Four-Point Probe Resistivity Measurement

(4ptprb)

1.0 Title

Four-Point Probe Resistivity Measurement

2.0 Purpose

The 4-point probe is a simple device used to measure resistivity of a thin film or diffusion layer on an insulating material.

There is another four-point probe (VEECO FPP-5000) located next to the Cape terminal in R2. The operation procedures for VEECO FFP-5000 are included in the Appendix.

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

4.1 "VLSI Technology", Edit by S.M. Sze, pp. 184-186, McGraw-Hill, 1983.

4.2 VEECO FPP-5000 4-point Probe Operation Manual (Office copy).

4.3 Four point probe manual posted at EECS143 class website: **http://microlab.berkeley.edu/ee143/Four-Point_Probe/**

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:

$R_S = \rho * V/I$ where:

sheet resistance R_S is in Ω 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;

P (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 ($R_S = 4.5324$ 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

VEECO FPP-5000 4-POINT PROBE

Operation Procedures

12.1 System Description

The VEECO FPP-5000 4-point probe simplifies the measurement of resistive properties of semiconductor wafers and resistive films. The microprocessor based electronics permits direct computation of V/I, sheet or slice resistivity, and metallization thickness and P-N type testing. Unlike most four point probes and probing stations, which move the probe head into the wafer, the FPP-5000 is designed so that the wafer is moved into the probe head. This insures constant probe force independent of operator force and wafer thickness.

12.2 Keyboard Description

12.2.1 **V/I** – Displays measured V/I multiplied by programmed GEOM Constant.

12.2.2 **SHEET** – Displays sheet resistance based on measured V/I.

12.2.3 **SLICE** – Calculates the bulk resistivity of a slice of layer whose thickness is entered in the PRGM mode.

12.2.4 **THICK** – Calculates the thickness of a layer of slices whose bulk resistivity is entered in the PRGM mode.

12.2.5 **TYPE** – When selected, a type test is performed.

12.2.6 **PEN** – When selected, a penetrate voltage is applied to the sample.

12.2.7 **PRGM** – Put the keyboard into the PRGM mode for entering bulk resistivity or film thickness. Press STORE afterwards to store the input into system memory.

12.2.8 **SELF-TEST** – Performs a system self test.

12.2.9 **RETEST** – Performs a retest when the previous test failed.

12.2.10 **CONST** – Displays the selected input stored in the memory.

12.2.11 **Numerical Keys** – To enter the input required for calculation.

12.3 Measurement Procedures

12.3.1 Enable 4ptprb on the WAND (required for this automatic tool).

12.3.2 Press CLEAR to clear any error message on the display.

12.3.3 Select desired function. Select SHEET for sheet resistance measurement.

12.3.4 Place the wafer face down in the wafer holder (4”/6”).

12.3.5 Place the backing plate with the spiral side facing towards your wafer.

12.3.6 Open the cover, and put the wafer holder, with the wafer facing down, onto the platen.

12.3.7 Close the cover and hold it down to start a test. When the measurement is done, the result will be displayed. E02 error will appear on the display if the cover is released before the measurement is completed.