ENSC 495/851 Lab Electrical and Device Measurements
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Testing the devices is done after level 4 has been completed and wafers ENSC 495 students will do at least parts 1 to 5 on one chip. Graduates with a minor project the full set of tests on many positions. For the curve tracer use a digital camera to take the curve traces for the characteristics. Download the Tektronix 576 manuals to consult on using the curve tracer.

Basic Chip Layout

The ENSC 495/851 test chip layout (Figure 1) is a 5mm x 6mm (W x H). There will be more than 200 copies of this test chip on each wafer. The smallest feature size of these devices is 20 microns. Most lines are 40 microns wide. Figure 2 shows the labelled structures for the chip. Start with chips near the wafer centre.

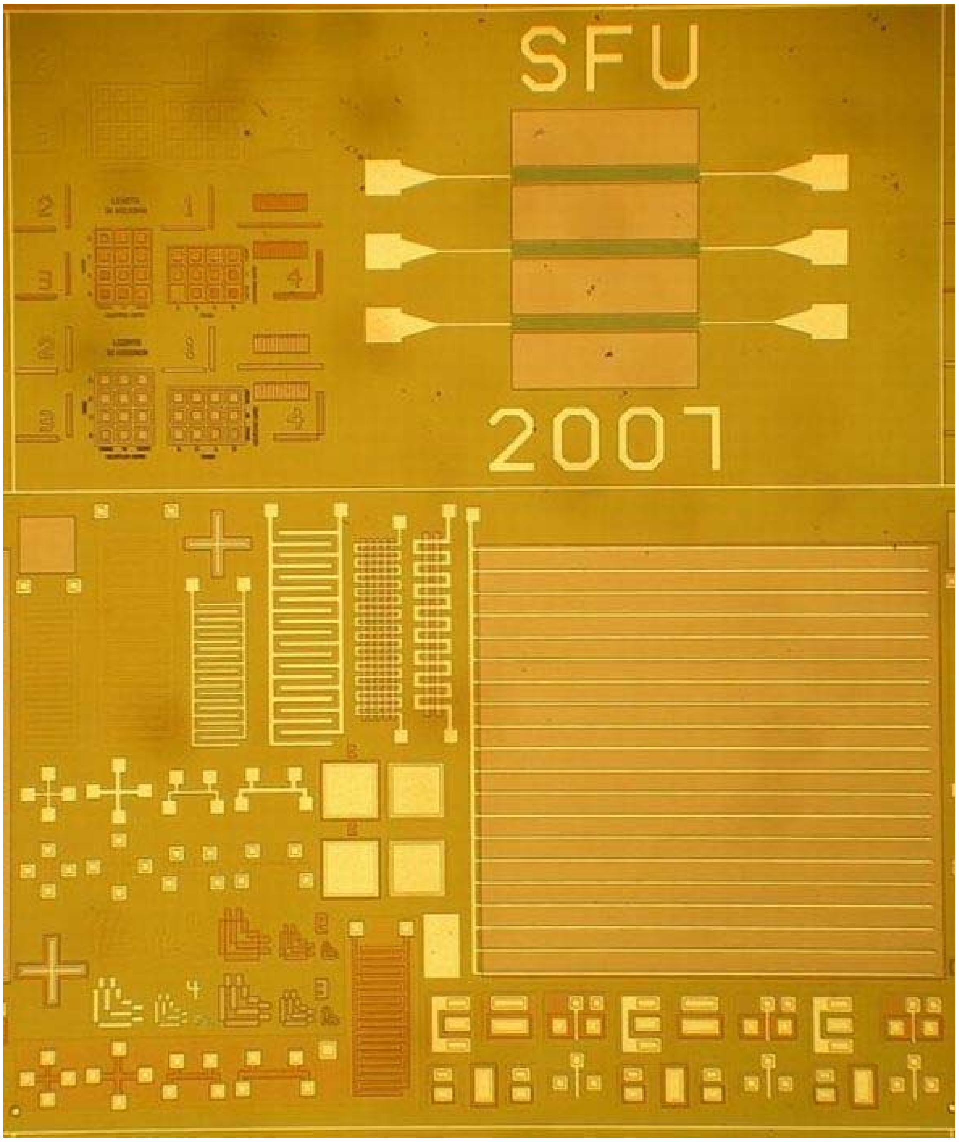
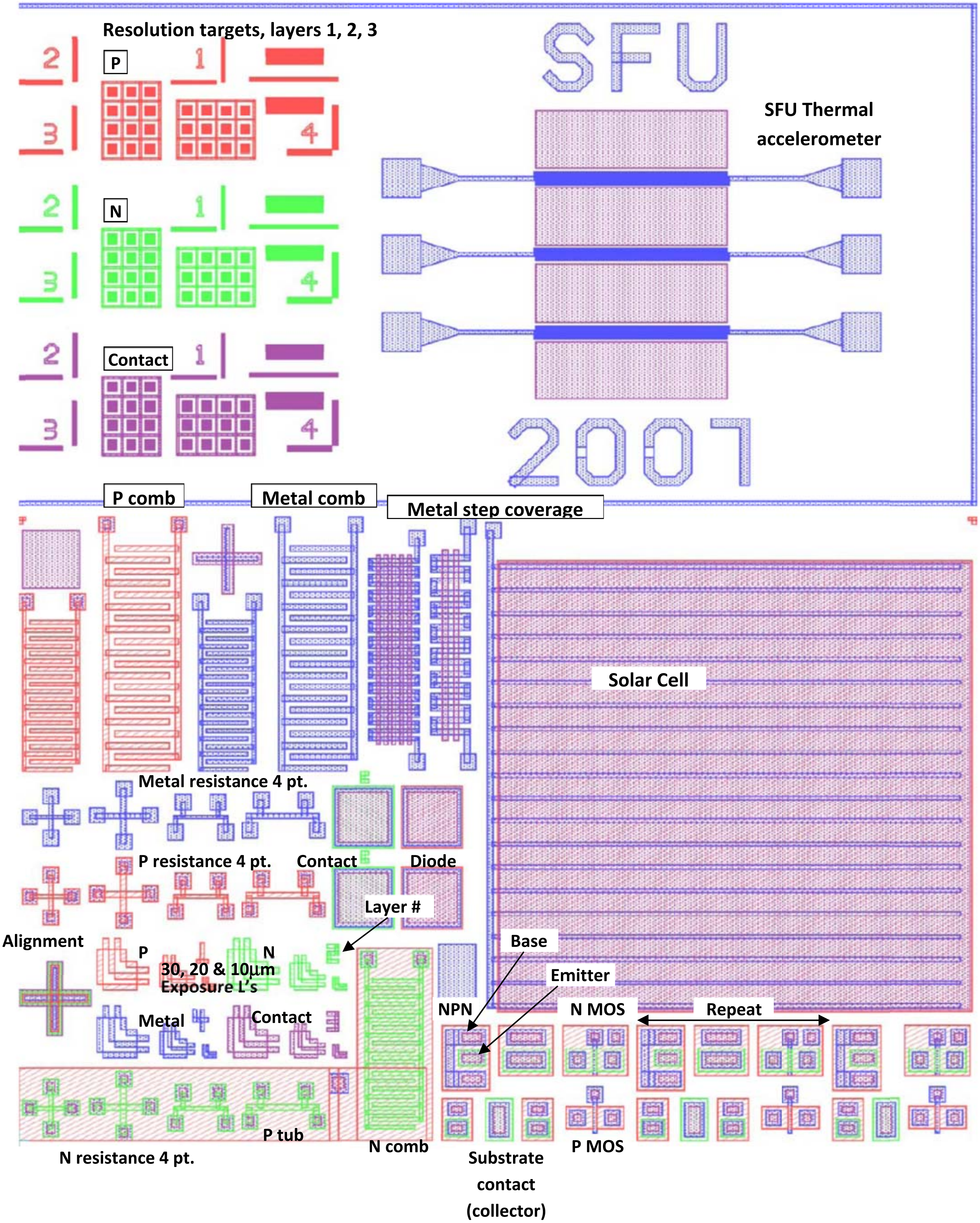


Figure 1: 5x6 mm ENSC 495/851 chip

Figure 2 ENSC 495/851 test chip layout



Prober (Micromanipluators)

The probes or micromanipulators (see Fig 2) consist of 3 axis controllers for X, Y and Z (up down) control (see Fig 2) at one end. Note the direction of motion is set by the arrows on the prober and may be different for different probes. The probe needle (Fig. 3) at the end is what makes contact and is roughly 5 um in size in this case. The probers can position within a micron if used right.

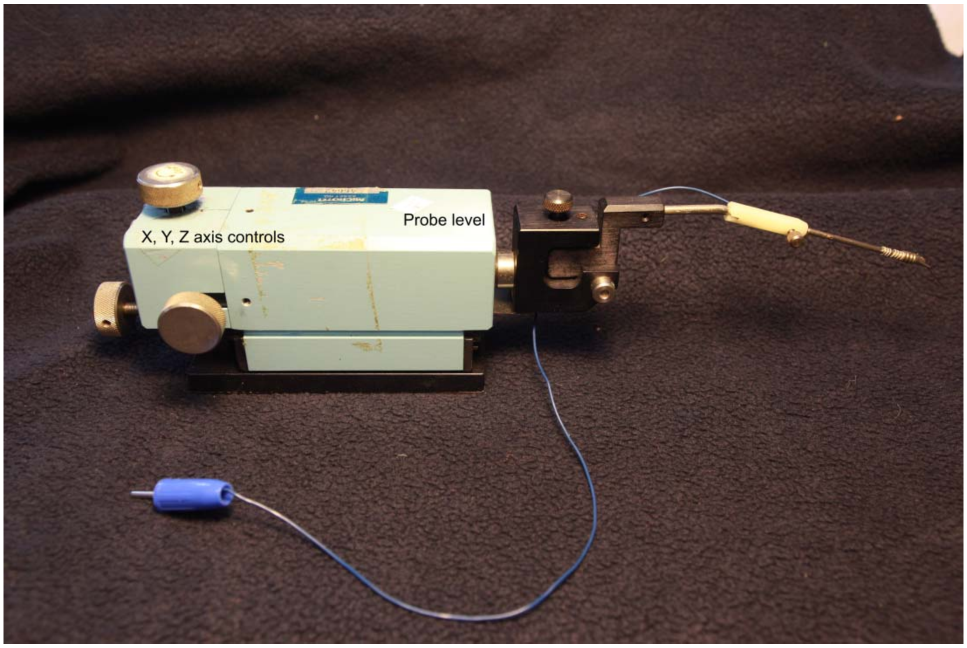


Figure 2: Micromanipulator probe

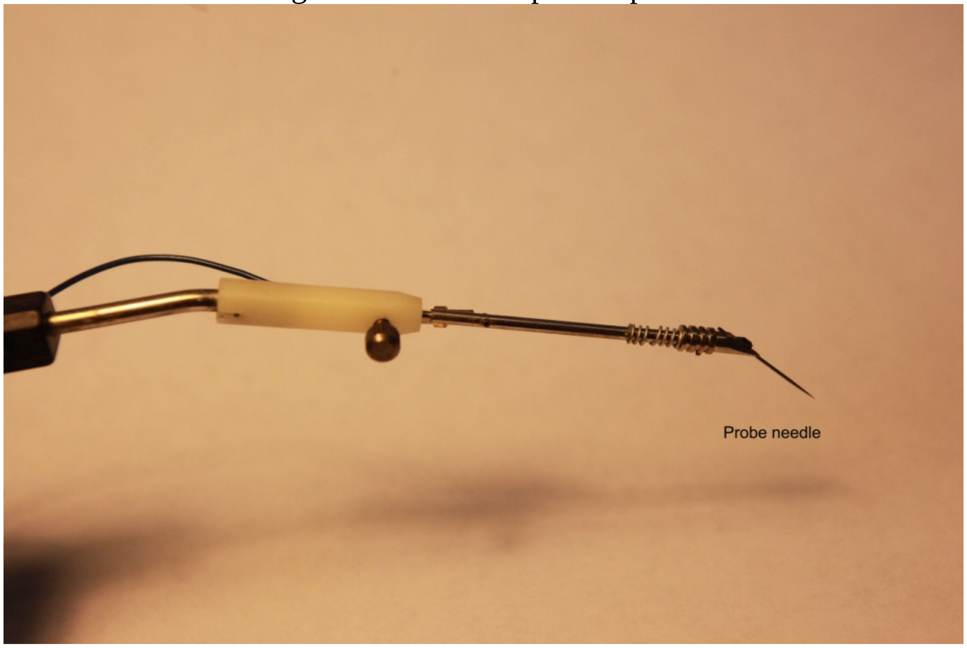


Figure 3: Probe needle in the prober

Probe Testing

Before starting any measurements confirm the probes are working properly. To do this place one probe on the contact pad (has a C above it on the chip) making good contact (instructions in the lab). Then place a second probe on the same contact pad and make certain that you get a short between them (use the curve tracer or ohm meter). Check each probe this way (this also gets you used to putting the probes down).

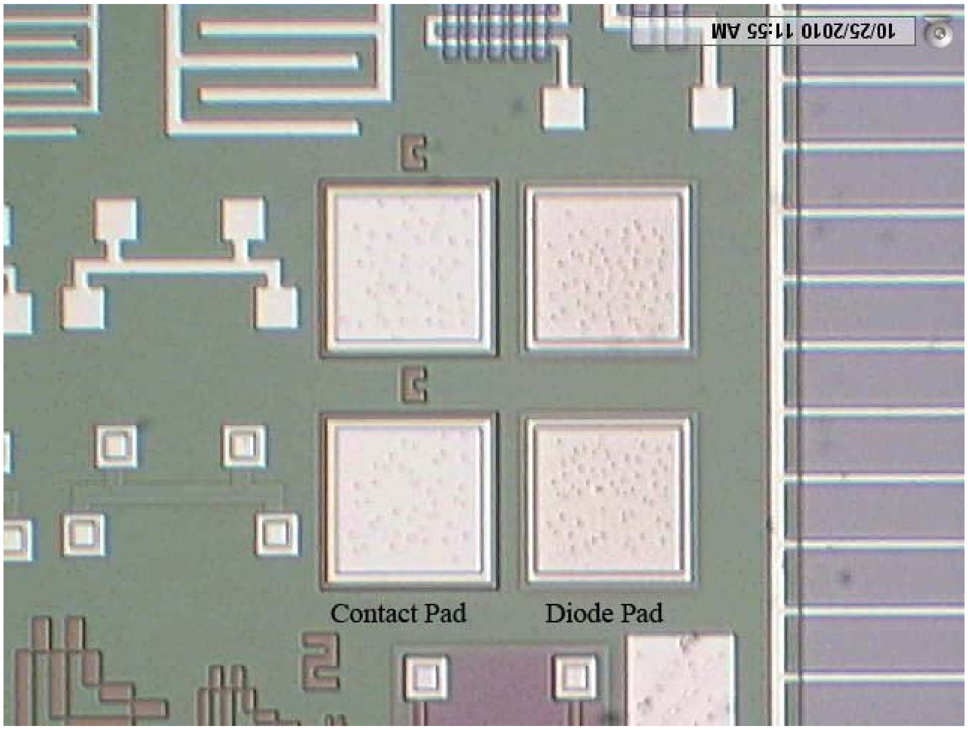


Figure 4: Contact cuts and diode pads

(1) Substrate Contact

Test the Aluminum is making good contact to the substrate. Place one probe on top contact pad and the second on the bottom (Fig. 5). Use the curve tracer first to check for ohmic contact (see Fig 5), ie a straight line in the IV ploy. Measure the resistance by the slope and by multimeter.

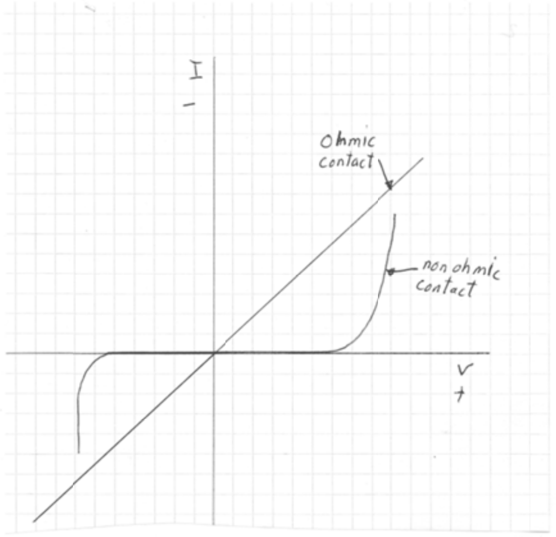


Figure 5: Ohmic contact compared to non ohmic

(2) 4 Point Sheet Resistance

Using the 20-micron Van de Pauw & 4-Point Kalvin resistance test structures shown in Figure 4,6 to measure sheet resistance of the aluminum, boron diffusion and phosphorus diffusion layers. Inner 2 pads (at top) are for the voltage, outer 2 for the current in the 4 point multimeter. Use dimensions given to calculate the sheet resistance for each layer. Compare the three sets of sheet resistance values (4-point probe, Van de Pauw, and 4-Points test structure) and comment on the difference observed. Check for ohmic contacts with IV curve

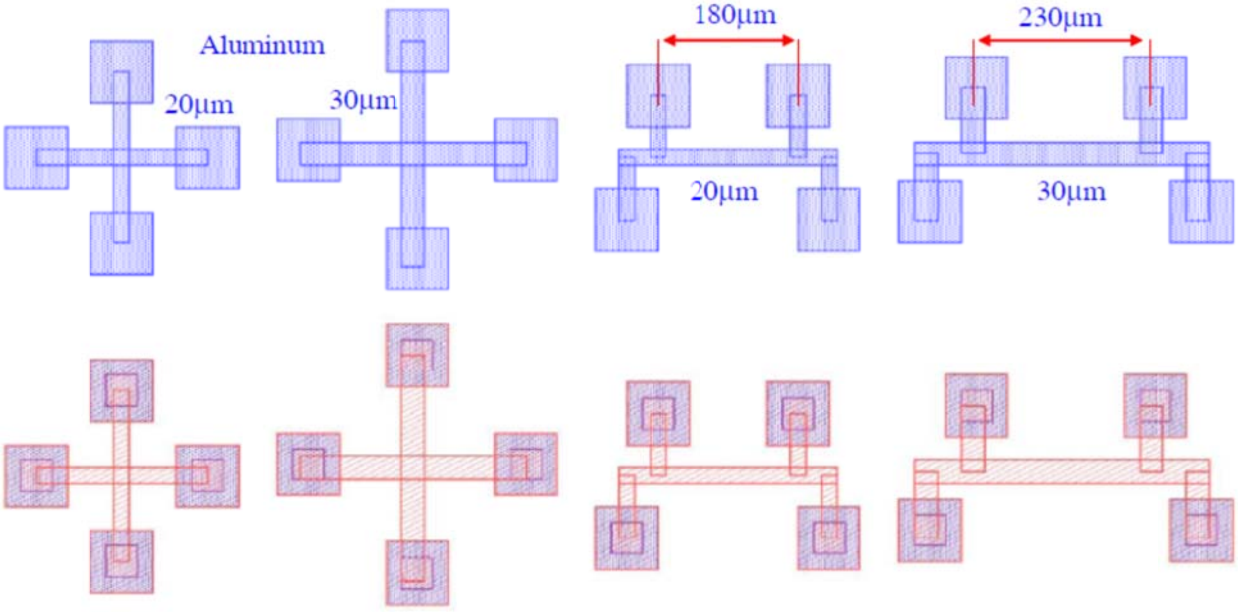


Figure 6: Van der Paw (2 on right) and 4 point Kalvin (2 on left) test structures

(3) Large Diode

Using the substrate contact and the diode (boron) contacts (see Figure 4) for the probe contacts and the curve tracer measure the diode IV characteristics. What is the turn on voltage? Take a photograph of the curve tracer screen to record the data. First take a IV plot for at a few volts to check for diode curve, and that there is no leakage (Fig 7). From the photographs of the curve tracer take measurements at a few forward and reverse voltages. Find the following: forward resistance of the diode, reverse leakage current, breakdown voltage (Fig. 8). Note if not seeing a diode curve go try chips at top, sides or bottom of wafer. Then check for reverse leakage (high curve tracer amplification) – at about neg 0.5 V. Finally measure reverse breakdown voltage (good if > -5V, great if > 20 V). Be sure to take photos showing the curve tracer numbers and do not get a reflection of yourself in the pictures.

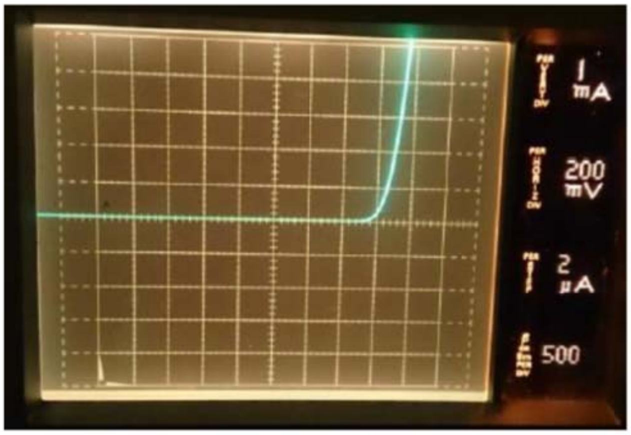


Figure 7: IV diode curve

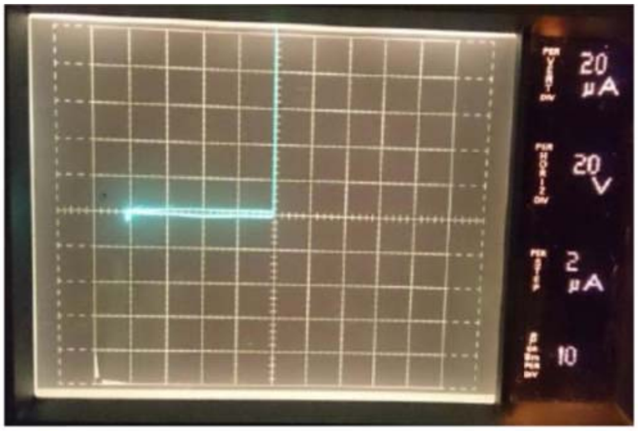


Figure 8: Reverse Breakdown

(4) Solar Cell

Use a curve tracer measure the solar cell first as a diode (in the dark). Use the substract contact (Figure 9) and the Solar cell contact pad for the measurement. Measure reverse leakage current and breakdown voltage. Repeat with microscope light turned on at different levels (control knob settings 1, 2 and 3). Note how much the diode moves into negative current. The square in the area below shows the efficiency of the solar cell (Fig. 10, 11). Measure the open circuit voltage and short circuit current.

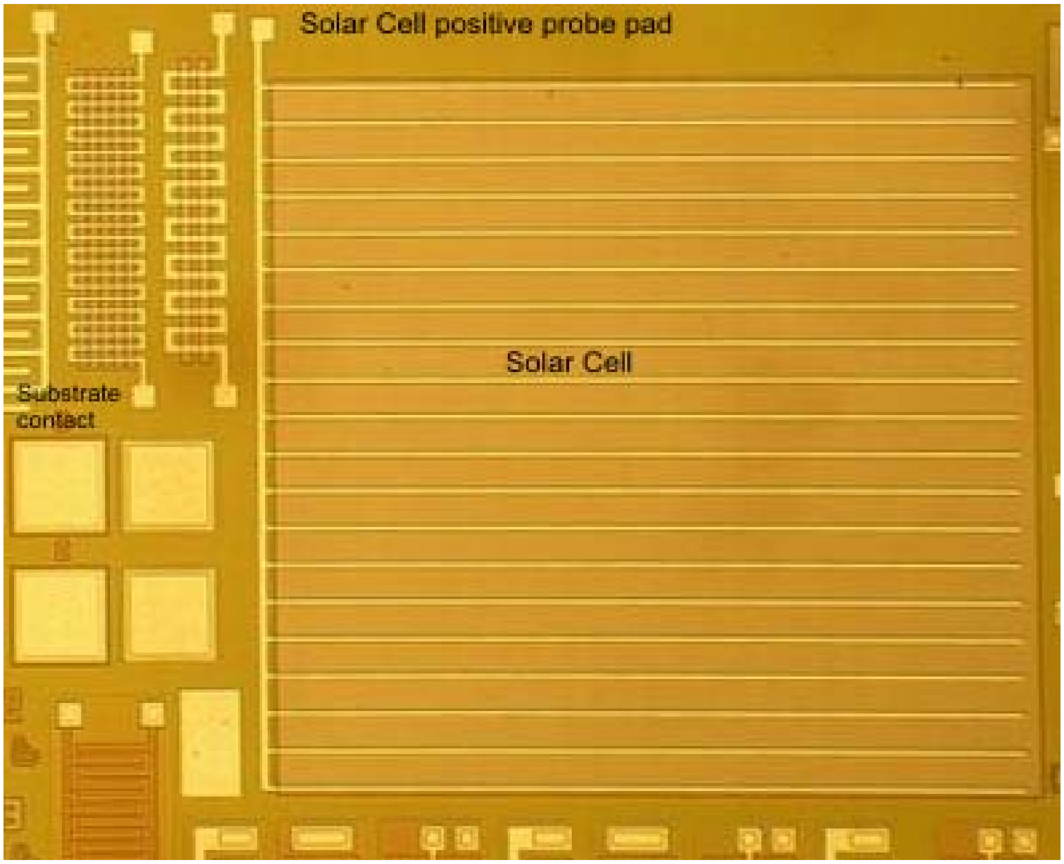


Figure 9: Solar Cell contacts

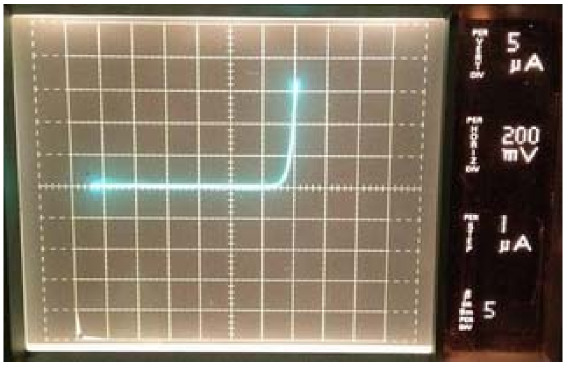


Figure 10: Solar cell diode

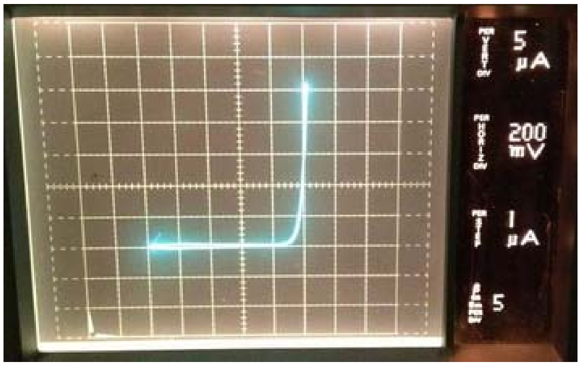


Figure 11: Solar cell with light on.

(5) NPN Transistor Test

Test the dual-base-contact NPN transistor using the curve tracer. Use the substrate transistor contact as the collector (See Figure 12 for the Collector, Base and Emitter contacts). Measure the transistor characteristics (in the dark). Measure the Base Collector, Base Emitter and Collector Emitter IV characteristics (Fig 13-15). Watch for breakdown of CE curve (it may be bidirectional diode). The put curve tracer in NPN transistor mode and take full characteristics (Fig. 16) What do the transistor action characteristic curves look like (note the base current, collector current etc)? Calculate the transistor beta (current gain) at collector currents around 100µA and 3mA.

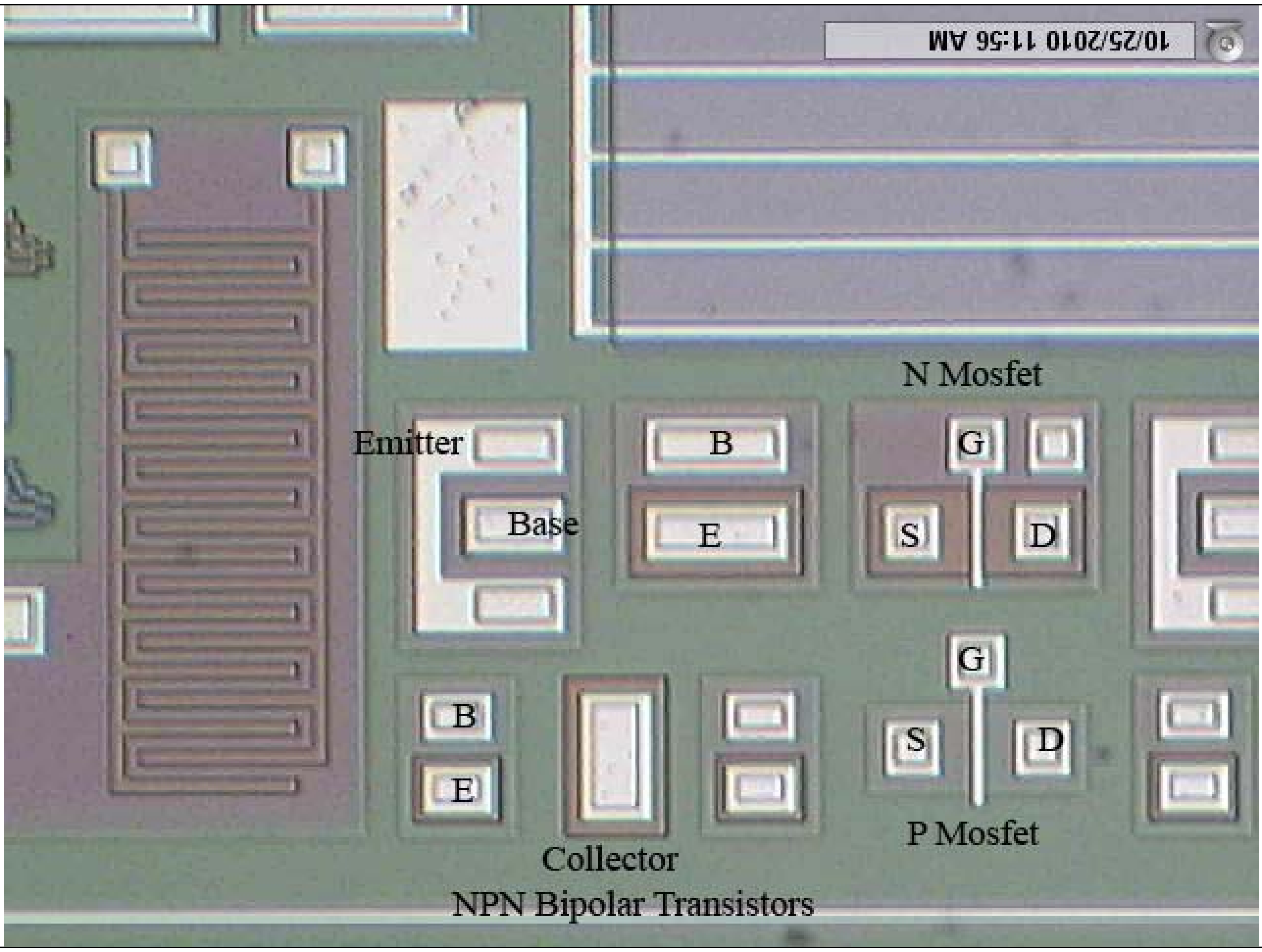


Figure 12: NPN Bipolar, N Mosfet and P Mosfet pads

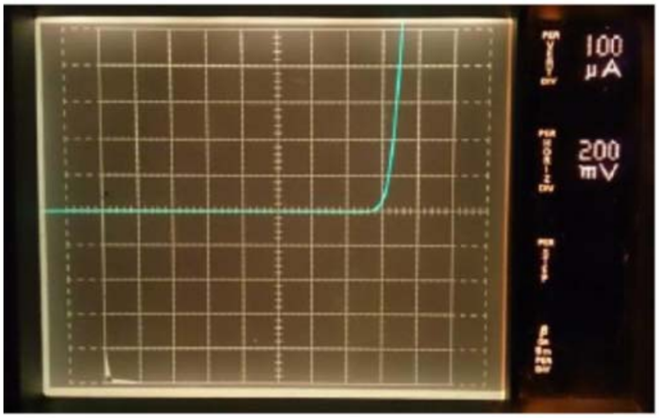


Figure 13:Base Collector IV

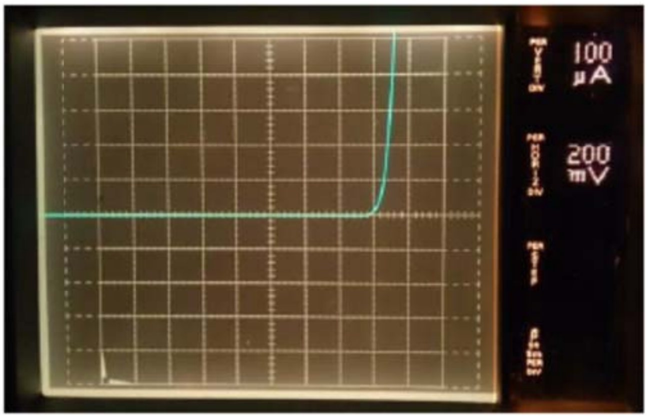


Figure 14: Base Emitter IV

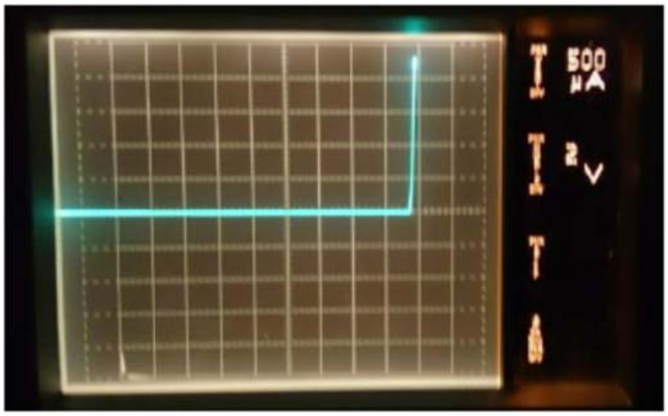


Figure 15: Collector Emitter IV

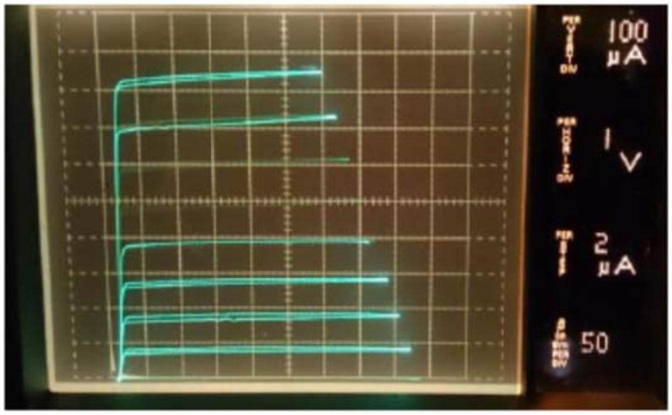


Figure 16: NPN transistor characteristics