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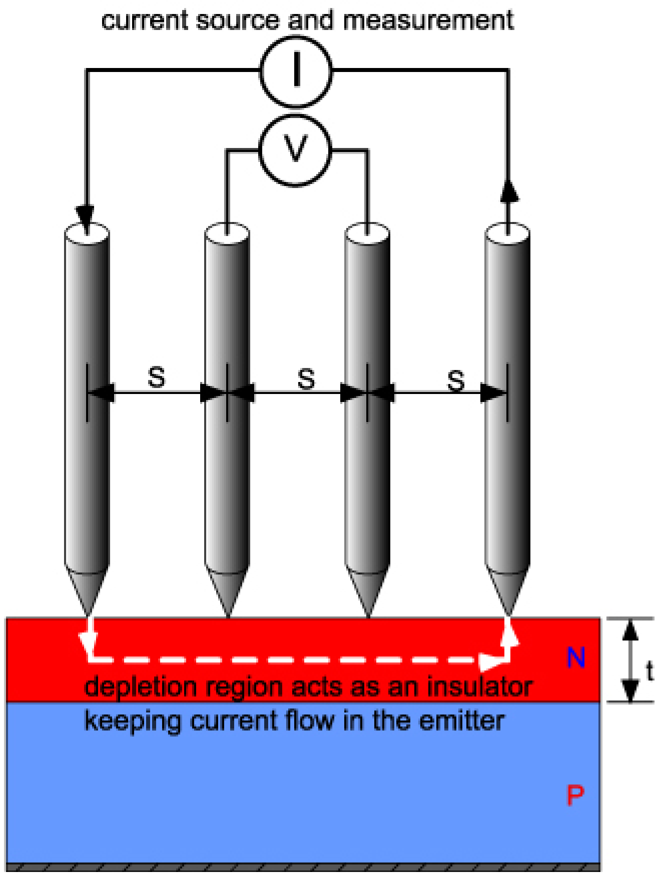
A four point probe is a simple apparatus for measuring the resistivity of semiconductor samples. By passing a current through two outer probes and measuring the voltage through the inner probes allows the measurement of the substrate resistivity.

The Measurement of Sheet Resistivity

The sheet resistivity of the top emitter layer is very easy to measure experimentally using a "four point probe". A current is passed through the outer probes and induces a voltage in the inner voltage probes. The junction between the *n* and *p* -type materials behaves as an insulating layer and the cell must be kept in the dark.



Use of a four point probe to measure the sheet resistivity of a solar cell.

Using the voltage and current readings from the probe:

$$\rho_{\square}\left(\frac{\Omega}{\square}\right) = \frac{\pi}{ln\,(2)}\frac{V}{I}$$

Where:

$$\frac{\pi}{ln2} = 4.53$$

The typical sheet resistivity of silicon solar cells lies in the range 30-100 Ω/□.

In typical usage the current is set to 4.53 mA so that the resistivity is simply the voltage reading in mV.

The Measurement of Bulk Resistivity

The measurement of bulk resistivity is similar to that of sheet resistivity except that a resistivity in cm^{-3} is reported using the wafer thickness, t:

$$\rho = \frac{\pi}{ln\,(2)} t \left(\frac{V}{I}\right) = 4.523t \left(\frac{V}{I}\right)$$

Where t is the layer/wafer thickness in cm.

The simple formula above works for when the wafer thickness less than half the probe spacing (t < s/2) (Schroder). For thicker samples the formula becomes:

$$\rho = \frac{V}{I} \frac{\pi t}{ln\left(\frac{sinh\left(\frac{t}{s}\right)}{sinh\left(\frac{t}{2s}\right)}\right)}$$

Where s is the probe spacing.

The following calculator implements the above equation:

Voltage across inner probes	0.16	volts
Current in outer probes	0.0045	amps
Sheet Resistivity	0	Ω/□
Wafer Thickness	0.0335	cm
Wafer Resistivity	0	Ω cm
Probe Spacing	0.1588	cm
Resistivity corrected for thickness	0	Ω cm

Measurement Problems

While simple in principle, there are experimental issues to take into account when using a four-point probe. In particular, the application of a metal to a semiconductor forms a schottky diode rather than an ohmic contact. Very high or very low resistivity samples require adjustment of the drive current to obtain a reliable reading. Samples with as cut or as lapped surfaces are easier to measure than samples with polished surfaces

High Resistivity Samples

For high resistivity samples the current is reduced so as not to have an excessively larger voltage at the contacts. It is recommended that voltage on the inner probes be less than 100 mV/mm (see reference)

Low Resistivity Samples

Low resistivity samples are usually much easier to measure as the contacts to the silicon are ohmic. For very low resistivity you will have to increase the current to 45.3 mA and set the voltmeter to a lower scale. For very low resistivity samples the current passing through the sample causes the res