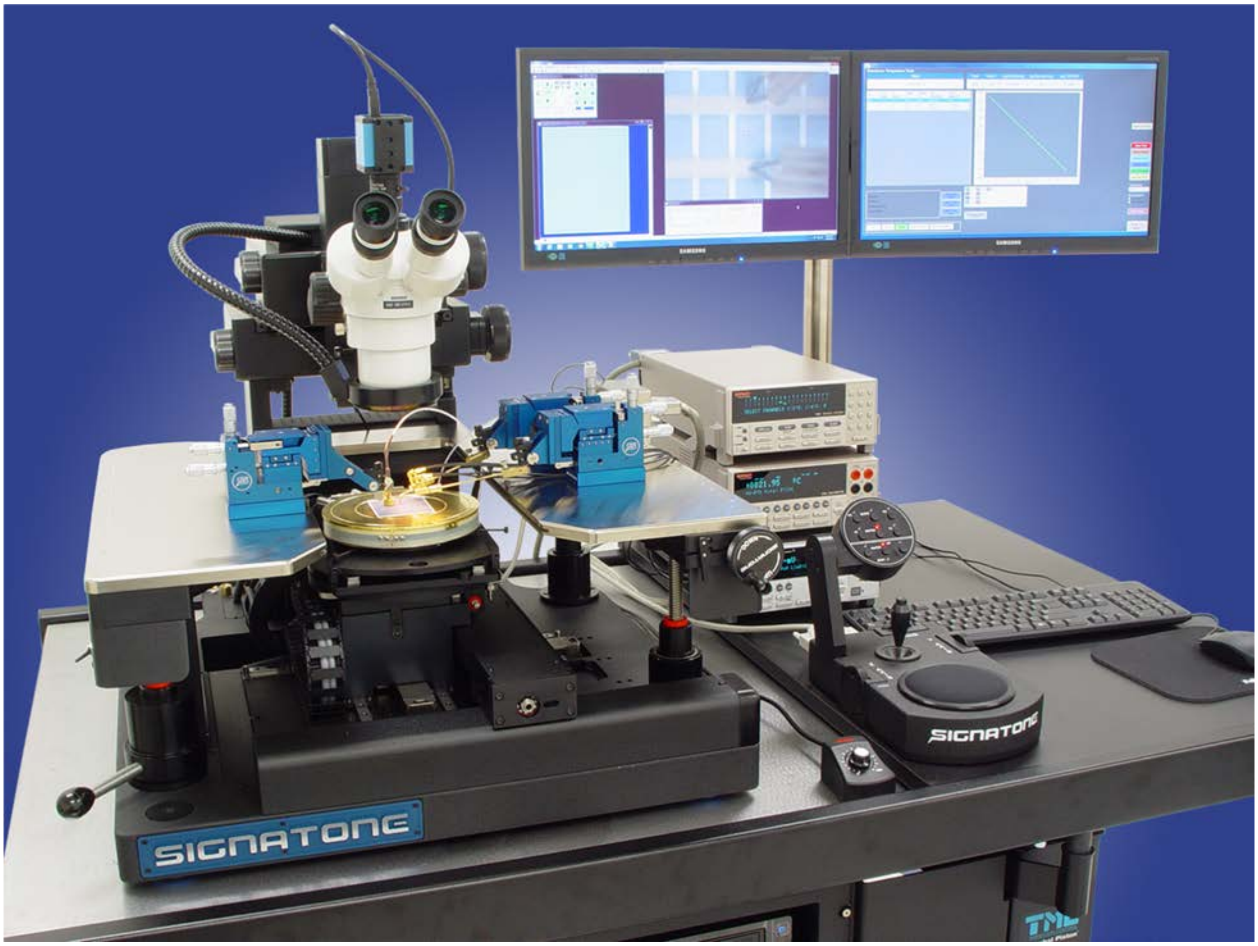
SIGNATONE ΩPro Resistance Testing System



❖ FEATURES / BENEFITS

ΩPro probe test solution performs numerous tests involving resistance measurements.

- Sheet resistance mapping of thin films with a collinear 4-point probe.
- Temperature co-efficient of resistance (TCR) of thin films with collinear 4-point probe.
- Precision temperature co-efficient of resistance (TCR) with 2-point Kelvin probes and precision surface temperature probe.
- Precision resistor testing with 2-point Kelvin probes.
- Precision resistor testing with a Kelvin probe card.
- Precision temperature co-efficient of resistance resistor test (TCR).
- Standard TCR test of multiple resistors with Kelvin probes or a probe card.

❖ ΩPro Overview of Operation

The *ΩPro* solution is the test management software integrated with Signatone hardware to achieve the desired measurements. The complete system includes a semiautomatic probe station equipped with a thermal chuck and microscope with CCD digital camera integrated with a vibration isolation table. Four independent probes, a 4-point probe, and probe card adapter and cabling provide the test signal connections between DUT and meters. The meter set includes a precision volt meter, source meter, and programmable switch. A precision temperature probe provides accurate surface temperatures for TCR tests.

The *ΩPro* test management software and results are viewed on one of the dual screen monitors. The other monitor displays probe station navigation and component status. Configurations are easily stored for future use. All test results may be exported to spread sheets or printed.

Sheet resistance mapping of thin films with a collinear 4-point probe

(photo left)

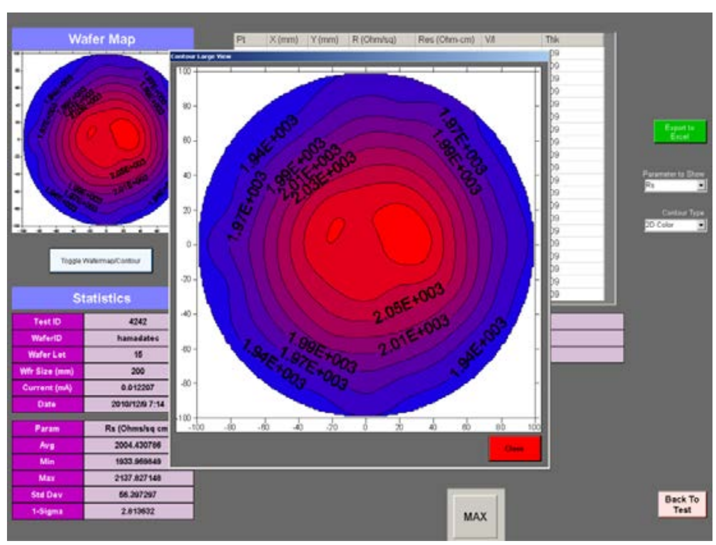
This test measures three parameters of thin films or thin materials – sheet resistance of the surface, resistivity of the material or thickness of the material. Results are reported in ohms-square, ohms-cm or microns. The measurements employ NIST standards SRM's 2541-2547 for measurement of semiconductor materials.

Maps of the entire surface in 2D or 3D

formats may be printed or exported to a spread sheet. The mapping features allows users to determine if their film deposit processes are uniform and within tolerance.

Once the test is defined and started, each test site is automatically tested and results recorded. False tests are determined and retested automatically. The statistical results of Average, Standard Deviation, Maximum, Minimum and 1-Sigma are prominently displayed.

(photo right)



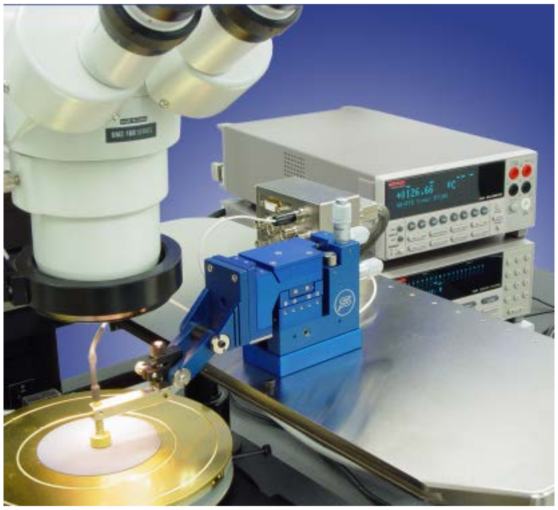
❖ More Key features of the ΩPro:

Some key features of the sheet measurement test include **Autorange, Dual Configuration,** and **Calibration.** *Autorange* automatically selects the proper current forced to achieve the measurement. The software controls stepping through several settings before selecting the current that meets the standard and produces repeatable results. *Dual Configuration* adds extra measurements with different pin selections to calculate and eliminate geometric and test set-up errors. *Calibration* verifies the system is measuring correctly when compared to a NIST standard.

The mechanical set up includes a 4-point probe mounted on a SM40 stable micropositioner. The SM40 features 12mm X-Y-Z positioning and probe planarization. The four-point probe heads have a variety of configurations available meet the test demands. The user has the option to use the semiautomatic probe station test site programming or the automated test site programing for determining actual test sites on the DUT

❖ Precision Colinear TCR Measurements:

This test builds on the capability of the sheet resistance test. Mechanically, the set-up is the same. However, the user may wish to add the precision surface temperature probe placed near the probe head. This will assure the surface temperature measured is correct. The surface temperature probe has 1/100 degree resolution utilizing a 4 wire RTD sensor.

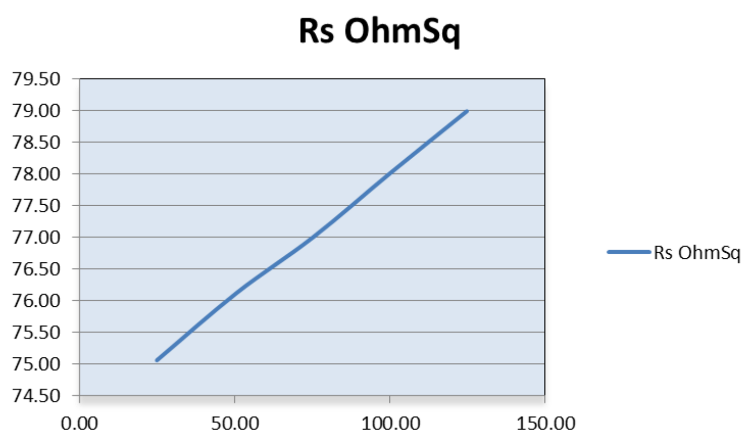


The *ΩPro* test manager allows the user to define settings and temperatures applicable to the DUT. The user defines the temperature range and number of temperature steps desired and settling time at temperature. For example, the user may set starting temperature at 25°C and ending temperature at 125°C with 4 steps. The results table is automatically created. (table below)

Target °C	Actual °C	Rs (Ω □)	Δ/°C	TCR-PPM
25	24.9	75.063	ref	ref
50	50.6	76.127	0.041400778	551.5470766
75	75.2	77.004	0.038588469	514.0810943
100	100.1	78.019	0.039308511	523.6735894
125	124.7	78.993	0.039378758	524.6094283

Precision Colinear TCR Measurements Continued:

Starting the test will drive the DUT to the 1st temperature and settle. The first Rs measurement is taken and recorded as the reference temperature. Automatically, the *ΩPro* drives the temperature to the next set point and settles. Once settled, the next Rs measurement is taken. Change per degree C and TCR in parts per million are calculated in comparison to the reference measurement. This same process repeats for all of the temperature settings. A line graph is also plotted showing the TCR measurement (line graph right)



TCR measurements are typically performed just at one site. However, the ΩPro manager allows users to define up 9 sites with graphics. In this automated mode, the sample is cycled at each selected site automatically.

Precision Resistor Testing with 2-point Kelvin Probes

This ***ΩPro*** test mode allows accurate measurements of structured resistors on the device under test (DUT). Two probe tips contact each contact pad and the Kelvin measurement method is used. The Kelvin or 4 wire sense mode of measuring resistance eliminates errors introduced from the wiring and fixtures assuring accurate measurements.

Integrated with the semiautomatic capabilities of the Signatone probe station and the 'Contact Sense' mode of the source meter, users may test a whole wafer or substrate unattended. Operators define the test criteria by selecting the test sites and pass/ fail criteria. The DUT is loaded onto the probe station and the 1st location tested manually to assure all is set correctly.

❖ Precision Resistor Testing with 2-point Kelvin Probes-Continued

Then the *ΩPro* manager begins testing by moving to the 1st site. The probe tips are brought into the contact position. The source meter verifies there is indeed contact using the built-in contact sense mode. If not, the DUT is moved up or down 5 microns, scrubbing the probe tips and contact is checked again. This continues for 10 checks or until contact is verified. The measurement is then taken applying the test settings and 4 wire sense mode. If the reading is within the defined tolerance, the wafer graph or DUT graph paints this location green. If the measurement is outside of the acceptable parameters, the site is painted red. The data is placed into a table and the statistical data is updated.

Statistics ↓

Average	75.011
Standard Deviation	.054984
Maximum	75.117
Minimum	74.916
1 Sigma	0.073
Yield	80%
1 Sigma	0.073
Yield	80%

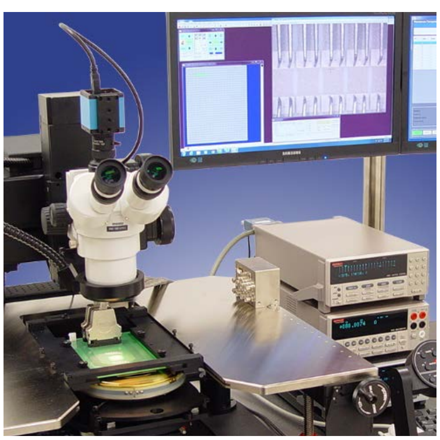
Results Table →

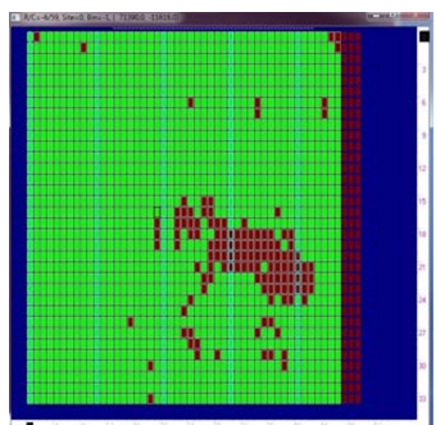
P	Col	Row	Ω Ohms	Status
1	1	1	75.063	pass
2	2	1	75.021	pass
3	3	1	75.117	fail
4	4	1	75.061	pass
5	5	1	74.989	pass
6	5	2	74.993	pass
7	4	2	75.003	pass
8	3	2	74.997	pass
9	2	2	74.951	pass
10	1	2	74.916	fail

❖ Precision Resistance Measurements on 1-10 Resistors using the Probe card

This ***ΩPro*** test mode allows accurate measurements of structured resistors on multiple devices by using a probe card. The test set up follows closely the Kelvin probe set up procedures.

The probe card (not included) should have 2 probes per pad independently wired to the 25 pin D-sub connections. Once the user defines the proper step size and aligns to the 1st position, the test is automated by the ***ΩPro*** manager. Each contact is verified on each resistor. The individual resistor is tested and using the switch technology. Results are recorded and the wafer graph updated according to the results.

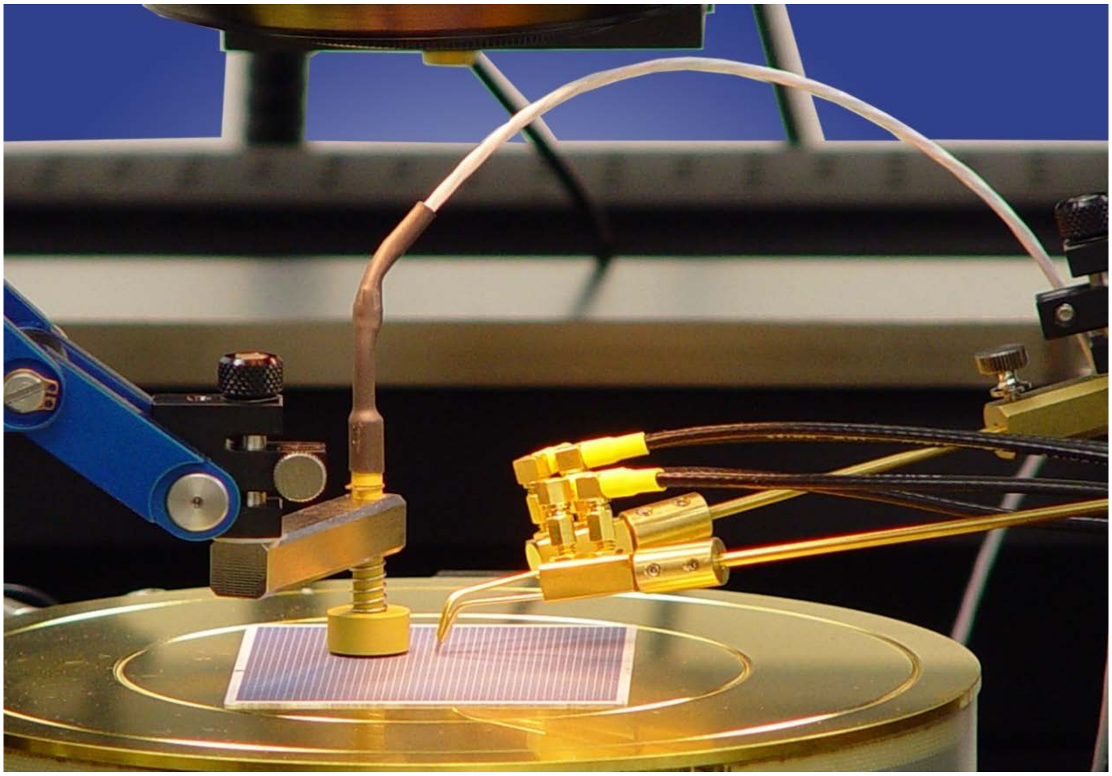




Signatone offers probe card adapters for 4.5 inch wide or 6 inch wide probe cards. The included switch can accommodate up to 10 4-wire connections or a 40 pin probe card. The test results are displayed the same as Kelvin probe testing. (wafer graph Image bottom left -probe card and adapter image bottom right)

❖ Precision Temperature Co-efficient of Resistance (TCR) with 2-Point Kelvin Probes Including an Accurate Surface Temperature Probe

This mode of the ***ΩPro*** manager permits precise TCR measurements on completed resistors. It is set up the same as a Kelvin resistance test but the accurate surface temperature probe is placed nearby. The thermal chuck heats the DUT and the temperature probe accurately senses the surface temperature. Several test sites may be defined for precision measurements. The test results will include line graphs for the first 9 test sites. The user defines the temperature range and number of temperature steps desired and settling time at temperature.



In keeping with the theory of TCR measurements, once the probes are verified to be in contact, they remain so throughout the temperature cycle and number of temperature steps desired and settling time at temperature. (image above: two kelvin probes and temperature probe)

ΩPro accurately manages the temperature cycle. The thermal chuck heats to the target temperature. After brief settling time, the surface temperature is checked. If the target temperature and the surface temperature are not within the predefined tolerance, ***ΩPro*** makes the necessary temperature adjustment until the temperature is stable and within the tolerance band (usually ±0.5°C). The resistance measurement is taken 5 times and the median value accepted and recorded. Change per degree C and TCR in PPM are calculated based as compared to the reference temperature.

The chuck then heats to the next temperature and settles. Then the next measurement is made. This continues until all temperature steps are complete. The chuck and sample are then cooled back to room temperature. If multiple test sites are programmed, the probe station moves the sample to the next site and starts the cycle again. This temperature and test cycle continue until all sites are measured.
(sample table of results – next page)

❖ Precision Temperature Co-efficient of Resistance (TCR) with 2-Point Kelvin Probes Including an Accurate Surface Temperature Probe- Continued

P	Col	Row	Target °C	Actual °C	Ω	∆/°C	TCR-PPM
1-r	17	11	25	24.9	75.063	ref	ref
1-1			50	50.3	76.127	0.041400778	551.5470766
1-2			75	75.2	77.004	0.038588469	514.0810943
1-3			100	100.1	78.019	0.039308511	523.6735894
1-4			125	124.7	78.993	0.039378758	524.6094283
2-r	18	21	25	24.90	75.059	ref	ref
2-1			50	50.10	76.127	0.04155642	553.6500651
2-2			75	75.40	77.004	0.038667992	515.1679618
2-3			100	100.20	78.019	0.039361702	524.410159
2-4			125	124.90	78.993	0.039418838	525.1713675

❖ Standard Co-efficient of Resistance Multisite Test with 2-Point Kelvin Probes or Probe Card

This mode of the ΩPro manager permits TCR measurements on completed resistors. It may be set up as a Kelvin resistance test with individual probes or a probe card. The thermal chuck heats the DUT. All test sites may be defined for measurements. The user defines the temperature range and number of temperature steps desired and settling time at temperature.

ΩPro accurately manages the temperature cycle and positioning. The thermal chuck heats to the target temperature. After predetermined settling time, the probes contact the DUT and contact is checked. If contact is not good, the chuck is raised or lowered 5 microns and contact is checked again. The resistance measurement is taken and then recorded as the reference (ref) resistance. The chuck temperature is also recorded. All of the predetermined test sites, which could be the whole wafer or substrate, are tested at this temperature.

The chuck then heats to the next temperature and settles. Moving back to the first test site, the resistance is measured once again. The resistance is compared to the reference measurement of the 1st test or (ref) value for that test site. The resistance, change per degree and TCR value are then recorded. Each site is recorded in the same way.

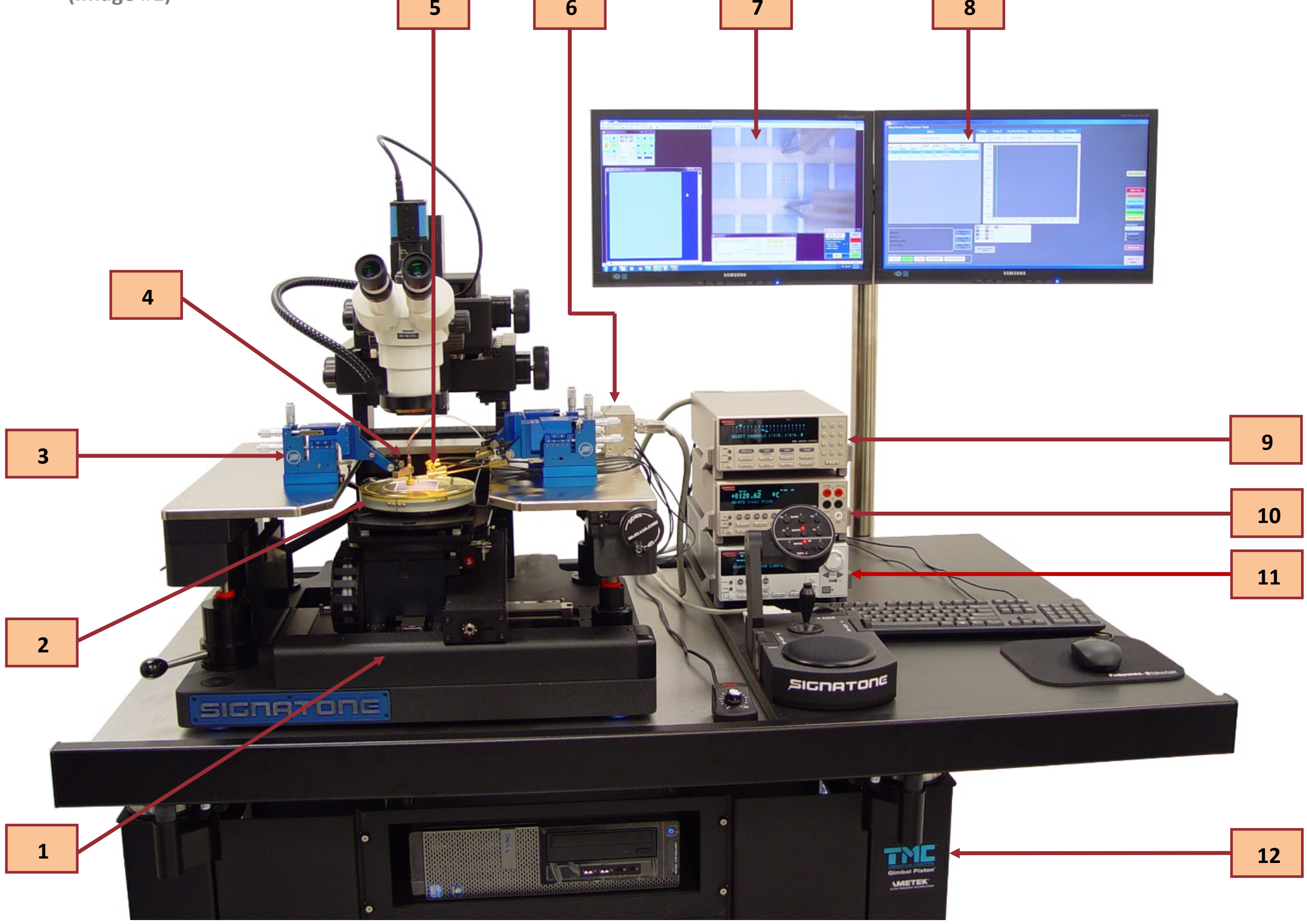
The chuck then heats to the next temperature and the testing cycle begins again. This testing continues until all preset temperatures and all test locations have measured. The following is a sample data table of a test with 15 locations and 3 target temperatures, 25°C, 75°C and 125°C.

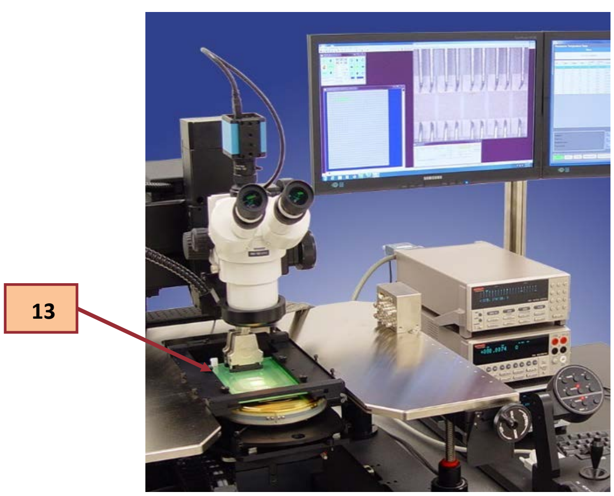
Note: *During the test a statistical table reports the progress. At the conclusion of the test, all data may be exported to a spread sheet for further analysis.* (see data table next page)

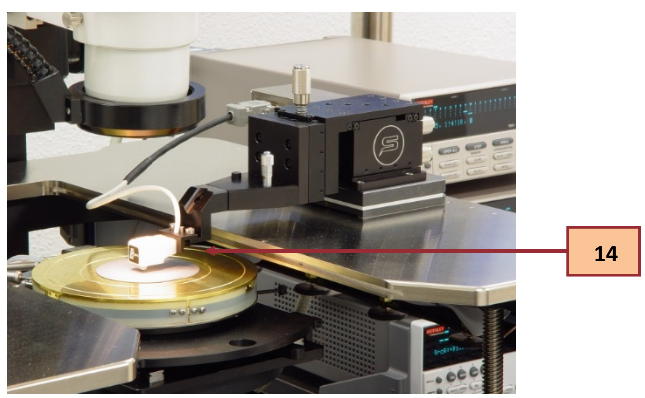
P	I	Col	Row	Target °C	Actual °C	Ω	Δ/°C	TCR-PPM
1	1	11	10	25.0	24.9	75.063	ref	ref
2	1	12	10	25.0	24.9	75.127	ref	ref
3	1	13	10	25.0	24.9	75.016	ref	ref
4	1	14	10	25.0	24.9	75.019	ref	ref
5	1	15	10	25.0	24.9	75.193	ref	ref
6	1	15	11	25.0	24.9	75.059	ref	ref
7	1	14	11	25.0	24.9	75.016	ref	ref
8	1	13	11	25.0	24.9	74.983	ref	ref
9	1	12	11	25.0	25.0	74.979	ref	ref
10	1	11	11	25.0	25.0	75.002	ref	ref
11	1	11	12	25.0	24.9	75.016	ref	ref
12	1	12	12	25.0	24.9	75.026	ref	ref
13	1	13	12	25.0	24.9	75.038	ref	ref
14	1	14	12	25.0	24.9	75.041	ref	ref
15	1	15	12	25.0	25.0	75.057	ref	ref
1	2	11	10	75.0	75.2	75.144	0.0016103	120876.80
2	2	12	10	75.0	75.2	75.204	0.0015308	115005.55
3	2	13	10	75.0	75.2	75.099	0.0016501	123783.86
4	2	14	10	75.0	75.2	75.099	0.0015905	119314.51
5	2	15	10	75.0	75.2	75.277	0.0016700	125570.82
6	2	15	11	75.0	75.2	75.137	0.0015507	116393.68
7	2	14	11	75.0	75.2	75.097	0.0016103	120801.11
8	2	13	11	75.0	75.2	75.064	0.0016103	120747.97
9	2	12	11	75.0	75.2	75.060	0.0016135	120982.05
10	2	11	11	75.0	75.2	75.081	0.0015737	118031.04
11	2	11	12	75.0	75.1	75.092	0.0015139	113570.04
12	2	12	12	75.0	75.1	75.106	0.0015936	119563.35
13	2	13	12	75.0	75.1	75.116	0.0015538	116592.91
14	2	14	12	75.0	75.1	75.120	0.0015737	118092.41
15	2	15	12	75.0	75.1	75.134	0.0015369	115357.07
1	3	11	10	125.0	124.9	75.225	0.0016298	121602.06
2	3	12	10	125.0	124.9	75.281	0.0015493	115695.58
3	3	13	10	125.0	124.9	75.182	0.0016700	124526.56
4	3	14	10	125.0	124.9	75.179	0.0016097	120030.40
5	3	15	10	125.0	124.9	75.361	0.0016901	126324.24
6	3	15	11	125.0	124.9	75.215	0.0015694	117092.04
7	3	14	11	125.0	124.9	75.178	0.0016298	121525.92
8	3	13	11	125.0	124.9	75.145	0.0016298	121472.46
9	3	12	11	125.0	124.9	75.141	0.0016298	121587.57
10	3	11	11	125.0	124.9	75.160	0.0015895	118621.78
11	3	11	12	125.0	124.9	75.168	0.0015261	114024.32
12	3	12	12	125.0	124.9	75.186	0.0016064	120041.60
13	3	13	12	125.0	124.9	75.194	0.0015663	117059.28
14	3	14	12	125.0	124.9	75.199	0.0015863	118564.78
15	3	15	12	125.0	124.9	75.211	0.0015462	115703.48

❖ The ΩPro Test Options Incorporate a Variety of Components and Features Integrated into the Signatone Line of Semiautomatic Probe Stations. (150mm - 300mm systems available)

(Image #1)







(Image #2)

(Image #3)

❖ The ΩPro Test Options Incorporate a Variety of Components and Features Integrated into the Signatone Line of Semiautomatic Probe Stations. (Continued)

1. Semi-Automatic Probe Station with motion control SW of DUT, Microscope X-Y-Z, Thermal control, on-screen image. Allowing programed points probing on single device, 150mm, 200mm, and 300mm wafers.
2. Precision 150mm-300mm, water cooled thermal chucks. Range 15˚C to 150˚C with 0.1˚ resolution.
3. SP-100M linear Micropositioner with micrometer controlled 1µ resolution placement of probes.
4. Precision RTD 4 wire thermal surface probe with .01˚resolution.
5. 2ea Kelvin probes shielded to 1mm from tip including 5µ spacing between probe tips.
6. ΩPro interface connection box (connecting from probes to meters…)
7. Monitor with navigation control software including programed positioning, wafer or test sample graph, on screen video, GP-IB interface.
8. ΩPro Test Control software. The software manages all of the tests with graphic reporting. Data may be exported to Excel.
9. Keithley 7001 Keithley 7012-S (2ea) programmable switch with 10 4 wire switching.
10. Keithley 2002 precise multimeter with 4 wire resistance or voltage readings.
11. Keithley 2601B source meter for contact sensing and precise current supply.
12. Integration vibration isolation table. The table improves TCR measurements by eliminating vibration. The shelf, dual monitor mount and controller rack create an integrated system.
13. Probe card adapter and 40 pin probe card. (ref. image #2 pg. #9)
14. Collinear 4-point probe (SP-4) mounted on SM40 micropositioner for sheet resistivity measurements. (ref. image #3 pg. #9)

❖ FOUR POINT PROBE – SELECTION GUIDE

How do I choose the best SP4 or HT4 for my application?

SELECTING THE BEST 4 POINT PROBE HEAD FOR YOUR APPLICATION

Choosing the right probe head is a matter of selecting the best spring pressure, probe tip radius, material and probe tip spacing for your application. The following is a guide for making the best selection; however, experience has shown best results are achieved by using guidelines to select the initial probe head, then experimenting with different spring pressures or materials to match the characteristics of your application.

Spring Pressure: The spring pressure is the pressure used to force each individual probe tip onto the sample surface to make electrical or ohmic contact. Lucas Signatone offers 45 gram, 85 gram and 180 gram spring pressures for standard probe heads (SP4 series) for testing below temperatures of 90 degrees C. Probe heads for use at higher temperatures (the HT4 series) have 180 gram spring pressures. The physical characteristics of the sample determine the correct spring pressure as follows:

A. For easily contacted films such as metal films or soft films such as conductive polymers or very thin films, start with the lowest spring pressure that gives satisfactory contact, usually 45 grams.

B. For difficult to contact samples such as high resistivity silicon or similar materials which naturally form a nonconductive layer when exposed to an air ambient, start with the high spring pressure of 180 grams. Note: Nonconductive layers may form when samples experience high temperatures; therefore, HT4 high temperature probes use 180 gram spring pressures.

C. For intermediate or unknown films start with an 85 gram spring pressure probe.

Probe Tip Radius: Lucas Signatone probe tips are micro-machined to have the shape of a section of a sphere at the tip. 1.6 mil, 5 mil, and 10 mil tip radii are available. Generally the large tip radius probes are more robust, but it is more difficult to make good electrical contact with these probes. Use the following guide for the selection of tip radius:

A. For easily contacted films and thin films start with a 5 mil tip radius.

B. For very thin films start with a 10 mil probe tip radius.

C. All other applications start with the standard 1.6 mil probe tip radius.

Probe Tip Material: Signatone offers 4-point probes with tips of either Tungsten Carbide or Osmium. Tungsten Carbide is a crystalline material that is very hard and can be broken along the crystal boundaries with horizontal motion of the probe. Osmium is an amorphous material and is also hard, but is more forgiving to small horizontal motion. It is believed that Osmium will give longer performance or more touch downs than Tungsten carbide, but it is slightly more expensive.

FOUR POINT PROBE – SELECTION GUIDE

Also, Osmium has the physical characteristic (work function) such that it can make better contact with some exotic materials. The following is suggested:

A. For laboratory and low volume usage start with Tungsten Carbide.

B. For production environment probing or contacting many points on the sample consider Osmium. Also, consider trying Osmium to improve contact.

Probe Spacing: The probes have a constant spacing, S, between each of the 4 tips. Lucas Signatone products use software with correction algorithms allowing for probing near the edge of the sample (to within a proximity of 4 x S) with 1% accuracy. Generally larger probe tip spacings give better results. Please use the following guide.

A. For samples with geometry greater than 0.5 inch in diameter use 0.0625 inch (62.5 mils) spacing.
B. For smaller samples or for probing closer than 0.25 inch to the edge use 0.040 (1mm or 40 mils) spacing.

$$$ SP4 / HT4 Pricing $$$

For pricing, please configure the part number by using the above information, then send us an e-mail at: Sales@Signatone.com

- **How do I clean the tips of my SP4?**

  Regarding the SP4 there is really no sure way to clean the tips. We certainly discourage the use of any chemicals, solvents or touching the tips with a cloth in attempt to wipe them clean. The only method that we have used is compressing the tips 20-50 times on a ceramic surface but there is no specification for the outcome of this process or guarantee that this will clean the tips, as in most cases this does not work. If there is visible debris on the tips you can try using high pressure air to blow away the debris. The SP4 is disposable and priced to be easily replaced and most models are on the shelf for immediate shipment ARO.

❖ FOUR POINT PROBE – SELECTION GUIDE

The SP4 probe head is designed for use with Signatone and other resistivity probing systems for the measurement of thin films and materials.
The SP4 head has several configurations parameters permitting users to define the probe head best for their application.

➢ Spacing Between Tips

0.0625 inches (62)
0.050 inches (50)
0.040 inches (40)

➢ *Pressure On Each Tip*

45 grams (045)
85 grams (085)
180 grams (180)

➢ *Probe Tip Material*

Osmium (0)
Tungsten Carbide (T)

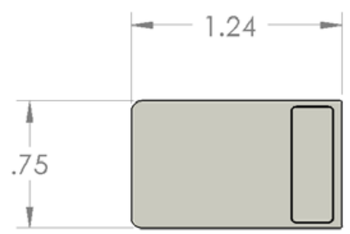
➢ *Tip Radius*

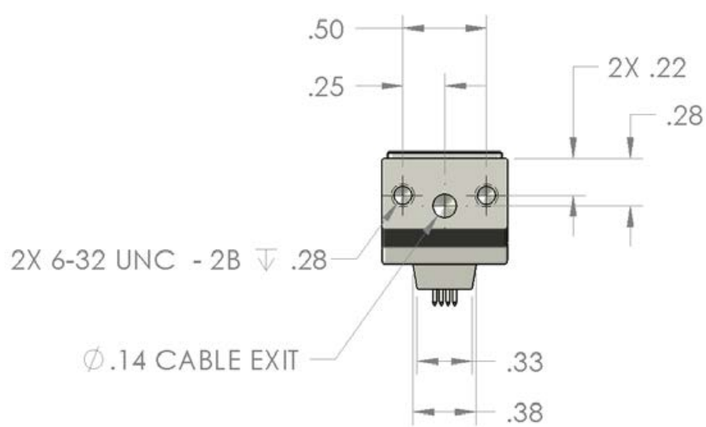
0.0016 inches [1.6mil] (R)
0.005 inches [5 mil] (F)
0.010 inches [10 mil] (B)

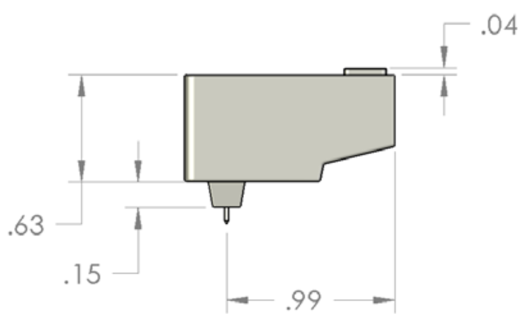
❖ *Electrical Connection Options*

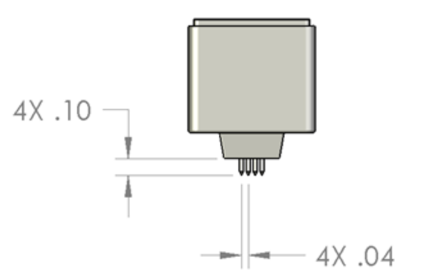
Flying lead termination, 15" wire	(S)
9 pin D sub with 15" wire	(Y)
9 pin D sub with 6" wire	(Q)
4 36" wires with Banana Plugs	(J) *
4 36" coax wires with BNC	(N)*
2 36" coax wires with BNC	(C)*
4 36" Triax wire with TRX (HT4)	(X)*
2 8" Triax wire with TRX (HT4)	(D)*

* for direct connection to various meters









FOUR POINT PROBE – MODEL MAKER

Standard Head (Delrin)

SP4- [ ][ ][ ][ ][ ][ ][ ][ ]

- S = Standard, flying lead termination
- Y = 15" wire, 9 pin D sub, for Pro4/S-302
- Q = 6" wire, 9 pin D sub, for QuadPro 2
- J = 36" wire with (4) Banana Plugs
- N = 36" Coaxial wire with 4 BNC

- R = 1.6 mil radius tip
- F = 5 mil radius tip
- B = 10 mil radius tip

- T = Tungsten Carbide
- O = Osmium

- 045 = 45 gram spring pressure
- 085 = 85 gram spring pressure
- 180 = 180 gram spring pressure

- 40 = 40 mil spacing between tips
- 50 = 50 mil spacing between tips
- 62 = 62.5 mil spacing between tips

SP4-62085TRY

Sample Part Numbers:

HT4-62180ORY

High Temperature or High Resistance Head (Macor)

HT4 -
HR4

[ ][ ][1][8][0][ ][ ][ ]

- S = Standard, flying lead termination
- Y = 15" wire, 9 pin D sub, for Pro4/S-302
- Q = 6" wire, 9 pin D sub, for QuadPro 2
- J = 36" wire with (4) Banana Plugs
- N = 36" Coaxial wire with 4 BNC connectors
- C = 36" Coaxial wire with 2 BNC connectors

- R = 1.6 mil radius tip
- F = 5 mil radius tip
- B = 10 mil radius tip

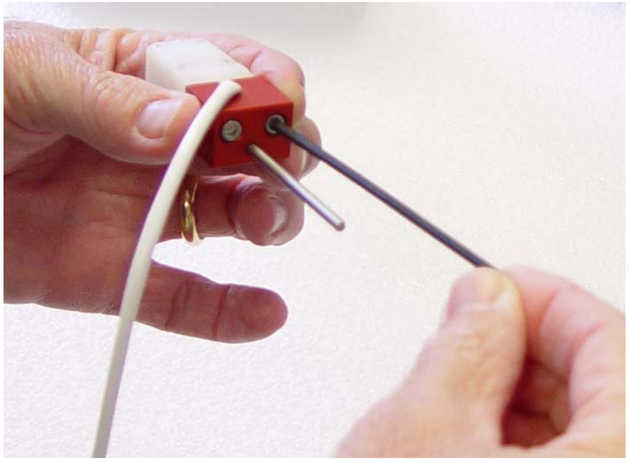
- T = Tungsten Carbide
- O = Osmium

- 180 = 180 gram spring pressure

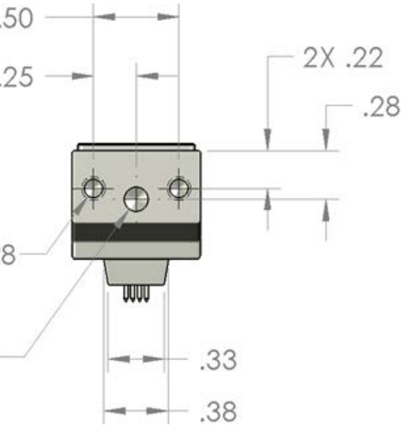
- 50 = 50 mil spacing between tips
- 62 = 62.5 mil spacing between tips

❖ FOUR POINT PROBE – MOUNTING OPTIONS

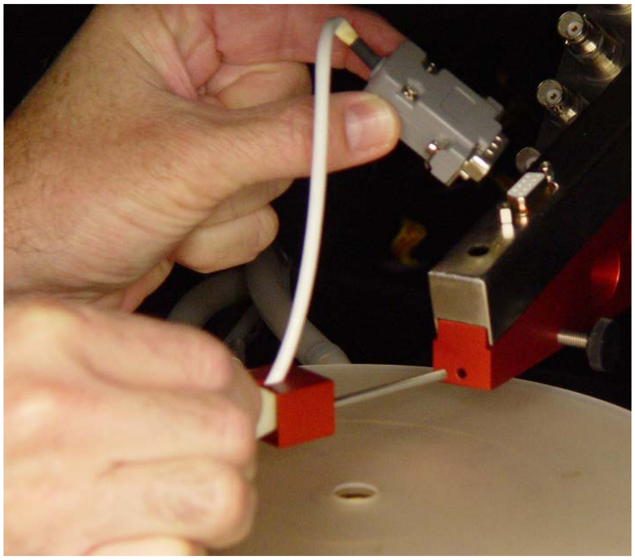
L-4PQM Quick Mounting Block
Use the L-4PQM to mount the SP4 and HT4 probe heads to any late model Lucas / Signatone Corp. resistivity test stand.



Back View
Mounting Holes



Use these dimensions to create your own mounting device.



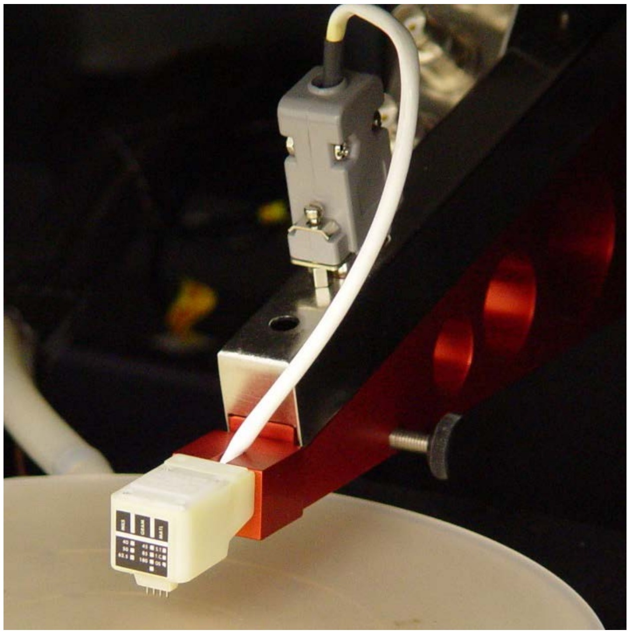


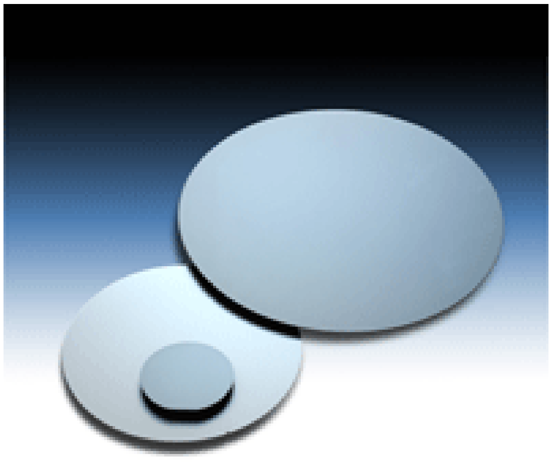
Photo: L-4PQM quick mounting block, holding SP4-62085TRQ mounted to our QuadProII S-A8 resistivity test station

VLSI CALIBRATION STANDARDS (NIST TRACEABLE)

- Resistivity Standards (RS) span 4 decades and are designed for resistance calibration of contact resistivity measuring instruments. The resistance calibration standard is created by sawing a doped single crystalline ingot into wafers, lapping and chemically cleaning them to VLSI Standards' specifications.

- The resistance calibration standards are bare silicon wafers available in 76.3mm, 200mm, and 300mm sizes. The silicon is p-type (Boron) doped to nominal resistivity values, from 0.002 ohm.cm to 3 ohm.cm as available on the 3" model. For enhanced resistance calibration and measurement standard on contact probes, the wafers are lapped and chemically polished. The increased surface roughness allows cleaner penetration through the native oxide layer and better contact.

- Each wafer is certified at its center and traceable for accuracy. Certificates of Calibration are provided with each resistance calibration standard and report the resistivity, sheet resistance and thickness calibration and measurement values with calculated uncertainties.



The Resistivity Standard, available in three wafer sizes, 76.2mm, 200mm & 300mm (upon request)

Wafer Size	Resistivity [Ohm.cm]	Sheet resistance [Ohms/Sq.]	Thickness	Signatone Part Number
76.2 mm	0.002	0.04	508 µm	**SRS3-0.002**
76.2 mm	0.008	0.16	508 µm	**SRS3-0.008**
76.2 mm	0.01	0.2	508 µm	**SRS3-0.01**
76.2 mm	0.03	0.6	508 µm	**SRS3-0.03**
76.2 mm	0.1	2	508 µm	**SRS3-0.1**
76.2 mm	0.3	6	508 µm	**SRS3-0.3**
76.2 mm	0.9	18	508 µm	**SRS3-0.9**
76.2 mm	3	59	508 µm	**SRS3-3**
76.2 mm	30	591	508 µm	**SRS3-30**
200 mm	0.01	0.14	710 µm	**SRS8-0.01**
200 mm	0.03	0.42	710 µm	**SRS8-0.03**
200 mm	0.1	1.4	710 µm	**SRS8-0.1**
200 mm	0.3	4.2	710 µm	**SRS8-0.3**
200 mm	1	14	710 µm	**SRS8-1**
200 mm	3	42	710 µm	**SRS8-3**
200 mm	10	141	710 µm	**SRS8-10**
200 mm	30	423	710 µm	**SRS8-30**
300 mm upon request				

IMPORTANT!

Calibration methods using Signatone's RS test software included with our Pro4, QuadProII and ΩPro test systems are highly repeatable when used with these high-quality materials. When a VLSI, NIST traceable standard is used, the measurements may be set to correlate with the standard. Calibration should be done weekly or after changing probe heads. When performing calibration measurements with a 4-point-probe instrument, you must ensure that the probes and the silicon make solid, repeatable contact. Poor contact is revealed by a high standard deviation of multiple measurements taken from the same area or in some cases, zero-voltage readings.

Note: Typical delivery lead times for these wafers is 6-10 weeks and varies per product.

❖ Four Point Probe Theory

Resistivity, ***Rho***, is a particularly important semiconductor parameter because it can be related directly to the impurity content of a sample; the four-point probe is the apparatus typically used to determine bulk Resistivity.

The mobility of the carriers depends upon temperature, crystal defect density, and ALL impurities present. Hall Effect Measurements can determine the mobility of the carriers in a given sample to allow for more accurate dopant concentration measurements, but Hall measurements are usually destructive to the sample.

The four-point probe contains four thin collinearly placed tungsten wire probes which are made to contact the sample under test. Current ***I*** is made to flow between the outer probes, and voltage ***V*** is measured between the two inner probes, ideally without drawing any current. If the sample is of semi-infinite volume and if the inter-probe spacing is ***s1*** = ***s2*** = ***s3*** = ***s***, then it can be shown that the Resistivity of the semi-infinite volume is given by:

Rhoo = (Pi s) V/I (1)

The subscription in the preceding equation indicates the measured value of the Resistivity and is equal to the actual value, ***Rho***, only if the sample is of semi-infinite volume. Practical samples, of course, are of finite size. Hence, in general, ***Rho*** ! = ***Rhoo***. Correction factors for six different boundary configurations have been derived by Valdes (1). These show that in general, if ***l***, the distance from any probe to the nearest boundary, is at least 5s, no correction is required. For the cases when the sample thickness is 5s, we can compute the true Resistivity from:

Rho = a 2 Pi s V/I = Rhoo (2)

Where ***a*** is the thickness correction factor which is plotted (on page 3). From an examination of the plot we see that for values of ***t/s >= 5*** times the probe spacing, no correction factor is needed. Typical probe spacings are 25-60 mils and the wafers used in most cases are only 10-20 mils, so unfortunately, we cannot ignore the correction factor. Looking again at the plot, however, we see that the curve is a straight line for values of ***t/s <=0.5***. Since it is a log-log plot the equation for the line must be of the form:

a=K (t/s)^m (3)

where ***K*** is the value of ***a*** at ***(t/s) = 1***, and ***m*** is the slope. Inspection of the plot shows that in this case ***m = 1***. ***K*** is determined to be 0.72 by extrapolating the linear region up to the value at ***(t/s) – 1***. (The exact value can be shown to be ***1/(2 ln 2)***.) Hence for slices equal to or less than one half the probe spacing ***a = 0.72 t/s***.

When substituted into the basic equation we get:

Rho = a 2 Pi s V/I = 4.53 t V/I, (t/s) <= 0.5 (4)

All samples we will be using in the lab satisfy the one-half relationship so we can use the above formula to determine ***Rho***. We will perform Resistivity measurements on the starting material for each experiment. The value of ***r*** obtained will be referred to as the bulk Resistivity, and the units are Ohm-cm.

the end-to-end resistance of a rectangular sample. From the familiar resistance formula:

❖ Four Point Probe Theory continued:

Rs = Rho/t = 4.53 V/I for ***t/s <= 0.5*** (5)

which we refer to as sheet resistance. When the thickness ***t*** is very small, as would be the case for a diffused layer, this is the preferred measurement quantity. Note that ***Rs*** is independent of any geometrical dimension and is therefore a function of the material alone. The significance of the sheet resistance can be more easily seen if we refer to the end-to-end resistance of a rectangular sample. From the familiar resistance formula:

R = Rho l/wt (6)

we see that if ***w = l*** (a square) we get:

R = Rho/t = Rs

Therefore, ***Rs*** may be interpreted as the resistance of a square sample, and for this reason the units of ***Rs*** are taken to be ohms-per-square or ohm/sq. Dimensionally this is the same as ohms but this notation serves as a convenient reminder of the geometrical significance of sheet resistance.

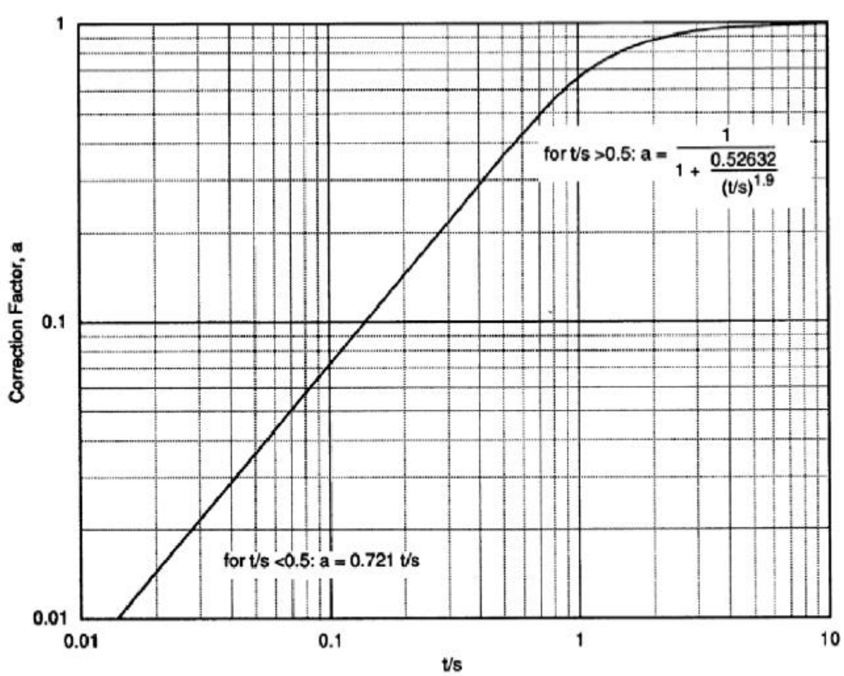
So far in our discussion of Resistivity measurements we have assumed that the size of our sample is large compared to the probe spacing so that edge effects could be ignored. This is usually the case for the bulk Resistivity measurement. However, our sheet resistance measurements will be made on a "test area" on our wafer and the test area dimensions (nominally 2.9 by 5.8mm) are not that large compared to the probe spacing (25 mils). In order to get accurate measurements, we will need to correct for the edge effects. In general, then:

Rs = C V/I (7)

where ***C*** is the correction factor. Note that for ***d/s > 40, C = 4.53***, the value we had as the multiplier in Equation (5).

References: Valdes, L.G., Proc. I.R.E., 42,pp. 420-427 (February 1954) Smits, F. M., "Measurements of Sheet Resistivity with the Four Point Probe," BSTJ, 37, p. 371 (1958).

Same as BT Monograph, 3894, Part 2 Courtesy of: ECE344: Theory and Fabrication of Integrated Circuits Electrical and Computer Engineering University of Illinois – Urbana/Champaign



❖ WARRANTY

- Standard Warranty 12 months *
- For Extended Warranty and Service Contracts : Contact Signatone Corp. for more information

**** See Signatone Corporate Terms and Conditions of Sale for further details.***

Ask us about our family of Resistivity Test Equipment
Key features included in all Signatone systems include *Autorange* and *dual configuration*. *Autorange* automatically finds the ideal current setting to meet the parameters of the standard for measuring. At the first test site, the software controls the current source to step through a number of settings until the measured voltage is in target range as defined by the standard. This current is then used for all subsequent measurements of the sample. *Dual configuration* mode applies the standard ## to automatically correct for geometric errors caused by probe spacing and/or edge proximity improving overall accuracy.

Signatone offers Family of Products- The QuadPro 2 for R&D and the Pro4 for basic, manual measurements, ΩPro - Resistance Testing System. Each family has a variety of options and configurations. With over 60 configurations to choose from, Signatone has the product that will meet your application.

QuadPro2 Resistivity Test System

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