Chapter 8.2

Manual Four-Point Probe Resistivity Measurement System

(4ptprb2 - 380)

1.0 Title

4ptprb2 Four-Point Probe Resistivity Measurement System - Manual System

2.0 Purpose

The manual 4-point probe is a simple set up used to measure resistivity of a conductive thin film or a diffusion layer on an insulating material i.e. SiO2 layer.

3.0 Scope

This document describes the procedure for measuring sheet resistance of a thin film material and/or doped layers on an insulating substrate. Some trouble shootings are also included.

4.0 Applicable Documents

Revision History


4.2 Four point probe manual posted at EECS143 class website:
http://nanolab.berkeley.edu/labmanual/chap8/8.024ptprb2.pdf

5.0 Definitions & Process Terminology

Sheet Resistance: The electric resistance of a square sheet of a film. It is independent of the size of the square, but depends only on the film resistivity and the thickness of the film.

6.0 Safety

Follow the general safety guidelines in the lab.

7.0 Statistical/Process Data

N/A

8.0 Available Processes, Process Notes

8.1 Available Programs

The four-point probe is manually operated. There is no recipe or program. See Section 9.2 for operating procedures.

8.2 Process Notes

8.2.1 The four-point probe only works on blank wafers with continuous film on top. It does not work on patterned wafers.

8.2.2 If your sample size is small, or your measurement point is close to the edge of your sample, you need to check 4.1 reference for the geometric correction factor.

8.2.3 The measurement is destructive. The four-point probe will make four dents on the film measured.

8.2.4 There should be a layer of insulator, e.g. silicon oxide, between a silicon substrate and the film to be measured. Otherwise, the sheet resistance measured will be erroneous.
9.0 **Equipment Operation**

9.1 **Equipment Description**

The four-point probe station consists of a SIGNATONE probe station (four probe tips), an ampere meter (FLUKE8010A), a DC current source (HP6181C), and a voltmeter (KEITHLY195). This set up can measure resistivity of thin film material, as well as diffusion layers. The four probes are arranged in a linear fashion, where the two outer probes are connected to a current supply, and the inner probes to a voltage meter. As current flows between the outer probes, the voltage drop across the inner probes is measured. The relationship of the current and voltage values is dependent on the resistivity of the material under test, and the geometrical characteristics of the probe as per follows:

\[
R_S = \rho \times \frac{V}{I}
\]

where:
- \(R_S\) is the sheet resistance in \(\Omega\) per square;
- \(V\) (in mV) is the voltage drop across the inner two probes;
- \(I\) (in mA) is the current flow between the outer two probes;
- \(\rho\) (rho) is the geometric factor for thin film measured on four-point probe, which equals to 4.5324, if the size of the sample is 40 times larger than the spacing between the probes (\(R_S = 4.5324 \frac{V}{I}\)).

The Four-Point Probe is set up in such a way that the DC current source delivers 0.453 mA through its outer two probes. This simplifies the \(R_S\) measurement by letting members arrive at sheet resistance values equating to 10 times the voltage value (mV) measured between the two inner probe tips (voltmeter).

9.2 **Measurement Procedures**

9.2.1 Check that the ampere meter, DC current source and the voltmeter are on. (It is not required to enable it on the WAND).

9.2.2 Make sure your sample is clean and dry. Use the nitrogen gun to blow away any particles that may be on your sample.

9.2.3 Raise the probe head by swinging the arm all the way to the right (counter-clockwise).

9.2.4 Carefully slide the sample holder disk out from under the probe head.

9.2.5 Place your sample on the disk. Slide the disk back, and align the sample so that the spot to be measured is under the probe head.

9.2.6 Lower the probe head onto the sample by slowly swinging the arm over to the left (clockwise).

9.2.7 Make sure the ampere meter reads 0.453 mA. If not, adjust the DC current source to arrive at that value.

9.2.8 Wait a few seconds for the voltage to stabilize. The sheet resistance is the voltage measured (in mV) multiplied by 10.

9.2.9 When you have finished, raise the probe head and slide the disk and your sample out. Remove your sample and replace the disk under the probe.
10.0 Troubleshooting Guidelines

10.1 There is no current.
   Cause: The probe did not contact the sample.
   Solution: Make sure the probe arm is all the way to the left. If there is still no current, the probe arm needs adjusting. Report on the WAND.
   If your sample is thinner than a regular silicon wafer, the same problem may occur. In this case, you can put a few pieces of paper under the sample disk, not the sample, to solve the problem.

10.2 The current could not reach 0.453 mA.
   Cause: The film resistance is too high.
   Solution: Adjust the DC current supply to get 0.453 mA. If the DC current supply is at the highest setting, record the current and voltage measured. Then use the equation listed in Section 9.1 to calculate the sheet resistance.

10.3 The voltage is too low and not precise.
   Cause: The film is too conductive.
   Solution: Adjust the DC current supply to higher setting. The voltage measured should increase too. When the voltage reaches the satisfactory range, record the current and voltage measured. Then use the equation listed in Section 9.1 to calculate the sheet resistance.

11.0 Figures & Schematics
   N/A

12.0 Appendix
   N/A