U. S. Department of Commerce
Frederick B. Dent
Secretary
National Bureau of Standards
Richard W. Roberts, Director

National Bureau of Standards Certificate

Standard Reference Material 1520

Set No.

Boron-Doped Silicon Wafers for Resistivity Measurements

This Standard Reference Material is intended primarily for use as a reference standard by both producers and consumers using the four-probe method of measuring semiconductor resistivity (ASTM F–84). This SRM consists of two wafers of silicon, A and B, with nominal resistivities of 0.1 and 10.0 ohm · centimeters, respectively. Each wafer has been individually measured for resistivity at the National Bureau of Standards.

	(0.1 Ω·cm)	(10·Ω·cm)
Wafer Number	A-______	B-______
Thickness	______ mm	______ mm
Diameter	______ mm	______ mm
Measuring Current (nominal)	______ A	______ A
Voltage-current ratio[1]	______	______
Resistivity[2]	______ Ω·cm	______ Ω·cm

[1] Measurement average-uncorrected.

[2] Corrected for geometry and for temperature to 23 °C.

Resistivity measurements were carried out in accordance with ASTM Method F-84 at current levels of 10 mA and 1 mA for the 0.1 and 10 ohm·cm wafers, respectively. Correction factors applied to the data are those of ASTM Method F-84, a copy of which will be provided to those who purchase sets of wafers.

The experimental error of measurement has been determined at NBS using two operators on each of two instruments; no systematic effect due either to operator or to instrument was observed. The measurements further show the 95% confidence interval for each individual wafer, based on 10 replicate measurements, to be less than 1%, for each wafer. The wafer to wafer variability was found to have a standard deviation of 0.5% or less for both resistivity levels. However, to make allowance for possible variability between laboratories in a referee measurement context, it is recommended that the resistivities of the individual wafers be considered precise to within 2.5% of their certified values when using the recommended measurement method.

Washington, D. C. 20234
January 8, 1974

J. Paul Cali, Chief
Office of Standard Reference Materials

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PREPARATION - The wafers were cut from two single crystal silicon ingots, etched, and lapped to a final thickness of approximately 1 mm; the thickness of each wafer is uniform within 15 μm.

EXAMINATION - The normal to the wafer surface is within 1 deg. of the [111] direction as determined by x-ray crystallography. Less than 100 dislocations per cm^2 were found by both x-ray topography and preferential etching. Interstitial oxygen density (atoms per cubic centimeter) was found to be below the limits of detectability as tested, 1×10^{17} for the 10 $\Omega \cdot$ cm crystal and 7×10^{17} for the 0.1 $\Omega \cdot$ cm crystal.

STORAGE - This SRM should be stored in a noncorrosive atmosphere, so that surface layers are limited to those due to normal room temperature oxide growth. Suspected excess oxide growth or marked instability of resistivity measurements, after instrument problems have been eliminated, may be corrected by removing approximately 15 μm of material by lapping with a 5 μm grit aluminum oxide abrasive. Before use, the wafers should be washed according to the washing procedure of ASTM Method F-84.

SPECIMEN UNIFORMITY - Variation of radial resistivity, as measured by the four-probe method (ASTM Method F-84), between center and half radius points on the end slices from the crystal ingots was less than 2% for the 10 $\Omega \cdot$ cm crystal and less than 1.5% for the 0.1 $\Omega \cdot$ cm wafers.

An actual propagation of errors analysis including two operators and two different test sets, higher and lower current levels than allowed by the standard test method (ASTM F-84), smaller probe spacing than the recommended value (1.57 mm), measurement on either side of the wafer, and measurement with an error in the centering of the wafer under the probe by as much as two probe spacings (3.14 mm) yields a value for a two standard deviation interval on the average resistivity of an individual wafer smaller than the 2.5% value given. However ±2.5% is considered a reasonable value for referee measurement purposes. An estimate of the precision to be expected over the longer term in referee situations is being investigated by an extended multilaboratory intercomparison, the results of which will be available to all purchasers of sets of silicon resistivity standards.

The physical preparation and resistivity testing of these specimens was performed by M. Cosman, F. Brewer, and D. Ricks. Examination prior to resistivity testing was performed by E. Farabaugh, T. Leedy, and R. Thurber. Technical measurements were coordinated by F. H. Brewer, and overall direction of the technical activities was performed by J. R. Ehrstein of the Electronics Technology Division.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by W. P. Reed.