

SEMI M44-0702

GUIDE TO CONVERSION FACTORS FOR INTERSTITIAL OXYGEN IN SILICON

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1 Purpose

1.1 This guide is a compilation of the conversion and calibration factors used by different standards established for the measurement of interstitial oxygen in silicon.

2 Scope

2.1 This guide allows the user of the guide to convert quantitative values obtained from one standard to another.

2.2 This guide does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this guide to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Referenced Standards

NOTE 1: Unless otherwise indicated, all documents cited shall be the latest published versions.

3.1 SEMI Standards

SEMI M1 — Specifications for Polished Monocrystalline Silicon Wafers

SEMI M11 — Specifications for Silicon Epitaxial Wafers for Integrated Circuit (IC) Applications

3.2 ASTM Standards¹

F121-79 — Test Method for Interstitial Atomic Oxygen Content of Silicon by Infrared Absorption

F121-83 — Test Method for Interstitial Atomic Oxygen Content of Silicon by Infrared Absorption

F1188 — Test Method for Interstitial Atomic Oxygen Content of Silicon by Infrared Absorption (refers to IOC-88²)

1 American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, USA. Telephone: 610.832.9585, Fax: 610.832.9555 Website: www.astm.org

2 A. Baghdadi, W. M. Bullis, M. C. Croarkin, Y.-Z. Li, R. I. Scace, R.W. Series, P. Stallhofer, M. Watanabe, "Interlaboratory Determination of the Calibration Factor for the Measurement of the Interstitial Oxygen Content of Silicon by Infrared Absorption," *J. Electrochem. Soc.*, Vol. 136, p. 2015 (1989)

F1241 — Standard Terminology of Silicon Technology

3.3 DIN Standard³

DIN 50438-1[1994, 1995] — Determination of Impurity Content in Silicon by Infrared Absorption; Part 1 Oxygen⁴ (refers to IOC-88²)

DIN 50438 Part 1 [1978] — Determination of Impurity Content in Silicon by Infrared Absorption: Oxygen

3.4 JEITA Standard⁵

JEIDA 61 — Standard Test Method for Atomic Oxygen Content of Silicon by Infrared Absorption (refers to IOC-88²)

4 Terminology

4.1 Many terms relating to silicon technology are defined in ASTM Terminology F 1241.

5 Other Techniques

5.1 Other measurement techniques for measuring oxygen in silicon (e.g., SIMS or GFA) measure total oxygen whereas the referenced methods measure interstitial oxygen only. For details, refer to Volume 10.05 of *Annual Book of ASTM Standards*.

6 Conversion Factors Among International Standards

6.1 Table 1 gives the conversion factors to convert oxygen concentration of one standard to oxygen concentration of another standard.

6.2 Table 2 gives the calibration factors to relate peak absorption coefficient (cm^{-1}) to interstitial oxygen content in both parts per million atomic (ppma) and atoms/ cm^3 for various standards that have been replaced by newer revisions.

3 Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Burggrafenstrasse 4-10, D-10787 Berlin, Germany

4 In German – 1995 English edition available. DIN 50438-1 [1995] – Determination of Interstitial Oxygen Content of Silicon Intended for Use in Semiconductor Technology by Infrared Absorption spectroscopy (refers to IOC-88²)

5 Japan Electronics and Information Technology Industries Association, 3rd Floor Mitsui Kaijo Bldg. Annex 11, Kanda Surugadai 3-chome, Chiyoda-ku, Tokyo 101-0062, Japan

6.3 Irrespective of a standard, to convert oxygen density (atoms/cm³) to oxygen concentration (ppma), within the same standard, divide the value by:

$$5 \times 10^{16} \text{ (atoms per cm}^3 \text{ / ppma),} \quad (1)$$

and, to convert ppma to concentration (atoms/cm³), within the same standard, multiply the value by (1).

Table 1 Conversion Factors

TO: → Convert From: ↓	ASTM F121-79 ^A (Old ASTM)	ASTM F121-83 ^B (New ASTM) or DIN 50438 Part 1 (1978)	ASTM F1188 ^C or DIN 50438-1 ^C [1994, 1995] or JEIDA 61 ^C	“JEIDA Coefficient (Original)” ^D
ASTM F121-79 ^A (Old ASTM)	1	0.509	0.652	0.629
ASTM F121-83 ^B (New ASTM) or DIN 50438 Part 1 (1978)	1.965	1	1.282	1.237
ASTM F1188 ^C or DIN 50438-1 ^C [1994, 1995] or JEIDA 61 ^C	1.533	0.780	1	0.965
“JEIDA Coefficient (Original)” ^D	1.589	0.809	1.036	1

A. All ASTM F 121 from 1970 to 1979.

B. All ASTM F 121 at or later than 1980.

C. Each of these standards refers to IOC-88.

D. T. Iizuka, S. Takasu, M. Tajima, T. Arai, T. Nozaki, N. Inoue, and M. Watanabe, “Determination of Conversion Factor for Infrared Measurement of Oxygen in Silicon,” *J. Electrochemical Society*, Vol 132, pp 1707-1713 (1985).

Table 2 Calibration Factors

Calibration Factor	Value to Obtain Oxygen Content in ppma	Value to Obtain Oxygen Content in atoms/cm ³
ASTM F121-79 ^A (Old ASTM)	9.63	4.815×10^{17}
ASTM F121-83 ^B (New ASTM) or DIN 50438 Part 1 (1978)	4.90	2.45×10^{17}
ASTM F1188 ^C or DIN 50438-1 ^C [1994, 1995] or JEIDA 61 ^C	6.28	3.14×10^{17}
“JEIDA Coefficient (Original)” ^D	6.06	3.03×10^{17}

A. All ASTM F 121 from 1970 to 1979.

B. All ASTM F 121 at or later than 1980.

C. Each of these standards refers to IOC-88.

D. T. Iizuka, S. Takasu, M. Tajima, T. Arai, T. Nozaki, N. Inoue, and M. Watanabe, “Determination of Conversion Factor for Infrared Measurement of Oxygen in Silicon,” *J. Electrochemical Society*, Vol 132, pp 1707-1713 (1985).

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