

SEMI M88-0119

PRACTICE FOR SAMPLE PREPARATION METHODS FOR MEASURING MINORITY CARRIER DIFFUSION LENGTH IN SILICON WAFERS BY SURFACE PHOTOVOLTAGE METHODS

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1 Purpose

1.1 Shrinkage and advanced integration of semiconductor components demand lower metal contamination levels in component-fabrication processes and in base silicon wafer substrates. The industry has for some time widely employed surface photovoltage (SPV) measurements of minority carrier diffusion lengths as a technique to assess metal impurities in silicon wafers. Samples, however, often require surface preparation prior to SPV measurements because SPV measurements are sensitive to surface conditions. An associated problem is changes in surface characteristics of samples over time after preparation, samples need to be kept in a standardized condition until their surfaces stabilize. Together these factors created the need for standardization of a preparation method for stable surface with optimized stabilization times.

2 Scope

2.1 This Standard provides guidance on sample preparation methods when measuring the minority carrier diffusion lengths of silicon wafers using SPV methods.

2.2 This Standard applies to samples with *p*-type or *n*-type single-crystal silicon wafers and a polished front surface.

2.3 Additionally, it is also applied to silicon wafer which has an oxide layer grown with high-temperature oxidation or chemical-vapor deposition (CVD) films on the front surface of samples.

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 and Safety Guidelines

SEMI C1 — Guide for the Analysis of Liquid Chemicals

SEMI C28 — Specification and Guide for Hydrofluoric Acid

SEMI C30 — Specification and Guide for Hydrogen Peroxide

SEMI M59 — Terminology for Silicon Technology

SEMI MF391 — Test Method for Minority Carrier Diffusion Length in Extrinsic Semiconductors by Measurement of Steady-State Surface Photovoltage

3.2 ASTM Standard¹

ASTM D5127 — Standard Guide for Ultra-Pure Water Used in the Electronics and Semiconductor Industries

3.3 ISO Standard²

ISO 14644-1 — Cleanrooms and Associated Controlled Environments – Part 1: Classification of Airborne Particulates

¹ ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA; Telephone: +1.610.832.9585, Fax: +1.610.832.9555, <http://www.astm.org>

² International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland; Telephone: +41.22.749.01.11, <http://www.iso.org>

3.4 JEITA Standard³

JEITA EM-3509 — Sample Preparation Methods for Minority Carrier Diffusion Length Measurements in Silicon Wafers by Surface Photovoltage Methods

3.5 JIS Standards⁴

JIS K 8819:1996 — Hydrofluoric Acid (Reagent)

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

4 Terminology

4.1 Most definitions of terms and acronyms used in silicon technology can be found in SEMI M59.

4.2 Additional terms are defined below.

4.2.1 *surface photovoltage (SPV)* — the change in electrostatic potential occurring at the sample surface when irradiated by light.

4.2.2 *minority carrier diffusion length* — the distance minority carriers in semiconductors diffuse in their lifetimes.

4.2.3 *Fe-B (iron-boron) pair* — in B-doped *p*-type silicon, the pair that forms after an iron (Fe) donor binds with a boron (B) acceptor.

5 Summary of Practice

5.1 *p-Type Silicon Wafers* — After applying a hydrofluoric acid solution to remove the oxide grown by high-temperature oxidation or CVD or the oxide grown chemically with SC-1 cleaning or some other process, the wafer undergoes the following two-step annealing process in a cleanroom atmosphere. First, the sample is oxidized with a 210°C, five-minute heat treatment. Because this annealing step causes Fe-B pairs in the wafer to disassociate, the Fe-B pairs are recombined with a second 80°C, 30-minute heat treatment.

5.2 *n-Type Silicon Wafers* — After applying a hydrofluoric acid solution to remove the oxide grown by high-temperature oxidation or CVD or the oxide grown chemically with SC1 cleaning or some other process, the wafer is immersed in a hydrogen peroxide solution between 70°C and 80°C to grow an oxide chemically. Following this treatment, the wafer is left exposed to the atmosphere for no less than 100 hours.

6 Apparatus

6.1 Acid Surface-Processing Apparatus

6.1.1 The surface-processing device used when preparing *p*-type samples should be capable of removing the sample's oxide layer with a hydrofluoric acid solution, rinsing the sample with ultrapure water, and drying the sample. All operations are done at room temperature.

6.1.2 When preparing *n*-type samples, in addition to removing the sample's oxide layer with a hydrofluoric acid solution, rinsing the sample with ultrapure water, and drying the sample at room temperature, the surface-processing device should be capable of performing surface processing with a hydrogen peroxide solution heated to between 70°C and 80°C. This last function requires the device to be able to control temperatures with a heater and controller to warm chemical solutions. Figure 1 gives a block layout of an example surface-processing device.

6.2 Hot Plate

6.2.1 A hot plate is used in the 2-step annealing process applied during preparation of *p*-type samples after the hydrofluoric acid solution treatment. A hot plate is normally used because the sample should be heated rapidly to 210°C in the first annealing step. The hot plate should be capable of heating the sample to both 210°C and 80°C. Measures should be taken to prevent the hot plate from introducing metal contaminants to the sample. Therefore, it is recommended to pass heat through a purified silicon wafer or a Teflon sheet placed between the hot plate and the

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