Concept of Electrical Measurements

→ Electrical and electronic measurements of materials are among the most powerful techniques available for materials characterization.

→ The information that can be derived from these measurements are conductivity (resistivity), carrier concentration, mobility, bandgap and other details about material transport properties.

Conductivity Measurement.

→ A material's conductivity, σ, relates its ability to conduct electricity.

→ In metals, conduction of electricity is based on conduction of electrons whose density and scattering are important.

→ In semiconductors, conductivity is determined by the numbers of available charge carriers and carrier mobilities

→ Since the mechanisms for conductivity are different, its dependence on temperature are also different.

→ Conductivity increases with increasing temperature for semiconductors (more carriers are generated) and it decreases with increasing temperature for metals (more scattering by the lattice).

→ The conductivity is also dependent on the physical structure, crystal type, orientation, crystallites (grains).

→ The ~~c~~ accurate determination of a material's conductivity can be critical for understanding material composition.

→ The method used to determine conductivity depends on whether the material is a bulk sample or a thin film.

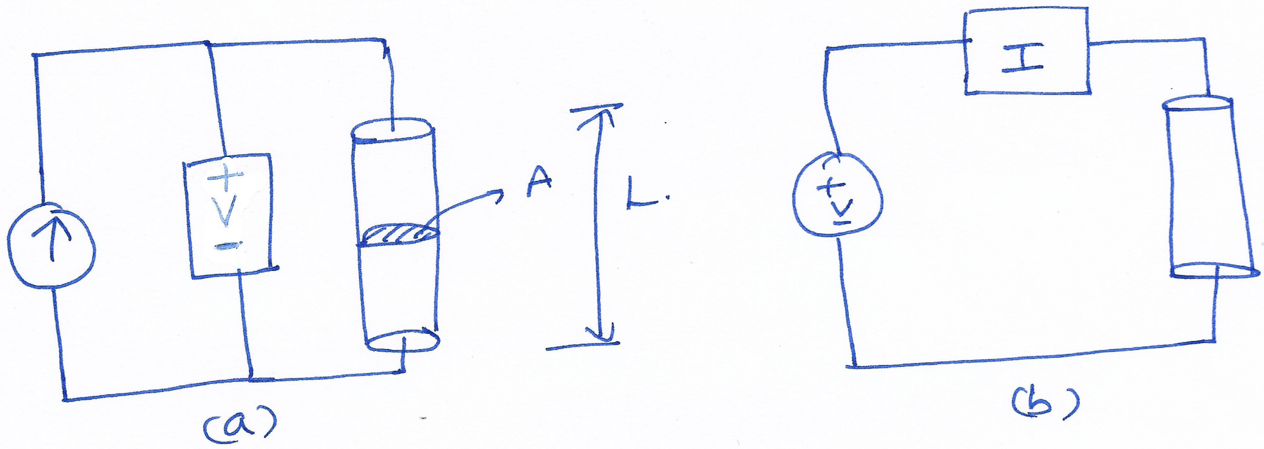
Two Point Probe Technique.

Principle

→ The Conductivity or resistivity of a bulk Sample is based on accurate measurement of both resistance and the sample dimensions.

→ The resistance is the ratio of the voltage measured accross the Sample to the current driven through the Sample (or) of the Voltage applied across the Sample to the measured Current.

Experiment.



Two_point measurement of a resistive bar of length L and Cross Sectional area, A using (a) an ideal voltmeter in parallel with an ideal Current Source and (b) an ideal ammeter in Series with an ideal voltage Source

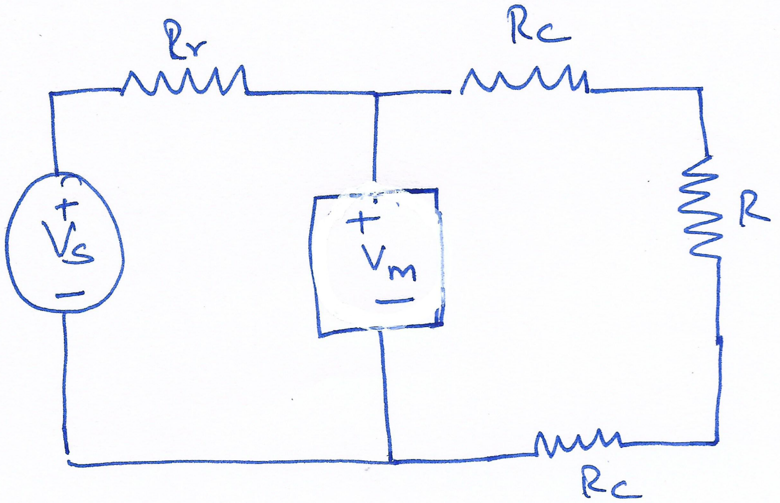
→ For a homogenous bar of length L, and uniform Crossection A the resistance R, is related to the resistivity, ρ by.

$$R = \frac{\rho L}{A}$$

→ The rod is connected in a "two-point" arrangement. The measurement apparatus is connected to the bar at the two end points.

→ The measurement apparatus is represented by an ideal Current Source in parallel with a high-impedance voltmeter.

→ The apparatus can also be realised using an ideal Voltage source in series with a low-impedance ammeter.



Two-point ohmmeter measurement circuit, which includes contact and cable resistance, R_c

→ This approach is a more realistic one.

→ A voltage source and a variable range resistance (R_r) supply the current, where R_r is adjusted to provide a convenient voltage across the voltmeter.

→ Typical values of R_r from 100 to 10,000 Ω.

→ R_c represents series resistance in cable and the wire-to-sample contact resistance.

→ The resistance in the bar is calculated as.

$$R = \frac{(R_r V_m / V_s)}{[1 - (V_m/V_s)]} - 2R_c$$

→ A long bar of resistive material is desirable to minimize the effect of extra resistance in the measurement system or inaccurate length measurement.

→ The two-point approach is most accurate for high-resistance measurements when usually small R_c term can be ignored.