



Standard Guide for Measuring Widths of Interfaces in Sputter Depth Profiling Using SIMS¹

This standard is issued under the fixed designation E 1438; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide provides the SIMS analyst with a method for determining the width of interfaces from SIMS sputtering data obtained from analyses of layered specimens. This guide does not apply to data obtained from analyses of specimens with thin markers or specimens without interfaces such as ion-implanted specimens.

1.2 This guide does not describe methods for the optimization of interface width or the optimization of depth resolution.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

E 673 Terminology Relating to Surface Analysis²

3. Terminology

3.1 Definitions:

3.1.1 See Terminology E 673 for definitions of terms used in SIMS.

4. Summary of Guide

4.1 This guide will allow interface widths to be calculated from plots of SIMS secondary ion intensity versus time that are acquired during sputtering of layered specimens. It assumes that a primary ion beam with a stable current density is being used. Briefly, these plots are obtained in the following fashion: an ion beam of a particular ion species, ion energy, and angle of incidence is used to bombard a sample. The beam is rastered or defocused so as to attempt to produce uniform current density in the analyzed area, that is defined by means of mechanical or electronic gating. The intensity of one or more secondary ions is monitored with respect to time as sputtering continues.

4.2 The interface width is then determined from the secondary ion intensity versus time data according to an arithmetic model described in the Procedure section. A measurement of the thickness of the layer overlying the interface is required. This measurement may be performed by another analytical technique.

5. Significance and Use

5.1 Although it would be desirable to measure the extent of profile distortion in any unknown sample by using a standard sample and this guide, measurements of interface width (profile distortion) can be unique to every sample composition (**1, 2, 3**).³ This guide, that describes a method that determines the unique width of a particular interface, is primarily intended to provide a method for checking on proper or consistent instrument performance, or both. Periodic analysis of the same sample followed by a measurement of the interface width, in accordance with this guide, will provide these checks.

5.2 The procedure described in this guide is adaptable to any layered sample with an interface between layers of differing compositions. It has been shown that for SIMS in particular (**4, 5**) and for surface analysis in general (**6, 7**), only rigorous calibration methods can determine accurate interface widths. Such procedures are prohibitively time-consuming. Therefore the interface width measurement obtained using the procedure described in this guide may contain significant systematic error (**8**). However, this does not diminish its use as a check on proper or consistent instrument performance, or both.

6. Apparatus

6.1 The procedure described in this guide can be used to determine an interface width from data obtained with virtually any SIMS instrument.

6.2 Use of the interface width measurement from a layered specimen as a check on proper or consistent instrument performance, or both, does not assume that the sample of interest contains no interface roughness. Rather, it assumes that the interface roughness is consistent from one analyzed area to

¹ This guide is under the jurisdiction of ASTM Committee E42 on Surface Analysis and is the direct responsibility of Subcommittee E42.06 on SIMS.

Current edition approved Sept. 15, 1991. Published November 1991.

² *Annual Book of ASTM Standards*, Vol 03.06.

³ The boldface numbers given in parentheses refer to a list of references at the end of this guide.

the next. Any layered sample that meets this criterion is suitable for the use intended by this guide.

7. Procedure

7.1 This procedure for measurement of depth resolution is based on the amount of time required for the signal of one of the major elements of the layer overlying the interface to be reduced from 84 to 16 % of its average intensity in the overlying layer. The ratio of this interface sputtering time to that of the sputtering time of the overlayer is equated to the ratio of their respective thicknesses in order to obtain the measurement of interface thickness. This is expressed in the form of the following equation (refer to Fig. 1):

$$\Delta Z = [\Delta t/t] * Z \quad (1)$$

where:

ΔZ = interface width,

Δt = sputtering time for decrease from 84 to 16 % of the signal intensity,

t = time required to sputter through overlayer, from $t = 0$ until t is equal to the time at which the major element reaches 50 % of its value in the overlayer, and

Z = thickness of overlayer.

7.1.1 The measurement of sputter time (t) for the interfacial region and for the overlying layer thickness should be acquired graphically from the plot of secondary ion signal versus time.

7.1.2 The thickness of the overlayer (Z) is commonly obtained from a post-profile crater measurement and assuming

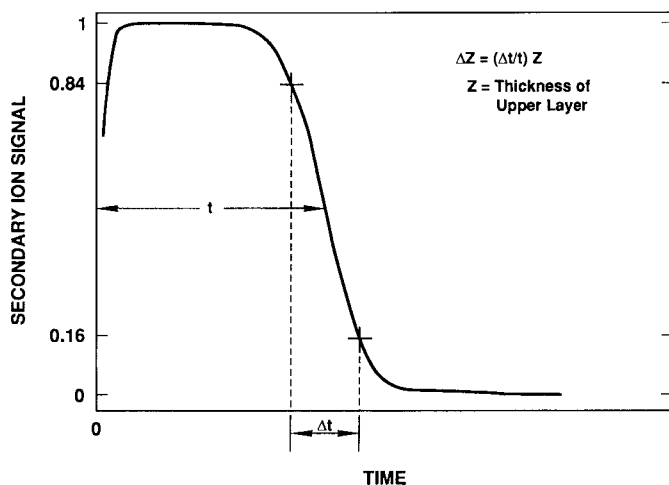


FIG. 1 Measurement of Interface Width, ΔZ , from a Plot of SIMS Intensity Versus Ion Bombardment Time

a constant sputter rate. The thicknesses of layers in a multilayered profile are only approximated by this procedure. A more accurate thickness value for the overlayer is obtained by halting the sputtering at the interface, and obtaining a crater measurement. Alternatively, other techniques may be used to measure the overlying layer. Some possible techniques that may be used include optical interferometry, ellipsometry, selective chemical etching followed by profilometry, and spectroscopic methods such as Rutherford Backscattering Spectrometry (RBS), X-ray Fluorescence (XRF), and Angle Resolved X-ray Photoelectron Spectroscopy (ARXPS).

REFERENCES

- (1) Wittmaack, K., "Vacuum," *Journal of Vacuum Science Technology*, Vol 34, 1984, p. 119.
- (2) Wittmaack, K., *Journal of Vacuum Science Technology*, Vol A3, 1985, p. 1350.
- (3) Boudewijn, P. R., Leys, M. R., and Roozeboom, F., *Surface Interface Analysis*, Vol 9, 1986, p. 303.
- (4) Galuska, A. A., "SIMS V, Proceedings of the Fifth International Conference," Springer Verlag: New York, 1986, p. 363.
- (5) Galuska, A. A., *Analytical Chemistry*, Vol 55, 1984, p. 74.
- (6) Kirchhoff, W. H., Chambers, G. P., and Fine, J., *Journal of Vacuum Science Technology*, Vol A4, 1986, p. 1666.
- (7) Fine, J., et al., *Journal of Vacuum Science Technology*, Vol A3, 1985, p. 1413.
- (8) Hofmann, S., and Sanz, J. M., "Thin Film and Depth Profile Analysis," H. Oechsner, ed., Springer-Verlag: New York, 1984, pp. 141-158.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).