Lucas / Signatone Corporation – Since 1968

393-J Tomkins Court • Gilroy, California 95020-3632 • USA

Tel: 408-848-2851 • Fax: 408-848-5763

e-mail: sales@signatone.com web: www.signatone.com

Lucas/Signatone Four Point Probe Part Numbers

Standard Head (Delrin)

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

S = Standard, flying lead termination
Y = 15" wire, 9 pin D sub, for Pro4
Q = 6" wire, 9 pin D sub, for QuadProII
J = 36" wire with 4 banana jacks
N = 36" Coaxial wire with 4 BNC connectors
C = 36" Coaxial wire with 2 BNC connectors
other connectors available

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

Sample Part Numbers:

SP4-62085TRY

HT4-50180ORY

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
Q = 6" wire, 9 pin D sub, for QuadProII
J = 36" wire with 4 banana jacks
N = 36" Coaxial wire with 4 BNC connectors
C = 36" Coaxial wire with 2 BNC connectors
X = 36" Triax wire with 4 TRX connectors
D = 8" Triax wire with 2 TRX connectors

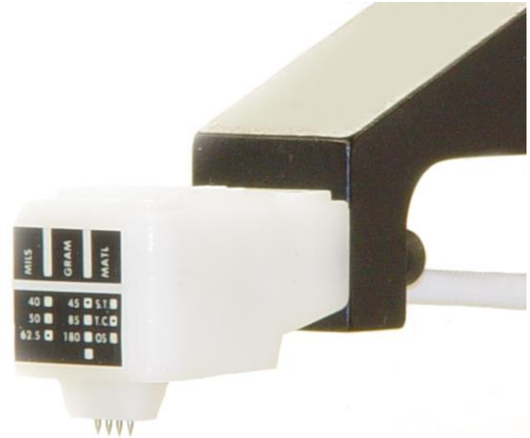
R = 1.6 mil radius tip
F = 5 mil radius tip
B = 10 mil radius tip

T = Tungsten Carbide
O = Osmium

180 = 180 gram spring pressure

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

SP4 Four Point Probe Head



The SP4 probe head is designed for use with Lucas/Signatone and other resistivity probing systems for the measurement of thin films and materials. The SP4 head has several configuration 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 probe 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 option

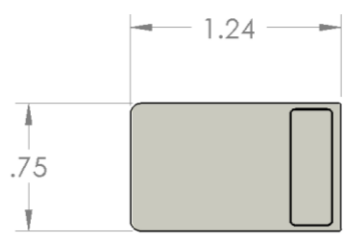
Flying lead termination, 15” wire	(S)
9 pin D sub with 15” wire	(Y)
9 pin D sub with 6” wire	(Q)
4 36” wires with Banana Jacks	(J)*
4 36” coax wires with BNC	(N)*
2 36” coax wires with BNC	(C)*
4 36” Triax wire with TRX (HT4)	(X)*
2 8” Triax wire with TRX (HT4)	(D)*

* for direct connection to various meters

Ordering Model Maker Information
SP4-[Spacing][Pressure][Material][Radius][Termination]

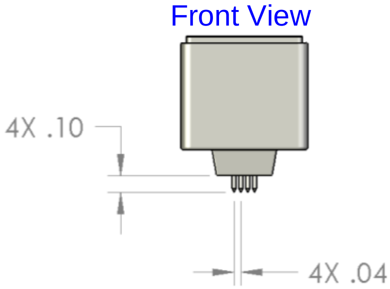
Sample Part Number: SP4-40085TRS

Dimensions (inches)

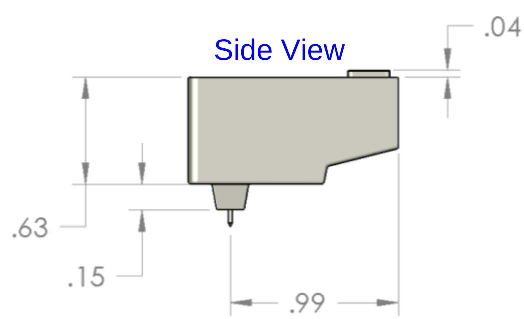


Top View

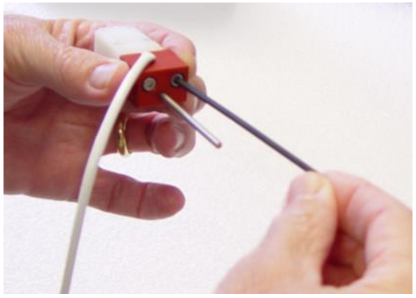
Front View

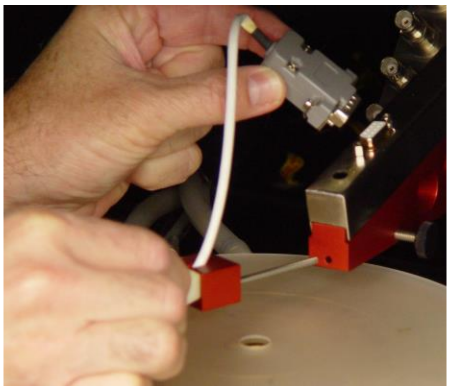


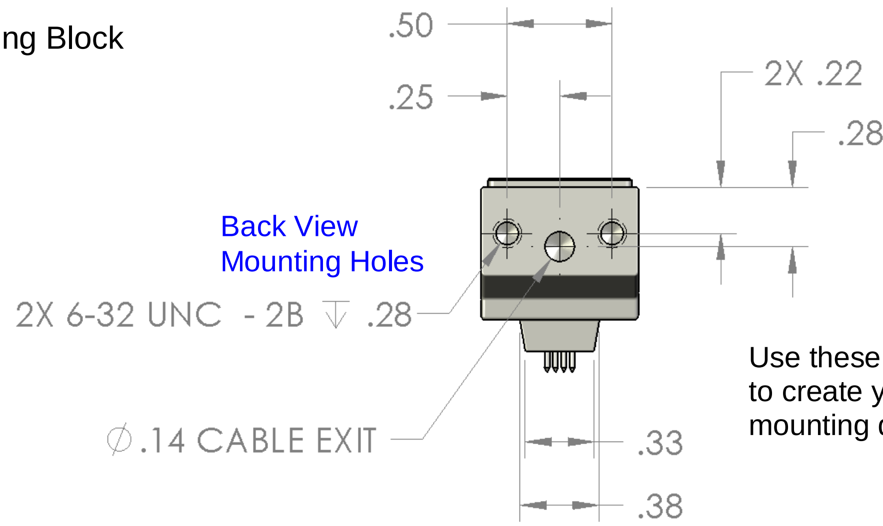
Side View



Mounting Options
L-4PQM Quick Mounting Block







Use these dimensions to create your own mounting device.

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

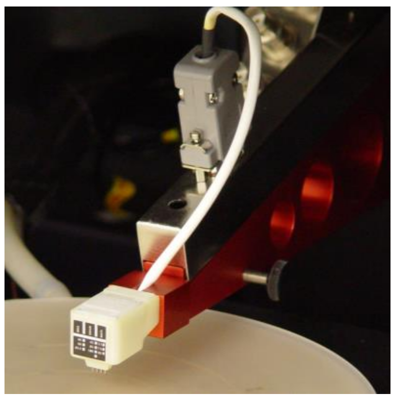


Photo: L-4PQM quick mounting block, holding SP4-62085TRQ mounted to our QuadProII S-A8 resistivity test station.

FAQ: 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: Lucas 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. 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.

http://www.fourpointprobe.com/applications/resistivity.asp

$$$ SP4 / HT4 Pricing $$$

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

FAQ: 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.

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 2 product families- The QuadProII for R&D and the Pro4 for basic, manual measurements. 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.

QuadProII and QuadProII with TCR

A thermal chuck may be added to the QuadProII to allow mapping a sample at various temperatures. With the thermal chuck option, Temperature Coefficient of Resistance characteristics of a sample can be measured. The TCR software manages the whole tests and reports TCR in ppm also displaying a graph. A variety of thermal chuck options and temperature ranges are available and fully integrated into the system for automated test management.

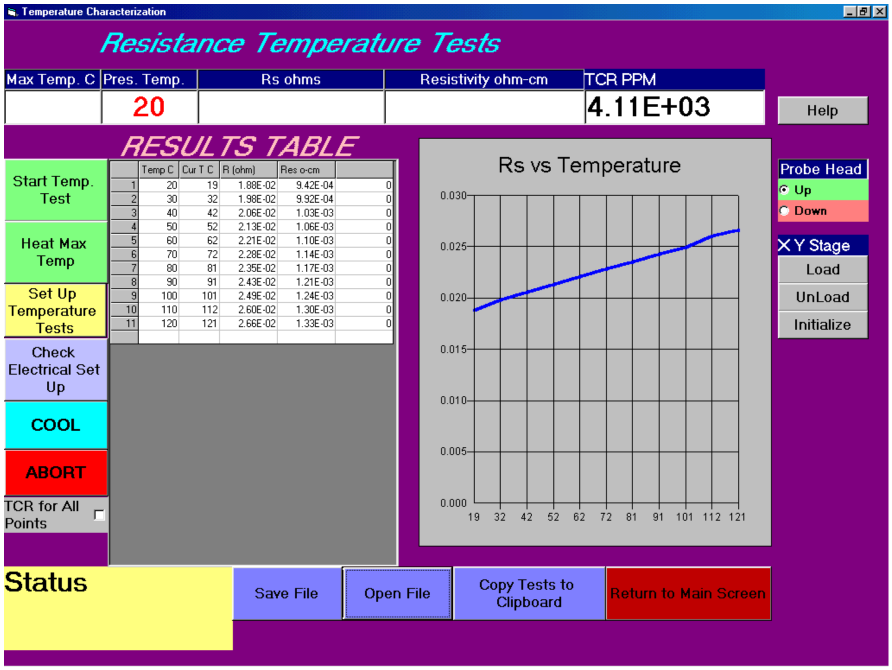
Photo: QuadProII SA8-00

QuadProII model maker

QuadProII-[range][type][size][TCR option][p and n typing][power conditioner]

E	Economic range: 1mΩ to 800KΩ
S	Standard range: 1mΩ to 1.2MΩ
C	Conductive range: 1µΩ to 1.2MΩ
M	Recommended range: 1µΩ to 100MΩ
G	High resistance range: 1mΩ to 10GΩ
F	Full range: 1µΩ to 10GΩ, includes
B	Manual bench top configuration, stand with position indication for manual mapping
L	Bench top stand (303) holds up to 300mm Devices
A	Semiautomatic stand alone configuration, automatic positioning and mapping
R	Integrated test package with Signatone semiauto probe station
0	No chuck size specified for the purpose of using option "R" above
S	Square 6 inch / 150mm chuck for solar cells
8	For samples 10mm - 200mm in diameter
C	For samples 10mm - 300mm in diameter
0	No TCR option
T	Standard TCR option: range of 10°C to 300°C, 1°C resolution
U	Low range, precision TCR option: range of 10°C to 125°C, 0.1°C resolution
-P	p/n type testing module
-0	No p/n type testing module
7	Power Conditioner for use in Russia, Turkey, Japan and China

Example of most popular QuadProII model configuration: **QuadProII-MACT-07**



Pro4

The Pro4 series is designed to be the basic tool for quick sheet resistance & resistivity measurements of a variety of materials in the lab. Signatone's popular 302 stand serves as the base station to hold the probe and trigger the test. A Keithley source meter is used for measuring the sample. All are driven through the Pro4 software communicating with the Keithley source meter. Users may define pass/fail limits for testing by operators for a quick verification of the film is within specification. The tabular data may be printed or exported to a spread sheet.

Pro4 model maker

Pro4-[size and stand type][source meter][computer][p/n typing]

4	For samples 10-100mm 302 stand
6	For samples 10-150mm 302 stand
8	For samples 10-200mm 302 stand
L	For samples 10-300mm 303 stand
B	For samples 10-200mm 304 stand with X-Y stage positioning, recomnded for hot chucks
U	For samples 10-300mm 305 stand with
R	Integrated components for mounting on a Signatone probe station
H	NO STAND / break-out box with wired remote switch for use with S-HH4
00	Cabling for Keithley 2400 series, source meter not included
40	Keithley 2400 included- range:1mΩ to 800KΩ
41	Keithley 2410 included- range:1mΩ to 800KΩ
M0	Cabling for Keithley 2601, 2602, 2611, 2612; source meter not included
M1	Keithley 2601 included- range: 1mΩ to 100MΩ
M2	Keithley 2602 included- range: 1mΩ to 100MΩ w/dual channel (source measurement unit)
G0	Cabling for Keithley 2635 or 2636, source meter not included
G1	Keithley 2635 included- range 1mΩ to 300MΩ *(requires dark box)*
0	No computer included
N	Notebook computer included
D	Desk top computer with flat panel screen, mouse & keyboard included
R	Industrial rack computer with source meter mounted in rack, flat panel screen, keyboard & mouse.
- P	P & N Type Testing Module
blank	No P & N Type Testing Module

Example of most popular model configuration: ***Pro4-4M1NP*** *…includes Pro4 stand and software, 4” Delrin chuck, Keithley 2601, Notebook computer and the P & N type testing module.*

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.

If both sides of the Equation (4) are divided by *t* we get:

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:

1. Valdes, L.G., Proc. I.R.E., 42,pp. 420-427 (February 1954)
2. 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