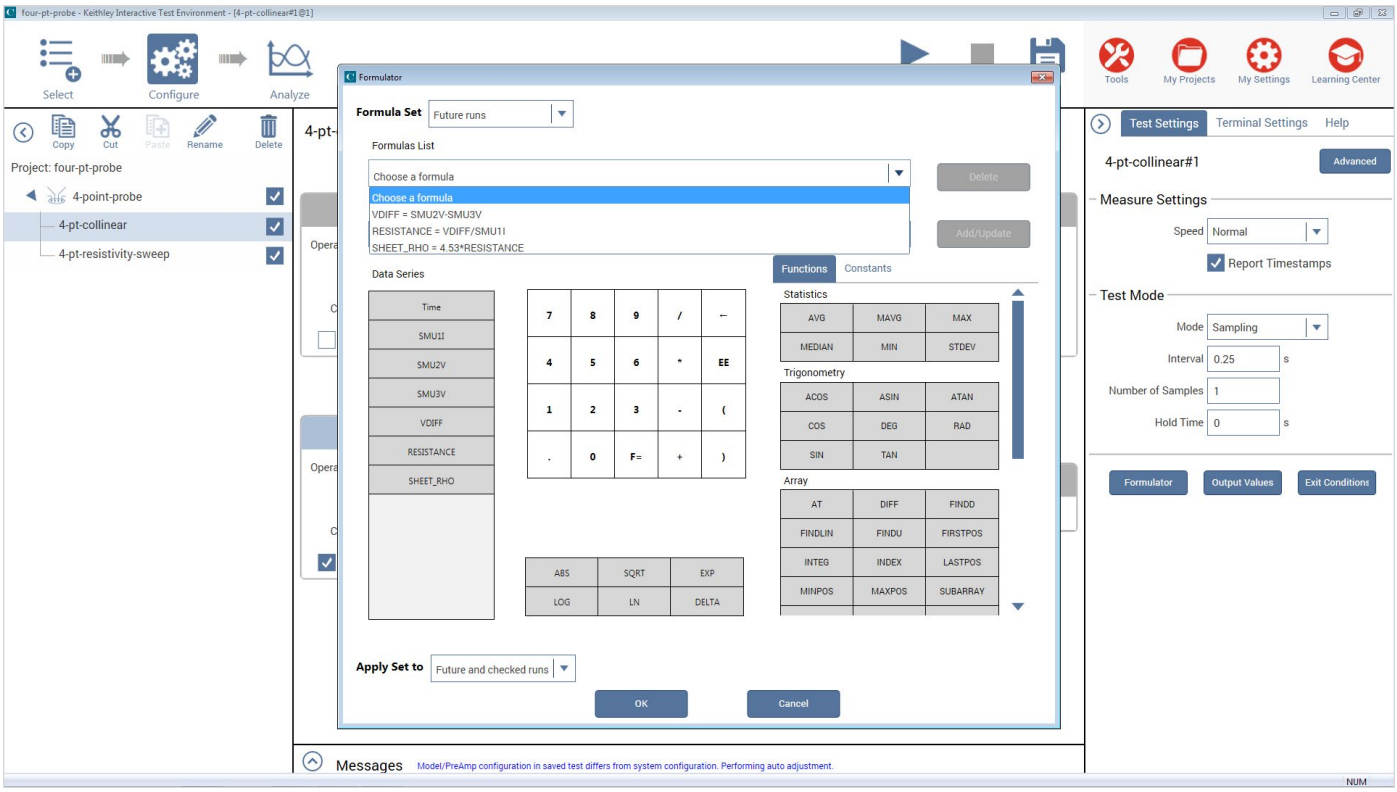

Figure 5. Formulator dialog box with resistivity calculations in the *Four Point Probe Resistivity Project*.

The Formulator in the Test Settings pane includes equations to derive the resistivity as shown in **Figure 5**. The voltage difference between SMU2 and SMU3 is calculated: VDIFF=SMU2V-SMU3V. The sheet resistivity (ohms/square) is derived from SMU1 current and voltage difference calculation, SHEET_RHO=4.532*(VDIFF/SMU1I). To determine the volume resistivity (ohms-cm), multiply the sheet resistivity by the thickness of the sample in centimeters (cm). If necessary, a correction factor can also be applied to the formula.

After the test is configured, lower the probe head so the pins are in contact with the sample. Execute the test by selecting Run at the top of the screen. The resistivity measurements will appear in the Sheet in the Analyze view.

Sources of Error and Measurement Considerations

For successful resistivity measurements, potential sources of errors need to be considered.

Electrostatic Interference

Electrostatic interference occurs when an electrically charged object is brought near an uncharged object. Usually, the effects of the interference are not noticeable because the charge dissipates rapidly at low resistance levels. However, high resistance materials do not allow the charge to decay quickly and unstable measurements may result. The erroneous readings may be due to either DC or AC electrostatic fields.

To minimize the effects of these fields, an electrostatic shield can be built to enclose the sensitive circuitry. The shield is made from a conductive material and is always connected to the low impedance (FORCE LO) terminal of the SMU instrument.

The cabling in the circuit must also be shielded. Low noise shielded triax cables are supplied with the 4200A-SCS.

Leakage Current

For high resistance samples, leakage current may degrade measurements. The leakage current is due to the insulation resistance of the cables, probes, and test fixturing. Leakage current may be minimized by using good quality insulators, by reducing humidity, and by using guarding.

A guard is a conductor connected to a low impedance point in the circuit that is nearly at the same potential as the high impedance lead being guarded. The inner shield of the triax connector of the 4200A-SCS is the guard terminal. This guard should be run from the 4200A-SCS to as close as possible to the sample. Using triax cabling and fixturing will ensure that the high impedance terminal of the sample is guarded. The guard connection will also reduce measurement time since the cable capacitance will no longer affect the time constant of the measurement.

Light

Currents generated by photoconductive effects can degrade measurements, especially on high resistance samples. To prevent this, the sample should be placed in a dark chamber.

Temperature

Thermoelectric voltages may also affect measurement accuracy. Temperature gradients may result if the sample temperature is not uniform. Thermoelectric voltages may also be generated from sample heating caused by the source current. Heating from the source current will more likely affect low resistance samples, because a higher test current is needed to make the voltage measurements easier. Temperature fluctuations in the laboratory environment may also affect measurements. Because semiconductors have a relatively large temperature coefficient, temperature variations in the laboratory may need to be compensated for by using correction factors.

Carrier Injection

To prevent minority/majority carrier injection from influencing resistivity measurements, the voltage difference between the two voltage sensing terminals should be kept at less than 100mV, ideally 25mV, since the thermal voltage, kt/q, is approximately 26mV. The test current should be kept as low as possible without affecting the measurement precision.

Conclusion

The 4200A-SCS Parameter Analyzer is an ideal tool for measuring resistivity of semiconductor materials using a four-point collinear probe. The built-in resistivity project and tests are configurable and include the necessary calculations.

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