of boron and silicon from a gated region within the area scanned by the ion beam are detected and mass-analysed. The intensities of these mass-analysed signals are monitored as a function of sputtering time. The depth of the crater formed by the ion beam is measured by stylus profilometry or optical interferometry for depth scale calibration.

NOTE Optical interferometry is generally applicable to crater depths in the range from 0,5 µm to 5 µm.

5 Reference materials

5.1 Reference materials for determination of relative-sensitivity factors

The reference materials should be as specified in ISO 14237:2010, Clause 4.

5.2 Reference materials for calibration of depth scale

For stylus profilometry calibration, certified reference materials or reference materials, which are traceable to certified reference materials, shall be used.

6 Apparatus

6.1 Secondary-ion mass spectrometer

The apparatus should be as specified in ISO 14237:2010, Clause 5.

6.2 Stylus profilometer

Use a stylus profilometer with the sensitivity and tip shapes suitable for the crater shapes to be measured.

6.3 Optical interferometer

Use an optical interferometer with the sensitivity and functions suitable for the crater shapes to be measured.

7 Specimen

The specimen shall be cut to an appropriate size for analysis and degreased and washed if necessary.

NOTE The accuracy of crater depth measurement is largely influenced by surface roughness. A mirror-polished wafer is preferable when accurate determination of the depth scale is necessary.

8 Procedure

8.1 Adjustment of secondary-ion mass spectrometer

8.1.1 For oxygen-ion beam use, see Table 1. For caesium-ion beam use, see Table 2. Other conditions not shown here shall be set in accordance with the manufacturer's instructions or a local documented procedure.

Table 1 — Measurement conditions for oxygen-ion beam

Primary-ion species	O_2^+
Secondary-ion polarity	Positive
Primary-ion scan region	> three times the linear dimension of the analysed region in all directions
Analysed region	Centred in the primary-ion scan region

Table 2 — Measurement conditions for caesium-ion beam

Primary-ion species	Cs^+
Secondary-ion polarity	Negative
Primary-ion scan region	> three times the linear dimension of the analysed region in all directions
Analysed region	Centred in the primary-ion scan region

8.1.2 For the primary-ion beam, the beam current and scan region can vary from specimen to specimen (see 8.5.2). However, when oxygen gas is introduced into the chamber during oxygen-beam irradiation, the oxygen pressure and all the primary-ion beam irradiation conditions shall be the same for the measurements on all specimens.

8.2 Optimizing the secondary-ion mass spectrometer settings

8.2.1 Set the required instrument parameters and align the ion optics in accordance with the manufacturer's instructions or a local documented procedure.

8.2.2 Ensure the stability of the primary-ion current and the mass spectrometer in accordance with the manufacturer's instructions or a local documented procedure.

8.2.3 For a mass spectrometer whose transmission can be varied, use the same transmission for the measurements on both reference materials and test specimens.