NEMO Name: KLA RS54 4-Point-Probe

Location: L04 Metrology Wall
Category: Cleanroom Metrology
Contact: Ben Newcomb, Connor Moorman, Elijah Shirman

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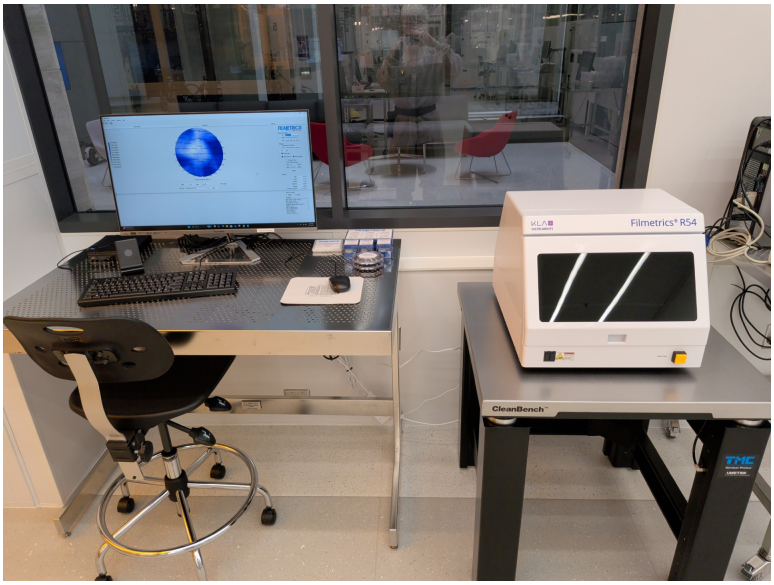


Figure 1: KLA Four Point Probe Setup.

1 Introduction

The KLA four point probe is a benchtop system for automated sheet resistance and resistivity mapping of conductive and semi-conductive films using contact four-point probe measurements. It supports precise multi-point mapping for substrates up to 200 mm and includes software for data visualization and reporting. It is best suited for measuring thin metal layers, implanted semiconductor wafers, transparent conductors, and uniform conductive coatings. It is not recommended for non-conductive films or fragile/soft films, since the probe tips can scratch and damage the films.

2 Safety

Hazards present in the system are possible pinch/crush points, and voltage. Exercise care when unloading samples from the chamber. Mechanical pinch/crush points exist with the enclosure door and changing the probe tip. Please keep your fingers and other body parts clear when closing the door. Do not touch the electronics in the back section of the enclosure. Under normal operation, the user is protected from these hazards by the system software and tool interlocks. Do not attempt to remove or defeat any interlocks, as you risk exposing yourself and others to these hazards.

If the tool is behaving dangerously or making loud noises, press the yellow **Motion Stop** button on the right side of the enclosure, alert the staff, and shut down the system in NEMO. DO NOT attempt to re-energize the tool.

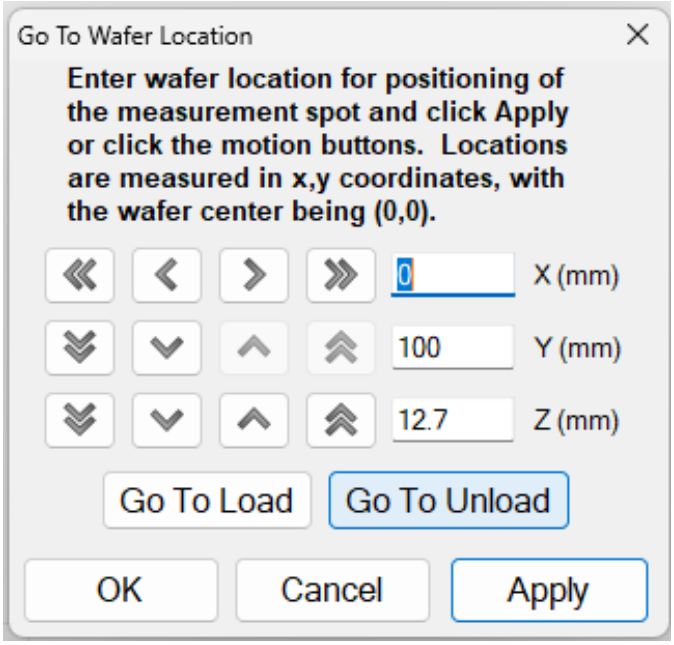
3 User Qualifications and Responsibilities

During training, you will learn to load samples and run recipes. To be considered qualified, you need to be trained by the staff in charge, be up to date with your safety trainings, and have a PTC-approved process. Photoresist is not allowed in the system and organics are prohibited. Circumventing these restrictions or running processes/-materials that have not been approved by the PTC can lead to disqualification from the tool.

Users are expected to remove their samples from the tool, and leave the enclosure door closed when they are finished. If you encounter any problems or notice anything unusual while operating the machine, report the issue in NEMO so the staff can promptly address it.

4 Procedure

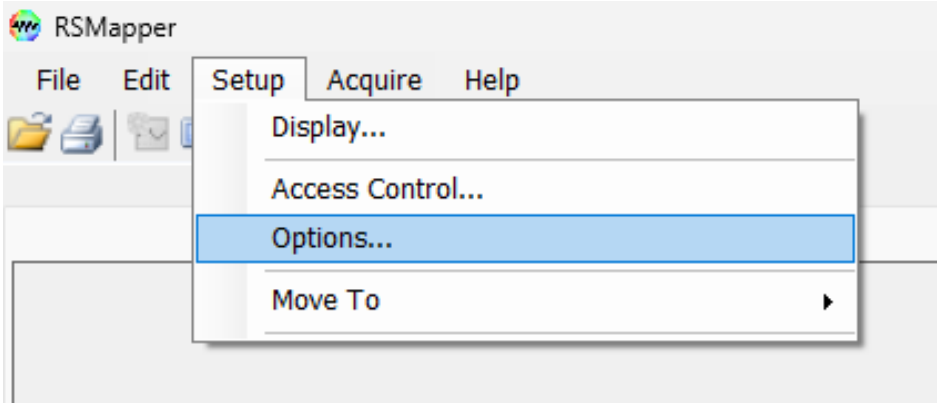
1. Check reservations in NEMO to ensure you have reserved the correct tool at the correct time. Engage the tool in NEMO.
2. On the computer, open the RsMapper software. It should load with the **Wafer Map** screen selected. Otherwise, click the **Wafer Map** tab at the top of the screen.
3. In the menu in the center of the screen, locate the **Go To...** button to move the stage. Make sure the door to the enclosure is closed. Click on **Go To Unload** and wait a few seconds for the display to show Y at 100 mm.

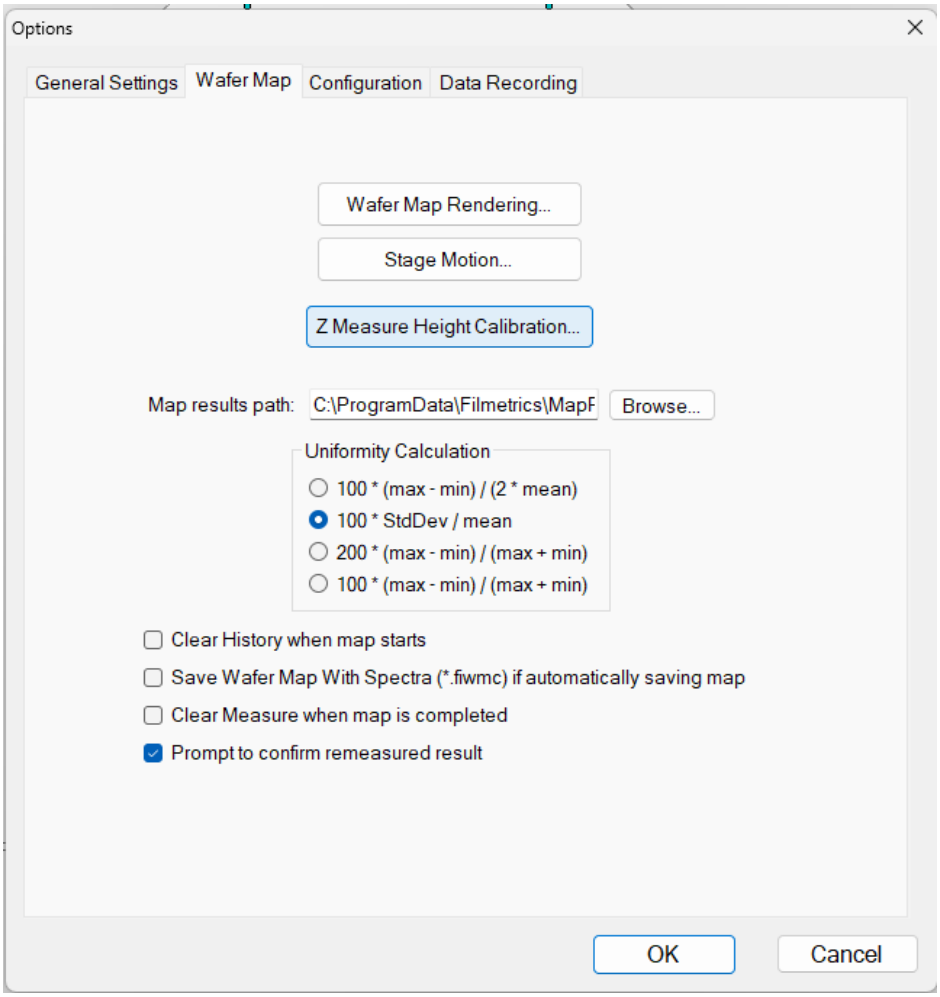


4. Open the door and place your sample centered on the stage. Each wafer size has an outline and label for where the wafer should be placed. If you have a small piece, center it on the cross in the middle of the stage.

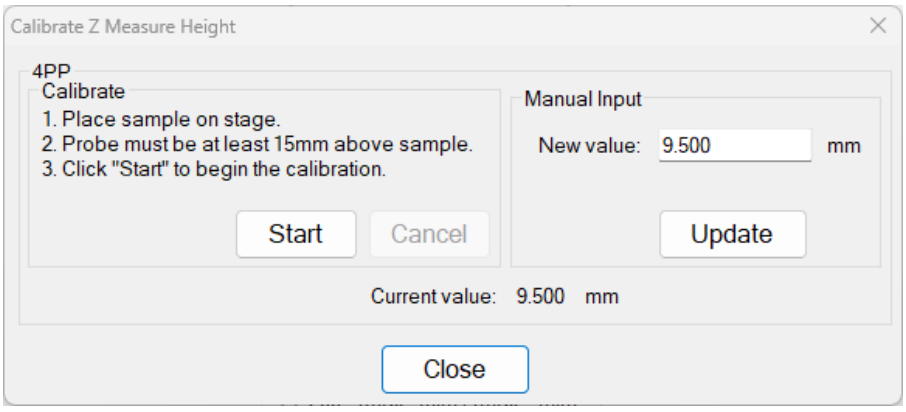
5. Close the door and click the **Go to Load** button. Wait a few seconds for the display to show Y at 0 mm.

6. Before starting a measurement, it is best to recalibrate the z-height to reduce damage to the film. In the top left of the screen, select **Setup** then **Options** from the drop-down. In the **Options** window, select the **Wafer Map** tab, then **Z Measure Height Calibration**.



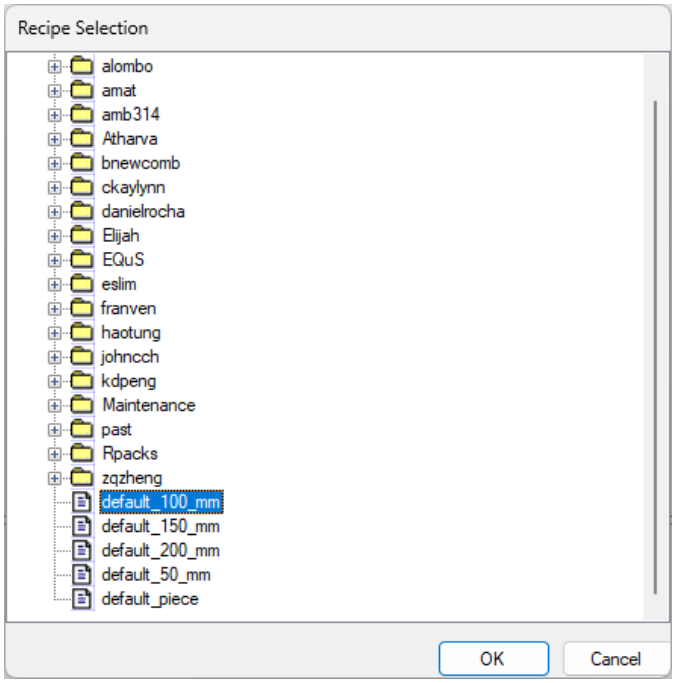


7. Click **Start** in the **Calibrate Z Measure Hight** window, then wait for it to display the ”Current value” in millimeters at the bottom. Typical values are between 8 and 13 mm. Enter the displayed value into the ”New value” box and click **Update**.

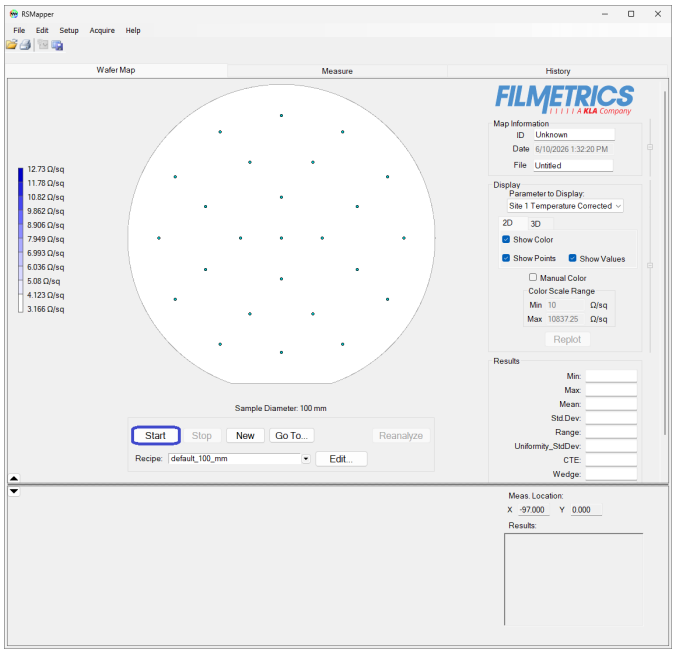


8. Click **Close** then **OK** on the two open windows to get back to the **Wafer Map** tab on the main screen. To the right of the displayed recipe name, click the small dropdown arrow to open the **Recipe Selection** window.

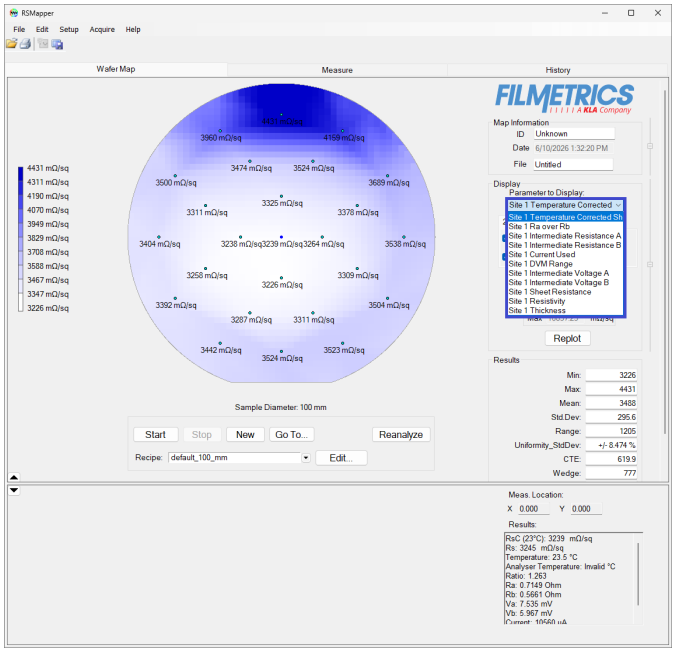
There are default recipes programmed for popular sample sizes available at the bottom. Select the one that best fits your substrate then click **OK**.



9. The default recipes automatically select the current for each measurement point on the sample using a target voltage of 7.5 mV and a starting current of 10 μA. See subsection 5.2 if you need to edit the measurement points or current. Click **Start** to begin the measurement. If the first point returns Invalid instead of a resistivity measurement, click **Stop** and see subsection 5.5 for troubleshooting.



10. Once your measurement is complete, use the **Parameter to Display** dropdown to view other parameters. See subsection 5.3 if you want to approximate resistivity and thickness. See subsection 5.4 for instructions on how to save the wafer map.



11. Repeat the steps above to measure the rest of your samples. If your samples are similar to each other, you can keep the same Z height setting without re-measuring.

12. When you are finished measuring, remove your samples from the tool and close the door. Disengage the tool in NEMO.

5 Appendix

5.1 Changing the Probe

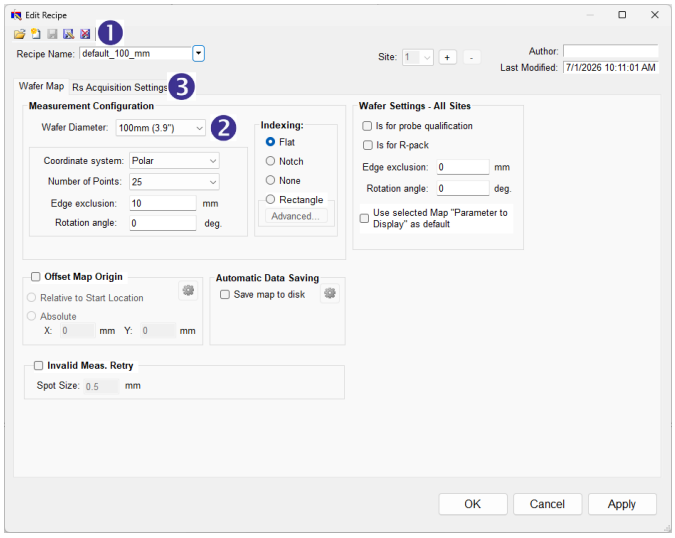
The following steps can be followed to switch between different four-point probe heads as required.

1. Pull open the locking lever on the probe assembly. You should not need to twist it.
2. Lift the probe straight up out of the assembly. Note that twisting or turning the probe while removing it may damage the 6-pin connector.
3. Place the probe in the Filmetrics provided storage case.
4. Place the new probe into the probe assembly, being careful to align the 6-pin connector.
5. Push down gently on the top of the probe until set in place.
6. Close the locking lever on the assembly. Again, you should not need to twist it.

5.2 Recipe Editing

Follow the steps below to make changes to the recipe. **Do not change the target voltage above 7.5 mV or current above 100 mA without discussing with the tool owner.**

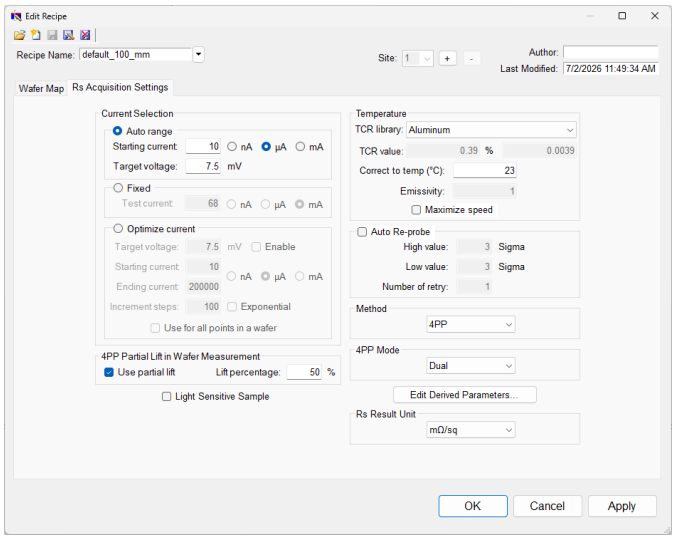
1. In the center of the main **Wafer Map** screen, there is an **Edit** button to the right of the recipe selection dropdown. Click the **Edit** button.
2. The first tab in the recipe edit screen is labeled **Wafer Map**.



In the figure above, there are five buttons to the left of number one. These allow the user to (in order from left to right): i. Open a saved recipe, ii. Start a new recipe, iii. Save the current settings, iv. Save the current settings as a new recipe, v. Delete the current recipe.

3. The measurement configuration (number two) is where you can specify the measurement points on your substrate. You can change the wafer diameter when indexing is set to flat or notch, and change the dimensions of a rectangular substrate when the indexing is set to rectangle. The coordinate system can be set to rectangular, polar, linear, or custom. Click **Apply** to preview the map in the main window.

4. You can proceed to the **Rs Aquisition Settings** tab (number three) to change the current specified for the measurement. **Do not change the target voltage above 7.5 mV or current above 100 mA without discussing with the tool owner.**

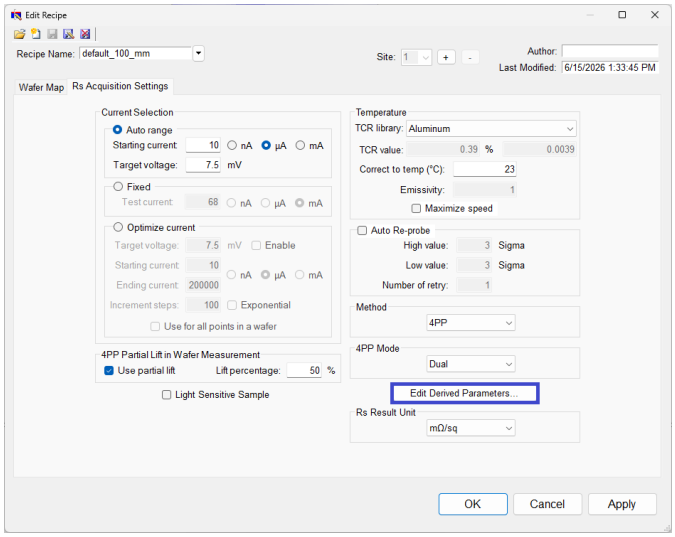


5. You can use either **Current Selection** of **Auto range** or **Fixed**. If you are having trouble with measurement points coming back as invalid, it may help to select **Auto range** with a low starting current.

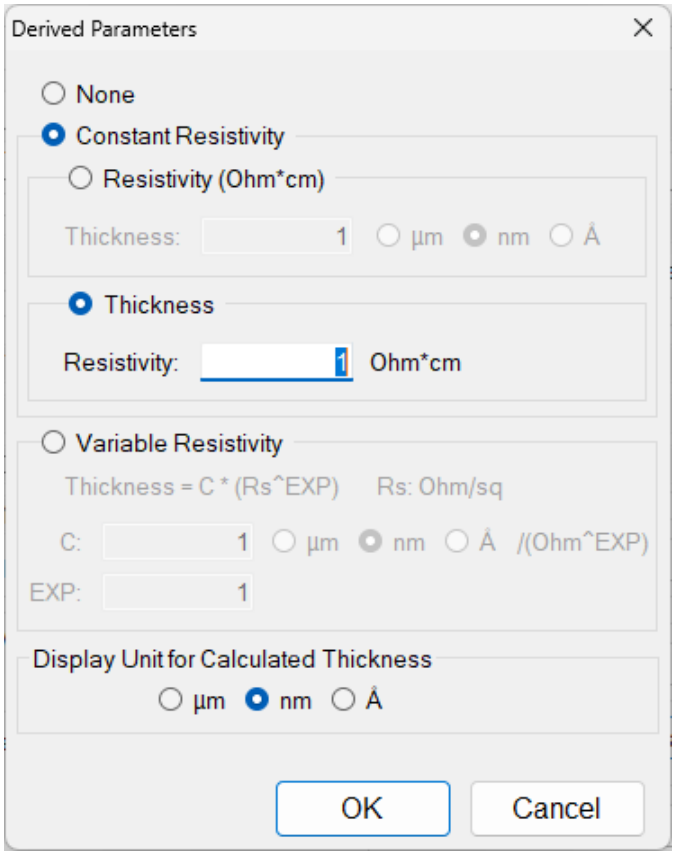
5.3 Resistivity and Thickness Approximations

If either thickness or resistivity of a film is known, the other can be measured by the 4PP by selecting the appropriate radio button and entering the known value. These controls are split into Constant and Variable resistivity sections. Constant assumes the values for thickness or resistivity are the same at all locations measured, while Variable allows for changes across the surface using the equation Thickness $= C * Rs^{EXP}$. When using variable resistivity, it is assumed that the user knows the constant (C) and exponential (EXP) values to be entered for this equation.

1. From the **Rs Acquisition Settings** page of the **Edit Recipe** window, select **Edit Derived Parameters**.



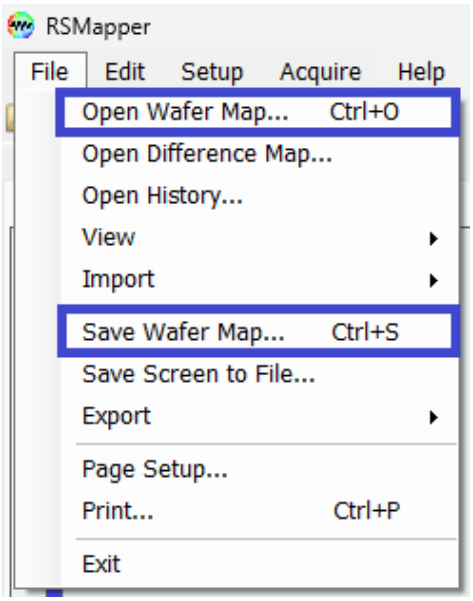
2. Select constant or variable resistivity, then enter the appropriate known values for your sample. Press **OK**.



3. You can view the results by changing the parameter to display in the drop down menu to resistivity or thickness.

5.4 Saving and Loading Wafer Maps

Once your scan is complete, you can save your result by selecting **File** in the top left corner of the application, then selecting **Save Wafer Map** or using the shortcut Ctrl + S. You can load a previous scan by selecting **File** in the top left corner of the application, then selecting **Open Wafer Map** or using the shortcut Ctrl + O.



5.5 Troubleshooting

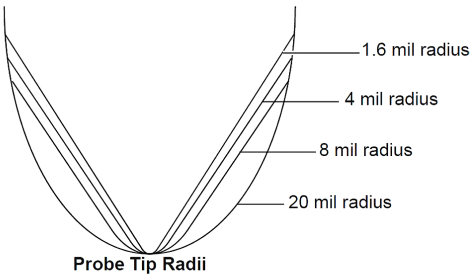
5.5.1 Invalid Measurement

Invalid measurements can be caused by any of the following issues: measuring a sample that is too resistive, measuring a resistive sample with the incorrect recipe settings or probe tip, the probe head is not properly seated in the 6-pin connector, or the probe tip is not making adequate contact with the sample. If only some of the measurement points are invalid, the film may be too resistive in some areas. You can retry these points offset by a small distance by clicking the point that was invalid on the map. If all points except the first come back as invalid, it is possible that the probe head became unseated during the first measurement.

First, check that the probe head is seated in the 6-pin connector by lightly pushing down on the center of it. If it was not seated correctly, fix it, and retry the measurement. Next, try lowering the **Auto range** starting voltage in the recipe editing window, see subsection 5.2. If these both fail, try changing the tip to type D.

5.5.2 Probe Tip Selection

Since each probe is not a single contact point but has multiple contact points due to the rough surface of the tungsten carbide, there are multiple resistances all in parallel. The effective resistance is a function of the resistance of all contact points. You can decrease the effective resistance by increasing the number of contact points. This is done by increasing the area of contact (i.e., the radius of the tip). The figure below shows the different probe tip types and their diameters.



Probe Tip Radius	Probe Head Type
1.6 mil (41 microns)	A, E & F
4 mil (102 microns)	B & G
8 mil (203 microns)	C & H
20 mil (808 microns)	D

Generally, type B is suitable for general purpose measurements, and type D is suitable for high impedance surfaces. A sharp probe, such as a 1.6-mil radius tip (types A, E, and F), works very well for metal layers where contact resistance and probe penetration are not a problem. Silicon wafers and wafers with implanted layers can have high contact resistance. For high dose implants ($>$1E14 ions/cm2) or low-resistivity silicon (lower than 10 -cm), a 4-mil radius tip is recommended. For medium-dose implants (1E14 – 1E13 ions/cm2) and medium-resistivity substrates (1–100 $\Omega - cm$), an 8-mil tip is more appropriate. For low-dose implants ($<$1E13 ions/cm2) or high resistivity materials ($>$100 $\Omega - cm$), a 20-mil probe tip will probably work best.

5.5.3 Software Initialization

If the RSMapper software gives an initialization error, open the Windows Task Manager, right click RSMapper in the Processes tab and click End task. Try to reopen the software once it closes. If it does not start normally, report a problem in NEMO and wait for staff to fix the issue.

5.5.4 Windows Login

The Windows username is **Operator1** and the password is **filmetrics**.