University of Minnesota Nano Fabrication Center
Standard Operating Procedure

Equipment Name: CVIV system

Coral Name:	cviv	**Revision Number:**	4
Model:	HP4145A & HP4280A	**Revisionist**:	Tony Whipple
Location:	Area 3	**Date:**	29 Sept 2008

1 Description

The uses of the capacitance-voltage (CV) and current voltage (IV) measurements systems available in the Microelectronics laboratory located in Area 3 are what is covered in this document. The mercury probe, when used with the HP4280A capacitance meter and a simple program, provides a quick, non-destructive C-V measurement, but it must be performed on a minimum area of 2 cm>2. The HP4145A Parameter Analyzer and Signatone probe station are set up to measure the I-V characteristics of a BJT, FET, or diode.

Photo 1: All components of the CVIV system.

2 Safety

The safety item beyond the normal electrical hazards as this system does use
Electrical power, is to watch out for the chuck as it can be heated to 250 degrees C.
The mercury probe does have a small amount of mercury that it uses, so do not handle the mercury if it is out of the container. Contact a NFC person about any such problems.

3 Restrictions/Requirements

Must be a qualified user on the cviv

4 Required Facilities

None as the system has a separate vacuum pump and a water cooling for itself.

5 Definitions

CV system is the HP4280A system that is the top instrument on the rack.
IV system is the HP4145A system is the bottom instrument on the rack.

6 Setup

No special setup is needed.

7 Operating Instructions

CV MEASUREMENT

1. Turn on the computer and the monitor. The CV measurement program should load automatically. If not, type "cviv" and press enter.
2. Turn on the HP 4280.
3. From the ten options select # 1: **SET PARAMETERS**
4. Answer the questions as they appear on the screen. To select the defaults, press enter at each question.
5. Turn on the vacuum pump. Open the valve that connects the Hg probe. Make sure the Hg pressure is properly adjusted. This can be done by placing a glass slide over the Hg contact and turning on the Hg contact switch. Hg should fill the contact holes, but not come out. This should be set at the lowest gas pressure. (Dial all the way counterclockwise) If you need to, only change it a little bit. Too much mercury will overflow the contacts, decreasing reliability, and spilling Hg into the vacuum lines. **Turn off valve.**
6. Place your sample on the chuck, with the area to be measured over the mercury contact and lower the backside ground plate lever. If there is an oxide on the back of the wafer, a diamond tip scribe might be used to make better contact by scratching the backside of the wafer.
7. Turn on the vacuum to hold the substrate securely.

Photo 2: Closer view of the Mercury probe with the lid open.

8. Select option #2 TAKE MEASUREMENTS. Make sure the Hg contact is off before continuing. The program will calibrate the meter. Watch the HP4280 and the display LEDs will blink as this happens. Then turn on the Hg contact when the computer program prompt says to. Wait a few seconds, as in 10 – 15 seconds, while the mercury is making contact with the surface and press enter. The computer will conduct the measurements.

Using the wafer probe area one can measure the capacitance of a structure at the wafer level. To do this the leads from the HP 4280 must be removed from the mercury probe and attached to the switch box. All other connections from the HP 4145 needs to be disconnected from the switch box. Also the wafer probes need to be connected to the side plug ins, having a complete circuit from the probe tips to the 4145. Have the LOW side wire from the 4145 connected to the larger sized structure on the wafer, which would be the ground plate, or substrate. The HIGH side connection should not be connected to the smaller sized feature yet, but the probe should be just above the area. Then after the software says to turn on the mercury you can lower the probe to make contact with the wafer. Make the measurement as before and then lift the HIGH side probe from the surface before making another measurement. After using the system reconnect the cables as they were before to the mercury probe.

9. Select QUICK PLOT option # 5 to graph the data on the screen.
10. Select SAVE DATA TO DISK option #4 to save the data to a 3.5" disk in an ASCII file. The file has a list of Voltage and Capacitance values. The format for the filename is anything for the first eight characters and it must end with 3 characters such as : **TEST123.DAT**
If the data is to be read into the CVIV computer having the file end in .DAT seems to work best. The data can be used with other database type of programs like EXCEL.
12. Make sure to shut off the vacuum pump, unload your sample and turn off the HP4280A. The computer may stay powered on.

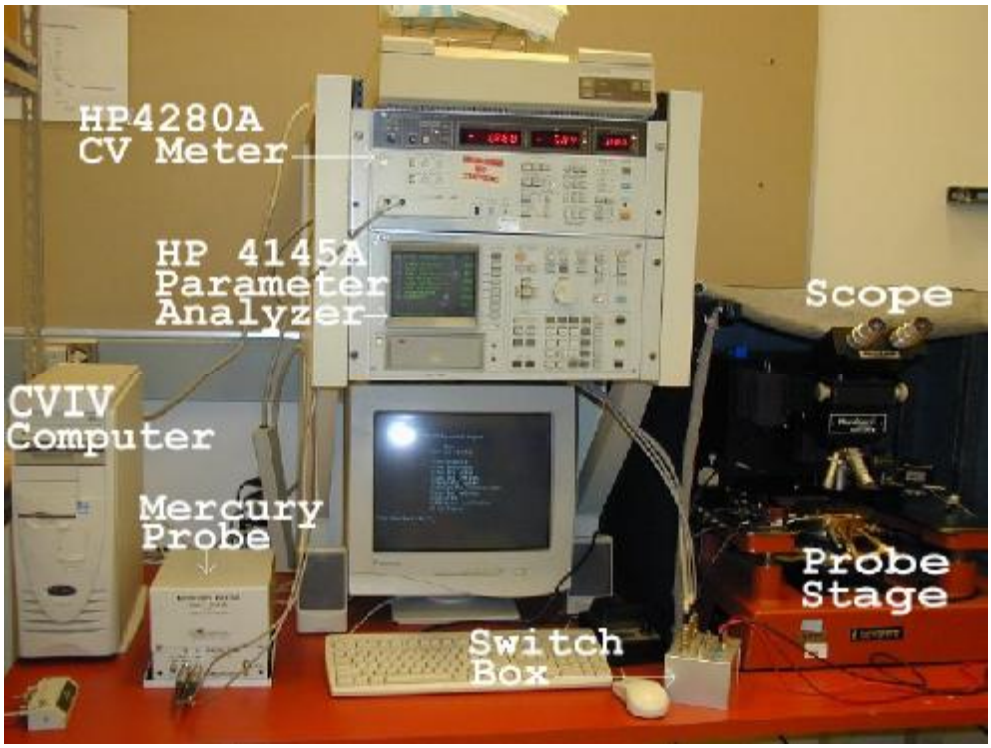


Photo 3: The main components of the CVIV system are labeled.

IV MEASUREMENT

Instructions:

1. The IV measurement system consists of a HP 4145A semiconductor analyzer and a Signatone probe station.
2. It is used to measure the IV curves of diodes, FETs and BJTs.
3.Explanation of keys:

Page control keys - control paging of CRT
- **MENU**- returns display to start up menu
- **NEXT**- advances display to start up menu
- **PREV**-returns display to previous page

Measurement keys - starts and stops measurement
- **SINGLE**-one single measurement is performed according to the setup
- **REPEAT**-measure is repeatedly made until stop is pressed

APPEND-new measurement is displayed along with old measurement
STOP-stops the measurement

Integer keys - selects the digital integration time

SHORT-measurement data is stored directly in memory
MED -sixteen samples are taken at each measurement point
LONG -256 samples are taken at each point.

Other keys:

PLOT- dumps whatever is on the CRT directly onto the plotter

PRINT- outputs alphanumeric data to the printer

BLUE/GREEN keys - adds more defined values to panel keys

ENTER - used to enter user inputs

EXECUTE - executes **GET**, **SAVE**, **PRINT**, **PLOT**, & **PURGE**

Cursor keys - controls field pointer

Marker control dial - controls marker on graphics

Data entry keys

Edit keys - used to edit data displayed on keyboard input board

SAVE and **GET** - used to store data files or recall them

4. Measurement Procedure

a. Depress line on/off to the on position. The start up menu will be displayed.

b. Choose Channel Definition from the menu. Select a predefined setup from the soft keys or assign your own current and voltage names, modes, and functions to each channel by using the field pointer and keying in the specific soft keys or panel keys.

c. Advance to the set up page. Select the sweep mode, start, stop, and step values. This is done by pressing the **NEXT** key.

d. Advance to Measure and Display mode setup page. Select the display modes for measurement, the monitor channels and display parameters.

e. Place the substrate on the Signatone probe station chuck. Turn on the chuck vacuum, if wanted.

f. Focus in on the measurement device using the microscope. Make sure to turn on the illuminator lamp, and position the microscope using the large black levers on the right side of the microscope assembly. The chuck can be moved using the black knobs on the right side of the base. The lamp on-off switch is on the left side of the probe station on the table.

g. Use the micropositioners to gently place the probe tips on the device features. DO NOT use any force more than needed with the micropositioners as they are fragile. Turning the knobs past their limits will cause the probes to be damaged.

h. Connect outputs SMU1-4 to appropriate color-coded connectors on the backside of the probe station.

i. Press one of the measurement keys to initiate the measurement, such as **Single Measurement**.

5. Hints

- Consult the HP 4145 Operators manual Section 3 for more information about taking measurements.

- Be careful in placing the probe tips onto the pads. Excessive force will ruin the tips.

6. Saving the data to the PC disk. The HP 4145 must be in the graphical screen, and a floppy in the PC.

This will get the data from the HP 4145 and have it stored on the floppy disk of the CVIV PC. The data is not formatted the best when it is stored on the disk, so some editing might need to be done.

On the PC keyboard, press option number 8, F8 key. This will ask for the variable you want downloaded from the HP 4145. Select the number 0 (zero) to select everything.

Next select option 9, F9 to start transferring the data to the PC. The screen on the PC should now start scrolling the data on the screen. Once the screen stops scrolling data and displays EOI.

Finally press option 10, F10 to save data to the floppy disk.

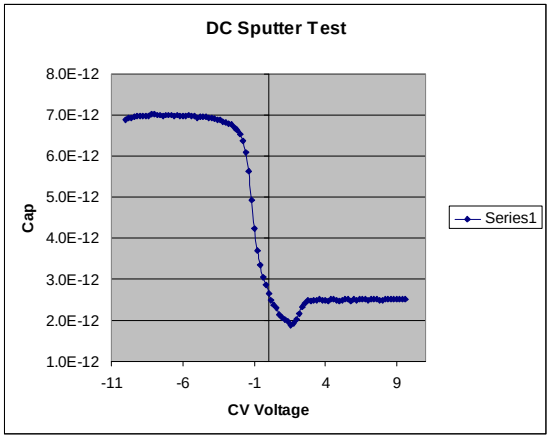
* To do more measurements you must press the LOCAL button that is located in the upper right corner of the HP 4145 panel. This will turn off the RMT LED which will allow you to do more measurements.

7 Problems/Troubleshooting

Not getting anything after a measurement was taken? The scale might be too small. On the soft keys press key label **Auto Scale**. The main item that is longer to check is make sure your connections go to the correct place. The circuit should not have any opens. The other problem that happens sometimes is that the micropositioners wire end connector does not fit into the probe station sock well enough, too loose. The solution that others have done was to place a small part of tin foil in the holes, making for a tighter fit.

If your data is there but looks wrong, check that the SMU cables are connecting to the right part of the device under test, as in are the cables swapped?

You can not get good grounding if you are using the wafer chuck as a substrate ground if there is still oxide or other films on the backside of the wafer. Even having a bare Si backside on the wafer most likely will not be good enough to give a backside ground for the device. This is solved by removing a layers of films from the backside and then putting on a layer of Ti and Au.



Graph 1: Data from the CV meter and into Excel.