



## Test Method for Quantifying Tungsten Silicide Semiconductor Process Films for Composition and Thickness<sup>1</sup>

This standard is issued under the fixed designation F 1894; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method covers the quantitative determination of tungsten and silicon concentrations in tungsten/silicon ( $\text{WSi}_x$ ) semiconductor process films using Rutherford Backscattering Spectrometry (RBS).<sup>2</sup> (1) This test method also covers the detection and quantification of impurities in the mass range from phosphorus  $\text{\AA}$  (31 atomic mass units (amu) to antimony (122 amu).

1.2 This test method can be used for tungsten silicide films prepared by any deposition or annealing processes, or both. The film must be a uniform film with an areal coverage greater than the incident ion beam ( $\sim 2.5 \text{ mm}$ ).

1.3 This test method accurately measures the following film properties: silicon/tungsten ratio and variations with depth, tungsten depth profile throughout film,  $\text{WSi}_x$  film thickness, argon concentrations (if present), presence of oxide on surface of  $\text{WSi}_x$  films, and transition metal impurities to detection limits of  $1 \times 10^{14} \text{ atoms/cm}^2$ .

1.4 This test method can detect absolute differences in silicon and tungsten concentrations of  $\pm 3$  and  $\pm 1$  atomic percent, respectively, measured from different samples in separate analyses. Relative variations in the tungsten concentration in depth can be detected to  $\pm 0.2$  atomic percent with a depth resolution of  $\pm 70 \text{\AA}$ .

1.5 This test method supports and assists in qualifying  $\text{WSi}_x$  films by electrical resistivity techniques.

1.6 This test method can be performed for  $\text{WSi}_x$  films deposited on conducting or insulating substrates.

1.7 This test method is useful for  $\text{WSi}_x$  films between 20 and 400 nm with an areal coverage of greater than 1 by  $1 \text{ mm}^2$ .

1.8 This test method is non-destructive to the film to the extent of sputtering.

1.9 A statistical process control (SPC) of  $\text{WSi}_x$  films has been monitored since 1993 with reproducibility to  $\pm 4 \%$ .

1.10 This test method produces accurate film thicknesses by modeling the film density of the  $\text{WSi}_x$  film as  $\text{WSi}_2$  (hexagonal) plus excess elemental Si<sup>2</sup>. The measured film thickness is a

lower limit to the actual film thickness with an accuracy less than 10 % compared to SEM cross-section measurements (see 13.4).

1.11 This test method can be used to analyze films on whole wafers up to 300 mm without breaking the wafers. The sites that can be analyzed may be restricted to concentric rings near the wafer edges for 200-mm and 300-mm wafers, depending on system capabilities.

1.12 *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.* The reader is referenced to Section 8 of this test method for references to some of the regulatory, radiation, and safety considerations involved with accelerator operation.

### 2. Referenced Documents

2.1 Terminology used in this document is consistent with terms and definitions as used in the *Compilation of ASTM Standard Definitions*, 8<sup>th</sup> ed ASTM, 1994, Philadelphia PA, USA, specifically for terms taken from the following ASTM standards:

2.2 *ASTM Standards:*<sup>3</sup>

E 135 Terminology of Analytical Chemistry for Metals, Ores, and Related Materials

E 673 Terminology Relating to Surface Analysis

E 1241 Terminology of Semiconductor Technology

### 3. Terminology

3.1 Numerous terms specific to RBS and ion stopping in solids can be found in the following references (1, 2)<sup>2</sup>.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1  $\text{WSi}_x$ —a tungsten silicide film characterized by a silicon/tungsten atomic ratio  $> 2.00$ .

3.2.2 *incident ions*— $\text{He}^+$  or  $\text{He}^{++}$  ions with energy in the range of 2.25 to 2.30 MeV delivered to a sample surface from an appropriate ion source and accelerator system.

<sup>1</sup> This test method is under the jurisdiction of Committee F01 on Electronics, and is the direct responsibility of Subcommittee F01.17 on Sputter Metallization. Current edition approved May 10, 1998. Published July 1998.

<sup>2</sup> The boldface numbers in parentheses refer to a list of references at the end of the text.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.