

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

ICS 71.040.40

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Summary of pages

This document comprises a front cover, an inside front cover, the ISO title page, pages ii to v, a blank page, pages 1 to 22, an inside back cover and a back cover.

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This British Standard, having been prepared under the direction of the Sector Committee for Materials and Chemicals, was published under the authority of the Standards Committee and comes into effect on 15 April 2000

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ISBN 0 580 34674 9

Amendments issued since publication

Amd. No.	Date	Comments

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

Analyse chimique des surfaces — Méthode par spectrométrie de masse des ions secondaires — Dosage des atomes de bore dans le silicium à l'aide de matériaux dopés uniformément



Reference number
ISO 14237:2000(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 14237 was prepared by Technical Committee ISO/TC 201, *Surface chemical analysis*, Subcommittee SC 6, *Secondary ion mass spectrometry*.

Annexes C and D form a normative part of this International Standard. Annexes A, B and E are for information only.

Introduction

This International Standard was prepared for the determination by secondary-ion mass spectrometry (SIMS) of boron atomic concentrations in uniformly doped silicon wafers.

SIMS needs reference materials to perform quantitative analyses. Certified reference materials are only available for limited matrix-impurity combinations, and they are costly. SIMS inevitably consumes these reference materials at every measurement. Thus, secondary reference materials which can be prepared by each laboratory and calibrated using a certified reference material are useful for daily analyses.

In this International Standard, a standard procedure is described for quantitative boron analysis in single-crystalline silicon using secondary reference materials calibrated by a certified reference material implanted with boron.

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

1 Scope

This International Standard specifies a secondary-ion mass spectrometric method for the determination of boron atomic concentration in single-crystalline silicon using uniformly doped materials calibrated by a certified reference material implanted with boron. This method is applicable to uniformly doped boron in the concentration range from 1×10^{16} atoms/cm³ to 1×10^{20} atoms/cm³.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, this publication do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 5725-2:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*.

3 Principle

An oxygen-ion beam or a caesium-ion beam is impinged onto the sample surface and the emitted secondary ions of boron and silicon are mass-analysed and detected.

Uniformly doped secondary reference materials are calibrated by using an ion-implanted primary reference material and are used as working reference materials.

4 Reference materials

4.1 Primary reference material

A primary reference material is used for the determination of the boron atomic concentration of the secondary reference materials. The primary reference material shall be a certified reference material (CRM) of silicon implanted with boron.

NOTE NIST Standard Reference Material 2137 (referred to hereinafter as NIST SRM) is the only CRM of boron in silicon at this moment.

4.2 Secondary reference materials

4.2.1 Secondary reference materials are used for the determination of boron atomic concentrations in test specimens. At least one boron-doped reference material together with one non-boron-doped reference material shall be used for daily analysis. Two other different boron-doping levels are recommended to be used to confirm the performance of the apparatus (see annex C).

4.2.2 The secondary reference materials (referred to hereinafter as bulk RMs) shall be single-crystal silicon wafers or epitaxial silicon wafers with a ca. 100 µm thick epitaxial layer, and shall be uniformly doped with natural-isotopic boron.

4.2.3 Boron-doped wafers with boron atomic concentrations between 1×10^{16} atoms/cm³ and 1×10^{20} atoms/cm³ shall be obtained. It is recommended that the three doping levels given in Table 1 are used. When only one level is used, RM-B or RM-C should be chosen. A non-boron-doped wafer shall be obtained for background checking.

Wafers with small boron concentration gradients shall be selected. The boron concentration gradient shall be less than 5 % per cm.

NOTE Approximate boron atomic concentrations can be determined as carrier densities from the resistivity of the wafers. The resistivity measurement procedures and the procedure for converting between resistivity and carrier density are presented in annex A.

Table 1 — Bulk reference materials

Name	Boron doping level	
	atoms/cm ³	
RM-A	low	1×10^{16} to 1×10^{17}
RM-B	middle	5×10^{17} to 5×10^{18}
RM-C	high	1×10^{19} to 1×10^{20}
RM-BG	none	$< 1 \times 10^{14}$

4.2.4 The isotope ratio of ¹¹B to ¹⁰B in the bulk RM chosen in 4.2.2 shall be determined by one of following methods.

- The isotope ratio shall be evaluated by a magnetic-sector SIMS instrument detecting BSi⁻ ions. The measurement procedure stipulated in 7.5.2 shall be used for this purpose.
- The bulk RM shall be assumed to have the accepted nominal natural isotopic composition of 19,9 atomic percent ¹⁰B and 80,1 atomic percent ¹¹B, i.e. a ratio of ¹¹B atoms to ¹⁰B atoms of 4,025. The boron isotope ratio in a specific material, however, can have ±5 % deviation from the natural isotope ratio.

NOTE SIMS will generally measure a deviated isotope ratio depending on type of instrument and detected ions. The deviation is smaller between ¹⁰B²⁸Si⁻ and ¹¹B²⁸Si⁻ than between ¹⁰B⁺ and ¹¹B⁺ in a magnetic-sector mass spectrometer (see annex B).

5 Apparatus

Secondary-ion mass spectrometry apparatus equipped with an oxygen-ion source and/or a caesium-ion source shall be used.