

SEMI M44-0305 (Reapproved 0211) GUIDE TO CONVERSION FACTORS FOR INTERSTITIAL OXYGEN IN SILICON

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1 Purpose

1.1 Over the years numerous calibration factors used to calculate the interstitial oxygen content of silicon from the peak room-temperature infrared absorption at 1107 cm^{-1} have been standardized by several standards development organizations in various parts of the world. All such standards have since been revised to use the IOC-88 calibration factor^{1,2} that more correctly relates the true oxygen content of silicon to the absorption peak. Nevertheless, many of the old calibration factors remain in common use throughout the industry.

1.2 This guide is a compilation of the conversion and calibration factors used in standards established by various organizations since 1970 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 Two tables are included in the guide.

2.2.1 Table 1 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oxygen content in both parts per million atomic (ppma) and atoms/ cm^3 for various standards, all of which have been replaced by newer revisions.

2.2.1.1 These calibration factors are at times referred to by common names as indicated in column one of the tables and at other times by the designation of the (obsolete) standard in which they were standardized (as indicated in the footnotes to Table 1). Despite the fact that there is a test method associated with each calibration factor, the detailed procedures in these test methods are usually ignored in common practice and measurements are most frequently made with automated (black-box) instruments that have internal algorithms. Thus, reference to a particular standard most often indicates only the value of the calibration factor to be used.

2.2.2 Table 2 gives the conversion factors to convert oxygen concentration of one standard to oxygen concentration of another standard.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Referenced Standards and Documents

3.1 SEMI Standards

SEMI M59 — Terminology for Silicon Technology

SEMI MF1188 — Test Method for Interstitial Atomic Oxygen Content of Silicon by Infrared Absorption with Short Baseline

¹ Baghdadi, A., Bullis, W. M., Croarkin, M. C., Li Yue-zhen, Scace, R. I., Series, R. W., Stallhofer, P., and Watanabe, M., "Interlaboratory Determination of the Calibration Factor for the Measurement of the Interstitial Oxygen Content of Silicon by Infrared Absorption," *J. Electrochem. Soc.* (1989): pp. 2015–2034.

² Baghdadi, A., Scace, R. I., and Walters, E. J., "Semiconductor Measurement Technology: Database for and Statistical Analysis of the Interlaboratory Determination of the Calibration Factor for the Measurement of the Interstitial Oxygen Content of Silicon by Infrared Absorption." NIST Special Publication (July 1989): pp. 400–482.

3.2 ASTM Standards

ASTM F121 (1970–1979) — Test Method for Interstitial Atomic Oxygen Content of Silicon by Infrared Absorption³

ASTM F121 (1980–1983) — Test Method for Interstitial Atomic Oxygen Content of Silicon by Infrared Absorption⁴

3.3 DIN Standard⁵

DIN 50438-1 (1978) — Determination of Impurity Content in Silicon by Infrared Absorption: Part 1 Oxygen

DIN 50438-1 (1994–1995) — Determination of Impurity Content in Silicon by Infrared Absorption: Part 1 Oxygen

3.4 Guo Biao Standard⁶

GB/T 1557-1989 — Test Method for Interstitial Oxygen Content in Silicon Crystals by Infrared Absorption Spectroscopy

3.5 JEITA Standard⁷

JEITA EM-3504 — Standard Test Method for Interstitial Atomic Oxygen Content of Silicon by Infrared Absorption⁸

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

4 Terminology

4.1 Many terms relating to silicon technology are defined in SEMI M59.

5 Other Techniques

5.1 Other measurement techniques for measuring oxygen in silicon (e.g., SIMS or gas fusion analysis, GFA) measure total oxygen whereas the infrared absorption methods, to which this guide applies, measure interstitial oxygen only.

6 Conversion Factors Among International Standards

6.1 Table 1 gives the calibration factors published in various standard test methods for determination of interstitial oxygen content in silicon by infrared absorption. The factor to obtain the oxygen concentration in parts per million atomic is given in column 2 while the factor to obtain the oxygen density in atoms/cm³ is given in column 3. The calibration factors are listed in order from the smallest value to the largest value irrespective of the time frame over which they were adopted.

6.2 Table 2 gives the factors to convert oxygen concentration of one standard to oxygen concentration of another standard. The interstitial oxygen content found by any procedure may be reported in any other standardized scale by multiplying the value by the appropriate conversion factor in Table 2. The factors are listed in the same order as in Table 1.

³ Revised to change the calibration factor in 1980; last available edition in the 1980 edition of *Annual Book of ASTM Standards*, Part 43. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, USA. Telephone: 610.832.9585; Fax: 610.832.9555; <http://www.astm.org>

⁴ Revised to change the calibration factor in 1980; last available edition in the 1980 edition of *Annual Book of ASTM Standards*, Part 43. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, USA. Telephone: 610.832.9585; Fax: 610.832.9555; <http://www.astm.org>

⁵ Deutsches Institut für Normung e.V., Available from Beuth Verlag GmbH, Burggrafenstrasse 4-10, D-10787 Berlin, Germany; <http://www.din.de>

⁶ China Electronic Standardization Institute, Beijing, China.

⁷ Formerly JEIDA 61; Japanese Electronic and Information Technology Industries Association, 3rd Fl., Mitsui Sumitomo Kaijo Bldg. Annex, 11, Kanda Surugadai 3-chome, Chiyoda-ku, Tokyo 101-0062, Japan. <http://www.jeita.or.jp>

⁸ This standard replaces the calibration factor reported in 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. Electrochem. Soc.* (1985): pp. 1707–1713, which was previously widely used in Japan.