MONTANA STATE UNIVERSITY | Montana Microfabrication Facility

Semiconductor Analyzer and Probe Station

Process Overview

The Probe Station and Keithley Semiconductor Parameter Analyzer are used for making IV and CV measurements of various electronic devices. Anywhere from 2-4 probes can be connected to the probe station to measure electrical characteristics of diodes, resistors, transistors, and other devices.

Restricted Materials and Processes

- There are no restricted materials for this tool.
- Restricted Processes
    - The current of the semiconductor analyzer is limited to 100 mA, and maximum bias for a device is 20 V. For most devices, their current and voltage limitations will be below this.
    - If you are connecting an external power supply to the probe station, please keep the current below 500 mA so as not to damage the probe tips.

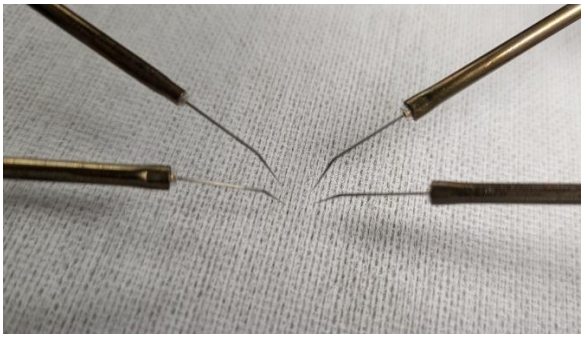
Operating Procedures

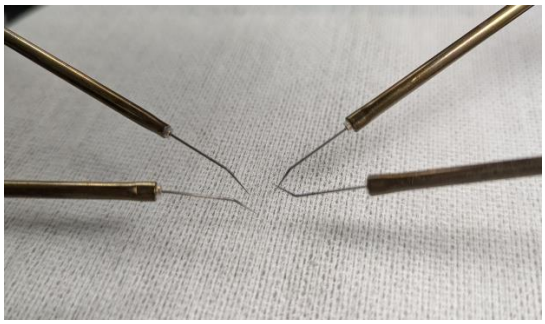
Setting up a measurement

1. Power on the system
    a. Turn on the semiconductor analyzer computer using the power button on the bottom right of the tool.
    b. Turn on the probe station light using the switch on the back left side of the tool.
2. Set the sample and probes
    a. Make sure the stage is in its lowest position by spinning the silver wheel under the stage. The big black and silver lever should be all the way down.
    b. If the probes are not already set in the configuration shown below, move the mounts so that there are two on each side of the wafer stage. They magnetically attach to the probe station, but it does take some force to move them. Move the probe tips as close together as they can be without touching and adjust them to be the same height using the silver knobs on the arm of the probe mounts. The set up should look like

the one in the picture below (minus the wafer):

c. If the tips are not already set, adjust them so that they are all pointing directly downwards. This can be done manually by gently rotating the tips with your fingers. If any of the tips are sideways, they will not contact your device properly.





The left image shows properly aligned tips, while the right image shows one misaligned tip.

d. Zoom all the way out on the microscope by using the white knob next to the Leica logo. Use the silver knobs on the back of the probe station to adjust the microscope field of view until you can see all the probe tips (they don't have to be in focus). To adjust the eye pieces, you can grab them and manually move them side to side.
e. Place the sample of interest in the center of the stage.
f. Raise up the wafer using the wheel under the stage until it is close but not touching the probe tips. Use the black focus knob to bring the wafer into focus.
g. Use the large knobs by the Cascade and Danger labels to move the substrate until the device of interest is centered in your field of view. The probe tips SHOULD NOT be touching the wafer when you do this.

3. Making contact
   a. To contact your device, lower the probe tips down using the silver knobs on the arm of the probe station and the silver wheel underneath the stage. If it is hard to see if

the probes are close to the contact pads, zoom in. The probe tips will also come into focus as they are lowered.

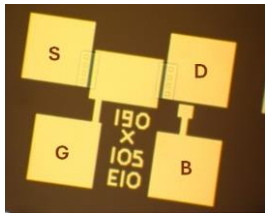
i. The UP knobs on top of probe mounts don't work.

b. To move the probes in the XY direction, use the silver knobs on the sides of the probe mounts. As you lower the probe tips down toward the wafer, their position will shift, so you will have to continually adjust these knobs.

c. Once it looks like the shadow of the probe tip is gone, the tip is in focus, and you feel some resistance when you lower the tip, verify that you have contacted the substrate. Gently move the probe tip laterally. If it looks like the tip is scratching the contact pad, then you have made good contact.

Making a Measurement (EELE 407)

1. Launch the Clarius software. In the upper right corner, click on the **My Projects** button. Select the project for the type of device you are measuring.
2. Resistor Measurement:
   a. Open the **EELE407_Resistor** Project.
   b. Set make sure points A and B are set to the probes on each side of the resistor. The probes are labeled with tape on each mount. A should be set to a voltage sweep and B should be a voltage bias (0 V).
   c. Voltage and step size are up to you, but collect at least 10 data points and don't set the voltage higher than 100 mV
3. Diode Measurement:
   a. Open the **EELE407_Diodes Project**. Double click on **vfd (forward bias test)** or **vrd (reverse bias test)** to load the test.
   b. Set up the anode and cathode parameters like the resistor measurement (you only need two probes).
   c. Set the sweep parameters for the anode. The min voltage should be -0.1 V – 0 V and the max voltage should be 1-2 V. Step size is up to you but collect ~10 data points.
   d. Click **Run**, then **Analyze** when the test is complete to view the IV curve.
4. Transistor Measurement
   a. Open the **EELE407_Transistor** project, then select your test by double clicking on the device (3 or 4 terminal n or p fet).
   b. Use the probes to contact the pads of the transistor. In the **Configure** tab, set the source, gate and drain to the corresponding probes. An image of the different contact pads is shown.

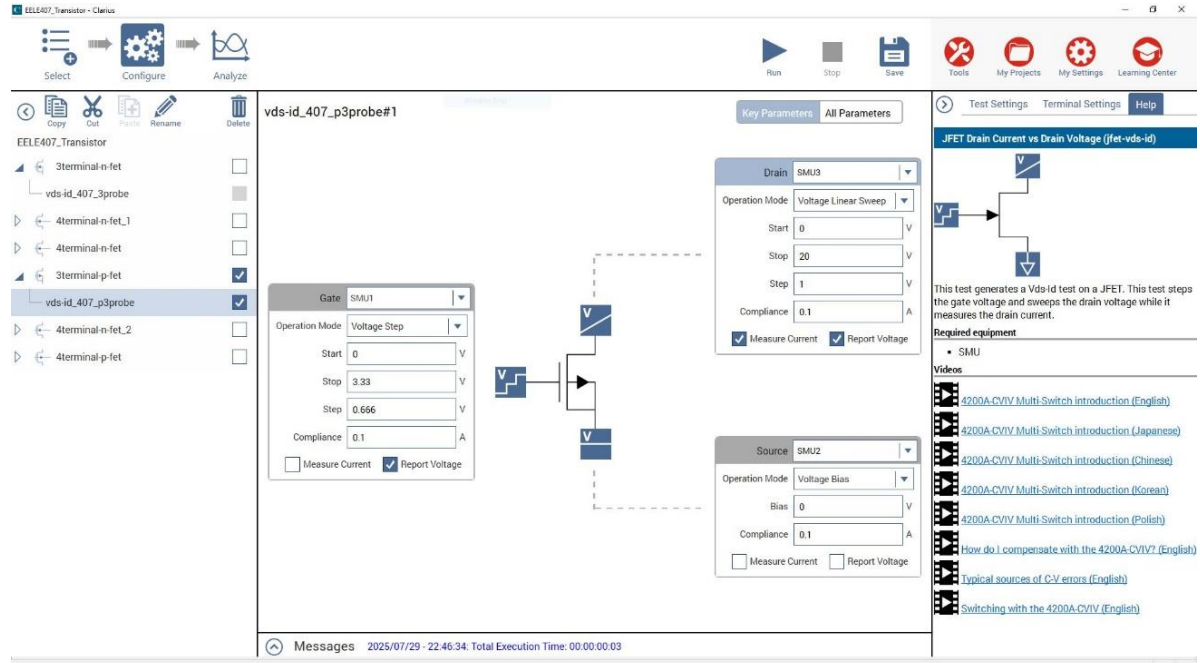


      i. If the test screen doesn't automatically open, double click on the test. The boxes next to both the device and the test should be selected.

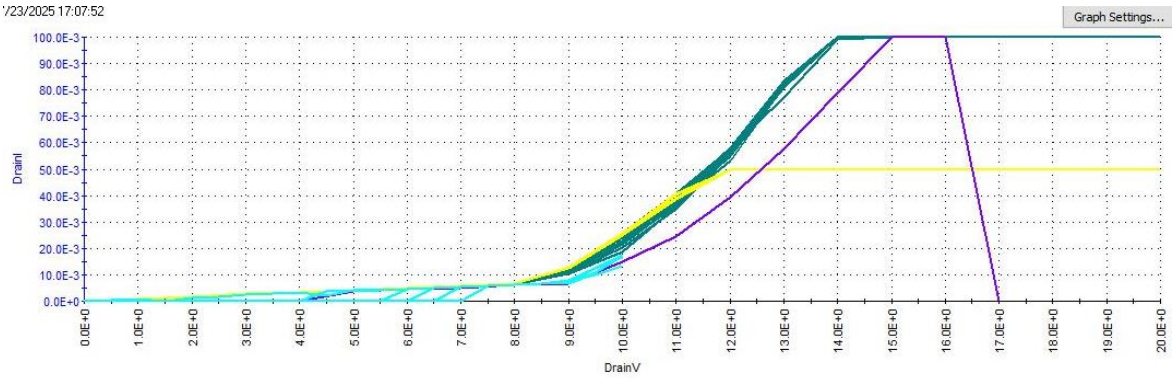
   c. Set up the gate voltage parameters as a voltage step. The specific values are up to you, but keep the gate voltage between 0-5 V, with fewer than 10 steps. Set the drain

to be a voltage sweep up to 20V (the transistors will saturate between 10 and 20 V) and the source to a bias of 0V.

d. Click **Run** then **Analyze.** Right click on the graph and select **Auto** Scale to get the best graph of your measurement. Below is an example measurement and resulting IV curve for one of the larger NMOS transistors.



5. To measure the PMOS transistors, the step and sweep values can be the same, but the gate and drain voltages need to be negative relative to the source instead of positive.
   a. The PMOS transistors do not usually work. If your IV curve looks like any of the ones below, it's likely a device problem and not a measurement set up problem.



Making a Measurement (General Procedure)

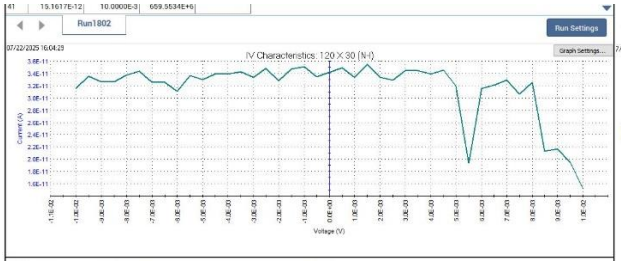
1. If you are measuring an IV curve for a resistor, diode, transistor or device that can be modeled as one of the three, you can use any of the preexisting 407 projects and modify the measurement settings. Otherwise, you will need to create a new project.
2. Make a new project: **Select Projects**, then select **New Project**, then **Create**. Say yes when prompted to replace an existing project, then **Rename** to give the project a new title.
3. To add a device to the project, go to **Select**, then the **Devices** tab, and search for the component you want to test.
4. To add a test for the specific device, go to the **Tests** tab and search for your device-specific test. Each test will be added underneath the device it corresponds to in the panel on the left.
    a. Once the tests are added you can modify the test parameters in the **Configure** tab.

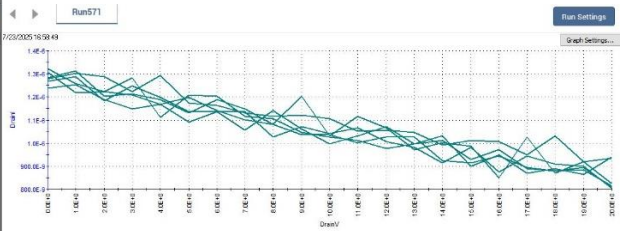
Shutdown and Cleanup

1. Lower the stage using wheel underneath it and remove your sample.
2. Save or record your data, then close out of the Clarius software and turn off the Semiconductor Analyzer.
3. Turn off the probe station by flipping the switch on the back left side.

Troubleshooting

1. The probe tips do not look pointy under the microscope
    a. It is possible the probe tips have been bent. Contact MMF staff (or your TA if in 407) to replace the probe tips.
2. Your graph looks like this after you auto scale it:
    a. You have an open circuit – make sure that the probes are contacted, the right probes are selected in the software, etc.





Version History

2025.1 First draft written with the help of RMOR