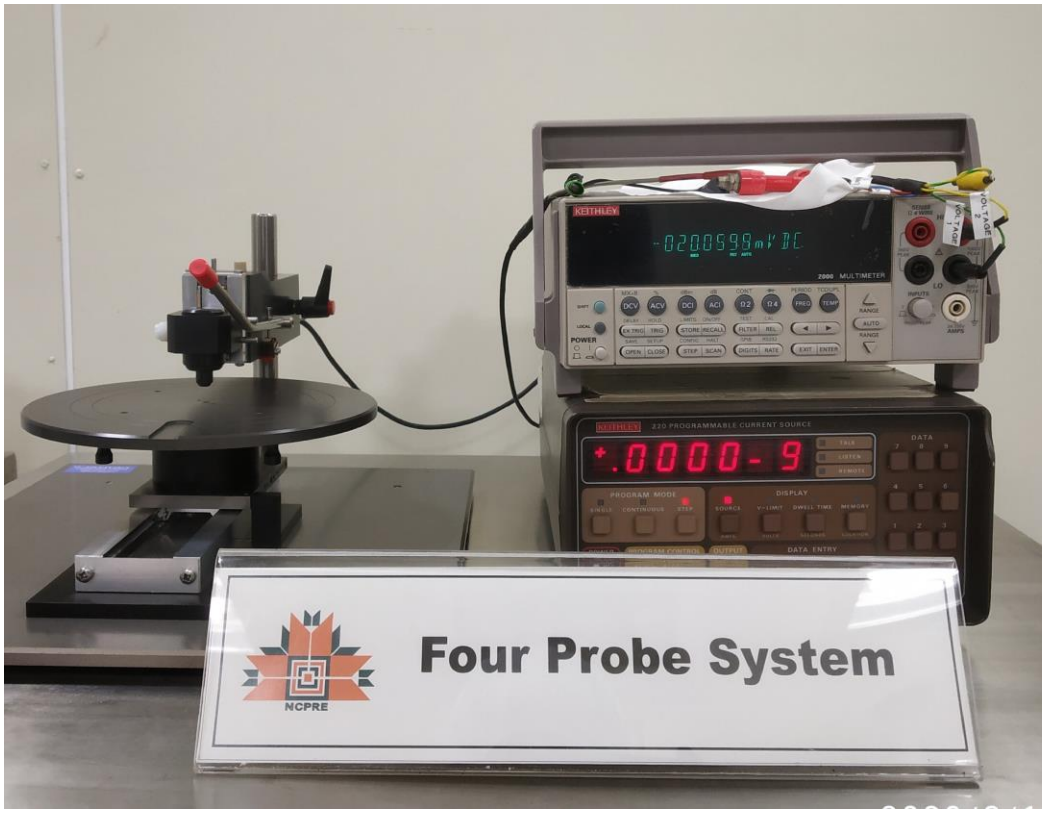
Four point probe measurement



STANDARD OPERATING PROCEDURES (SOPs) 2020 (v.1)

NCPRE

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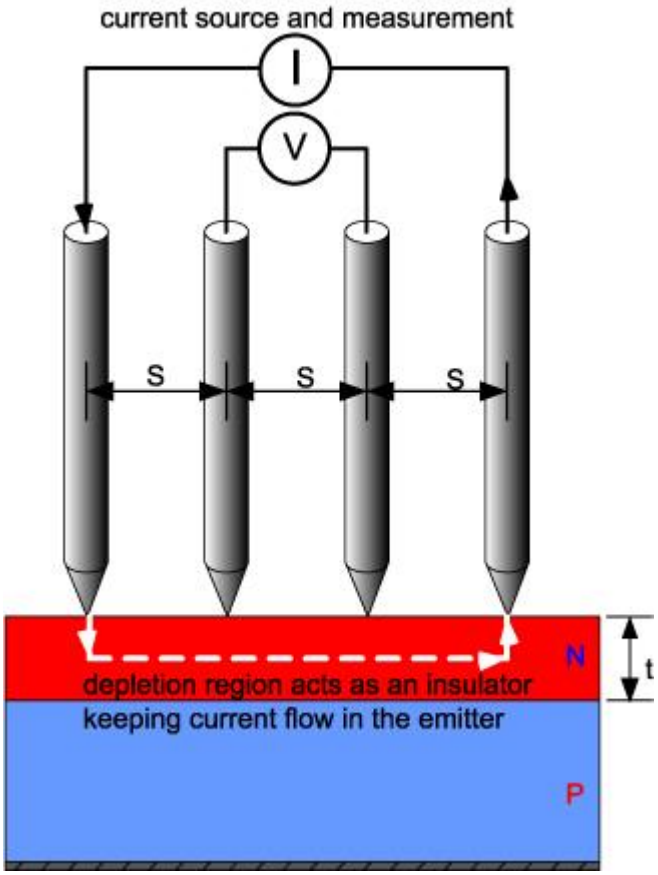
INTRODUCTION

Four point probe resistivity measurement:

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: ***π/ ln2*** = 4.532

The typical emitter 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.

Equipment Configuration:

- Keithley 220 programmable Current Source
- Keithley 2000 multimeter
- Movable sample table
- Probe Details: Spacing between the probes 1mm,
  Material: tungsten carbide

SAFETY PRECAUTIONS:

		
Ground Terminal	Electric shock hazard	Pinch point caution

CLEANING METHOD:

- Cleaning procedures should be done with alcohol using lint-free cloth.

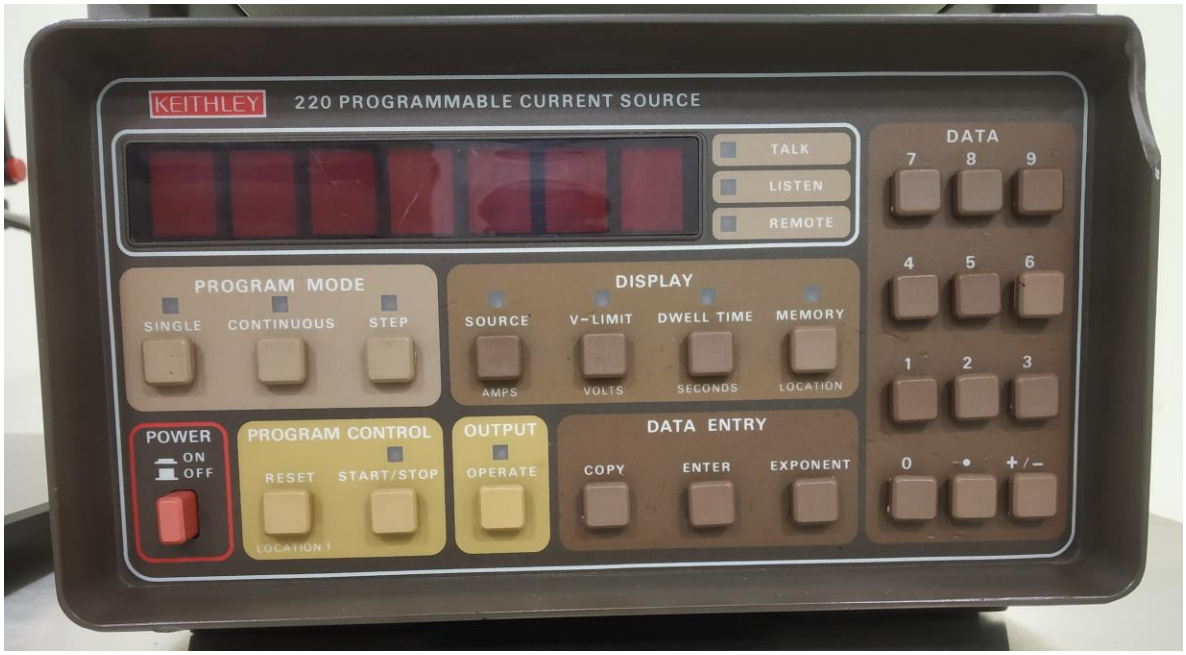
STANDARD OPERATIONAL PROCEDURE

1.1 PROBE MOUNTING PROCEDURE:

1) Place the sample to be measured on the base.
2) Clamp the dummy probe head in the mounting in such a way that its top is level with the probe head mounting block.
3) Slacken (turn) the clamp screw at the rear of the R & L assembly.
4) Lower the whole assembly by sliding it down the column until the tip of the dummy probe head touches the specimen. Gently lower the probe head slide until the micro switch operates. Tighten the rear clamp.
5) Raise the probe head slide with the long lever and unclamp the dummy probe head by the white thumb screw on the left of the head mounting block.
6) Insert the JANDEL cylindrical probe head so that it's top is level with the top of the mounting block just as the dummy probe head. Rotate the probe head so that the needles lie parallel to the front face of the mounting (use the two screws in the probe head as a guide).

1.2 Current & Voltage setting:

1. Check if the probes are mounted properly on the stage. Viz. if the probes touch the sample when the probe handle is lowered. If not, then refer the "*Probe Mounting Procedure*".
2. Check if the leads coming out of the probe assembly are connected to the Current Source and Voltmeter (or Electrometer used as Voltmeter)
3. Turn the Keithley Multimeter (used as Voltmeter) ON.
4. Turn the Keithley 220 Current Source ON. Allow some time for the instrument to warm up for accurate results.



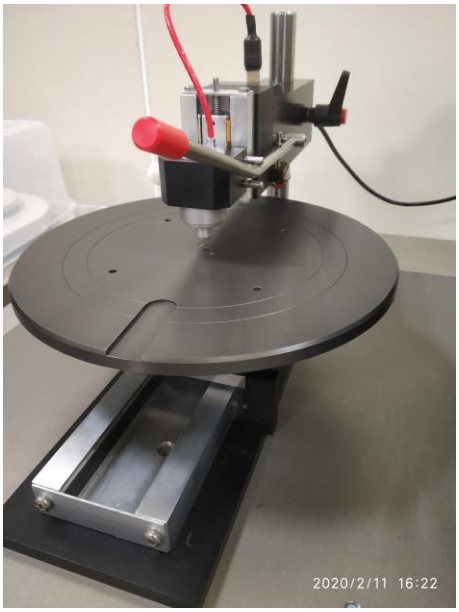
5. Program the current source.
    a) Press SOURCE
    b) Press the number(s) of the desired source current (.0000-9mA to 101.00mA). Note that upon power-up the source is set to ".0000-9". It is recommended not to source more than 10mA of current.
    c) Enter the value
    d) Press ENTER
6. Program the appropriate Voltage limit.
    a) Press V-Limit
    b) Press the number(s) of the appropriate compliance voltage limit (1 to 105V in one volt increments). Upon power-up the V-limit is set to 1V.
    c) Enter the value
    d) Press ENTER
7. Select the desired program mode (step, single or continuous)
8. Connect appropriate load
9. Press the OPERATE button in the Output mode and note the output on the voltmeter and current source.
10. To make measurements at different places on the sample, refer the "***How to measure at different location***" procedure.

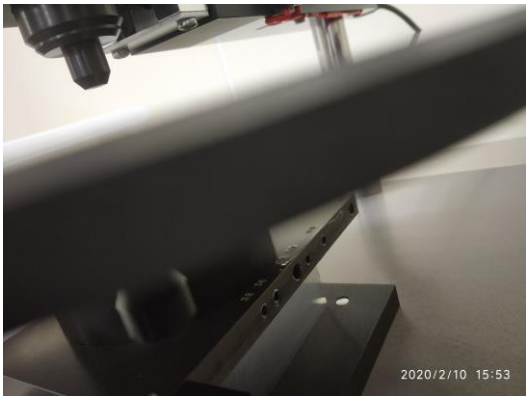
11. If your sample is not a conducting sample, you will have to do a "***Probe tip pressure adjustment***"
12. Gently pull the base out using the handle to change your sample.

1.3 How to measure at different location:

The base on which the specimen can be mounted has been provided with two movements. One is a linear translation with indents at 0, 32, 38, 50, 57, 69 and 94 cm.

a) Using the handle, gently slide the base and place the base in the indent by choosing one of the locations mentioned above.





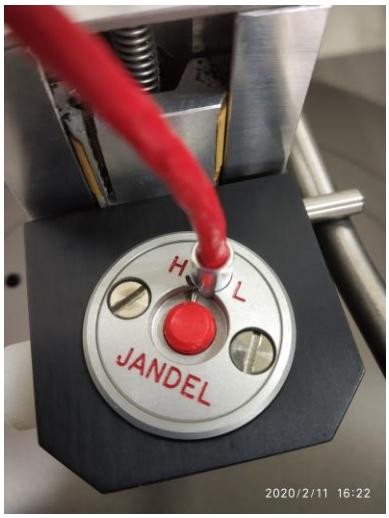
b) Another movement is rotation. The base can be rotated by entire 360o with indents at 90°.
c) Make sure that the base is rotated gently and placed in the indent using the knob underneath.
d) Indents are important for accuracy as they are calibrated!

1.4 Probe Tip Pressure Adjustment:

The probe has a user adjustable tip pressure with a factory set range of 60 to 150 grams of force per tip. Within that range, the user can adjust the

pressure by turning the small red knob on the top of the probe either clockwise so that it increases the pressure, or counterclockwise to decrease the pressure

In the case shown here, this is a “60+” probe which has the range of 60 to 150 grams of pressure, and which has been factory set to 100 grams of force per tip. Take a pointed object such as paperclip and gently turn the red knob by pushing the small metal peg located on this probe at the 6 o’clock position. Turning the knob counterclockwise towards the “L” will lower the pressure to a minimum of 60 grams. Turning the knob clockwise towards the “H” will increase the tip pressure up to a maximum of 150 grams. The mark on the body of the probe shows the value at which the pressure was originally set.



PRECAUTIONS!

1) There are two knobs, one to raise or lower the mounting adaptor and another to fix the probes onto the adaptor. **Do not turn the knob of raising or lowering (R&L) assembly** unless it is required to do so (as mentioned in Probe Mounting Procedure) and avoid probe breakage.
2) **Make sure that the probes are in contact at all times when the OPERATE button is pressed.** If you want to measure at another place on the sample,

make the OPERATE button OFF, move your sample, lower the probe handle to make contact, and press the OPERATE button again to make the measurement.

3) **Check if the operating lever is sufficiently stiff** in its functioning so as to hold the probe head fully raised. Adjust the socket set screw in the probe head support immediately above the operating lever shaft, clockwise makes the operation more stiff.
4) **Check that when the lever is pulled fully down the micro-switch has operated.** The probe needles should make contact with the wafer before the switch operates; if in doubt refer the Probe Mounting Procedure.
5) This is a restatement of point no.12. i.e. **Make sure that the base is gently pulled out using the handle before changing the sample.**