

SEMI AUX034-0519
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MINORITY CARRIER DIFFUSION LENGTH MEASUREMENTS BY
SURFACE PHOTOVOLTAGE METHODS

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The auxiliary information content is result of "Round-Robin Testing of Sample Preparation Methods for Minority Carrier Diffusion Length Measurements by Surface Photovoltage Methods" which was divided into JEITA document EM3509 as related information section.

1 Objective

1-1 Round-robin testing was employed to ascertain the appropriate preparation conditions and the variance among participating laboratories.

2 Detail of experiment

2-1 Sample Specifications - plain-oriented (100) Czochralski (CZ) silicon wafers with diameters of 200 mm were used in the round-robin tests, as shown in Table 1. Laboratory B applied SC-1 cleaning to all samples to initialize the surfaces before shipping the samples to the other laboratories participating in the round-robin tests.

Table 1 : Samples Used in the Round-Robin Tests

	Conductivity type	Resistivity ($\Omega \cdot \text{cm}$)	Annealing
p-PW-L	P	1.8	No
p-PW-M	P	10	No
p-PW-H	P	20	No
p-H-M	P	10	Hydrogen
p-Ar-M	P	10	Argon
n-PW-L	N	1.5	No
n-PW-M	N	7	No
n-PW-H	N	9	No

2-2 Test Procedure

2-2.1 p-Type Samples - different preparations were performed on the samples in the sequence (a) to (d) below. After each surface treatment, the minority carrier diffusion length was measured by a surface photovoltage (SPV) method. The goals set out were to confirm the superiority of the conventional preparation practice and the method defined in this standard over SC-1 cleaning by comparing the results of (a) with those of (b) and (c); to compare the minority carrier diffusion lengths obtained with the conventional method and with the method defined in this standard using the results from (b) and (c); and to confirm the extent of internal sample change caused by the annealing in method (c) by comparing the results from (b) and (d).

(a) As-received - The minority carrier diffusion lengths were measured in the as-received samples, which had undergone SC-1 cleaning at Laboratory B.

(b) Conventional method (first repetition) - The samples were immersed for 2 minutes in a 5% hydrofluoric acid solution. Following this, the samples were rinsed for 10 minutes in ultrapure water and then dried in a

spin dryer. After being exposed to a cleanroom atmosphere for 24 hours, the minority carrier diffusion lengths of the samples were measured.

(c) HF + 2-step annealing - The samples were immersed for 10 minutes in a 5% hydrofluoric acid solution. Following this, the samples were rinsed for 10 minutes in ultrapure water and then dried in a spin dryer. Next, the samples were subjected to a 2-step annealing process (210°C for 5 minutes and 80°C for 30 minutes) with a hot plate in a cleanroom atmosphere. Once the first-step heat treatment was completed, either the samples were rapidly cooled by placing them on an aluminum plate at room temperature or the samples were transferred within seconds to the second-step heat treatment by preparing separate hot plates side by side for the first-step heat treatment and the second-step heat treatment. Once the second-step heat treatment was completed, the samples were rapidly cooled by placing them on an aluminum plate at room temperature. The minority carrier diffusion lengths of the samples were measured immediately after this processing was completed.

(d) Conventional method (second repetition) - The samples were immersed for 10 minutes in a 5% hydrofluoric acid solution. Following this, the samples were rinsed for 10 minutes in ultrapure water and then dried in a spin dryer. After being exposed to a cleanroom atmosphere for 24 hours, the minority carrier diffusion lengths of the samples were measured.

2-2.2 n-Type Samples - The samples underwent four surface treatments given in the sequence (a) to (d) below. The minority carrier diffusion lengths of the samples were measured after each surface treatment. The goals set out were to confirm the superiority of boiling with hydrogen peroxide over SC-1 cleaning by comparing the results of (a) with those of (b) through (d); and to ascertain the most appropriate standing time by comparing the results from (b), (c), and (d).

(a) As-received — The minority carrier diffusion lengths were measured in the as-received samples, which had undergone SC-1 cleaning at Laboratory B.

(b) H₂O₂ — Samples were boiled for 10 minutes in a 30% hydrogen peroxide solution at a temperature of between 70°C and 80°C. Following this, the samples were rinsed for 10 minutes in ultrapure water and then dried in a spin dryer. The minority carrier diffusion lengths of the samples were measured by SPV immediately after they were dried.

(c) H₂O₂ + 48-hour standing period — After completing (b) above, the samples were stored in a silicon-wafer shipping box and left in a cleanroom for 48 hours. After this time, the minority carrier diffusion lengths of the samples were measured.

(d) H₂O₂ + 100-hour standing period — After completing (c) above, the samples were stored in a silicon-wafer shipping container and left in a cleanroom for 100 hours. After this time, the minority carrier diffusion lengths of the samples were measured.

2-3 Measurement Conditions - Minority carrier diffusion length measurements were made with the Linear Photovoltage, Constant Photon Flux (LPVCPF) method, one of the SPV methods defined in SEMI MF391-02. The detailed measurement conditions are described by (a) to (d) below.

(a) Illuminating light wavelengths — seven wavelengths from 0.8 μm to 1.0 μm

(b) Lock-in amplifier time constant — 100 m seconds

(c) Correction for wafer-thickness effects on minority carrier diffusion length measurements — None

(d) Measurement points — Measurements were taken at 5 points on each reference sample (see Figure 1)