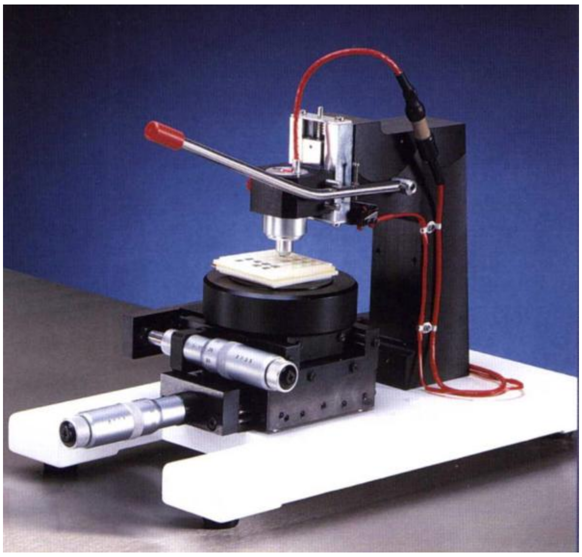
Maintenance and Use of the MICROPOSITION PROBE



Application

Measurement of resistivity of samples by the four point technique using a Jandel four point probe head
a) Where the probe needles need to be positioned very accurately on a small site
b) Where the whole sample is very small

Principal Features

- X-Y-θ stage offering 25mm x 25mm x 360° positioning
- Lever operated probe with switched current leads to prevent arcing
- Maximum sample size 76mm diameter
- Precision low maintenance vertical slide

General Construction

The latest addition to the Jandel range is the Microposition Probe. This incorporates use of a lever operated raising and lowering mechanism and an X-Y-θ stage. The sample can be retained by vacuum if necessary. It is ideal for very small samples especially when used in conjunction with a 0.500mm spacing probe. An optional probe head shroud affords the opportunity of shielding light from any sample up to 2" diameter.

Operation

There is no interlock on this manual probe, so the probe head must always be raised before the table is rotated or moved by the X-Y stage. The probe unit is supplied with a probe head in position, correctly set.

The equipment can be connected to the associated electronic measuring equipment by the 9-way plug provided (marked 4PL), wiring details are included with the plug and also attached to these notes. Raising the probe operating lever switches off the current via the micro-switch during the “lost motion” and then raises the probe head mounting slide, so that the sample can be loaded.

Adjustments

1. The operating lever should be sufficiently stiff in its functioning to hold the probe head fully raised. Adjust the socket set screw in the probe head support immediately above the operating lever shaft, clockwise makes the operation more stiff.

2. Check that when the lever is pulled fully down the micro-switch has operated. The probe needles should make contact with the wafer before the switch operates, if in doubt proceed as for:

Exchanging Probe Head

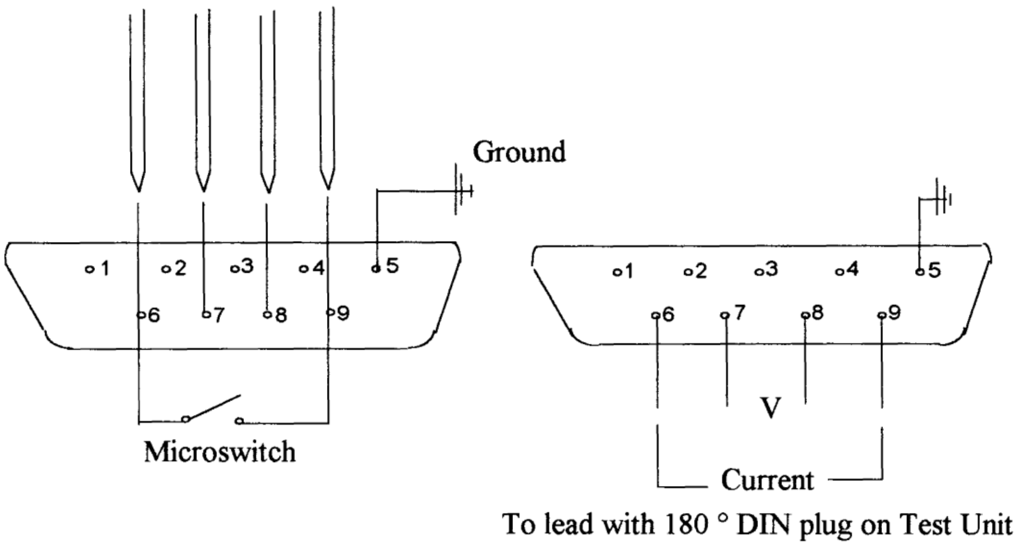
1. Remove the probe head by slackening the red clamp screw on the left hand side of the probe head mounting, lift out the probe head, unplug the lead.

2. Check the micro-switch setting by pulling down the operating lever so that the slide is fully down, observe that the micro-switch has just operated, if not, correct by adjusting the screw and locking it.

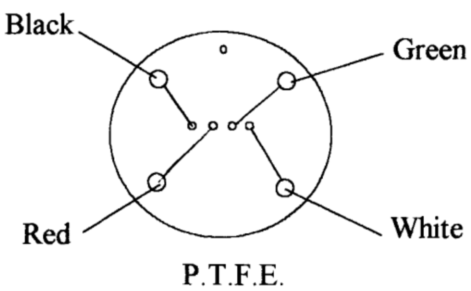
3. Fit a probe head into the mounting. Rotate the probe head so that the needles lie parallel to the front face of the mounting (use the two screws in the probe head as a guide).
Position a wafer (the thinnest wafer likely to be measured) on the table because its thickness is significant. If the thickest is used the probes will not be fully retracted when a thinner wafer is measured. Pull down the operating handle completely, and then push the probe head down on the wafer until the insulating pad lies on the wafer surface, i.e. the needles are fully compressed, then clamp the probe head firmly with the red clamp screw, do not tighten excessively. Ensure that the micro-switch has just operated. This can be observed by slackening the adjusting screw completely until the switch is obviously not operative, then screw the screw clockwise (down) until the switch clicks. Lock the screw with the hexagon nut. **RECHECK.**

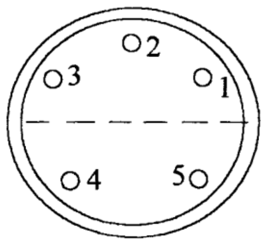
Microposition Probe Wiring Details

PLUG SOCKET



Pins in Probe Head Lemo 5-Pin on Column





P.T.F.E.	No. on 9-way	P.V.C.
White	9	Blue
Green	8	Green
Red	7	Yellow
Black	6	Red
Screen	5	Screen

Lemo	with P.V.C.	with P.T.F.E.
1	Blue	White
2	Green	Green
3	Yellow	Red
4	Red	Black
5	Screen	Screen

Choice of Probe Head

Nearly all 4-point measurements are made using a probe head which may be of various shapes and sizes, but all comprising four pointed probes spring loaded and electrically connected to the electronic equipment which supplies a constant DC measuring current and displays the measured output voltage. JANDEL probe heads offer very high precision needle spacing (±10μ) or a special execution (±5μ), checked on an interferometer microscope. The probes are precision ground tungsten carbide with 45º included angle tips and polished tip radii optically checked from 12.5 to 500 microns. The spring loading is checked electronically and can be from 10g to 250g preset. Spacings can be from 0.5mm to 1.59mm in a linear or square array. The needle guidance is by precision ruby jewel bearings at two levels.

The choice of probe head characteristics is dependent on the material to be probed. Note the following four point selection guide refers to the various possibilities, and the published ASTM Standards and recommendations can be used as a guide. Most materials can be probed with the three basic sets of characteristics viz. 1.00mm spacing, 25 micron tip radius, 100g load linear can be used to measure homogenous wafers (substrates), epitaxial layers, diffused layers, silicon on sapphire metallic films

OR

1.00mm spacing, 100 micron tip radius, 100g load linear for medium and high dose ion-implanted wafers, metallic films.

For low dose ion implants and shallow junctions it may be necessary to use tip radii between 200 and 500 microns.

Conditioning

All JANDEL probe head needles with a radius of greater than 25 microns are polished to an optical finish. In some situations the smooth finish does not furnish the best possible contact, so 'conditioning' may be necessary. This is effected by raising and lowering the mounted probe head on to a ceramic plate a number of times. This process produces both a cleansing action and creates microscopic asperities to promote good electrical contact with less noise without excessive penetration.

Sophisticated Resistivity Mapping Systems often incorporate software programmes to determine the standard deviation of a group of measurements on a representative wafer. In this way the enhancement of the probe head performance by conditioning can be studied and the appropriate programme of conditioning undertaken.

Notes on Four Point Resistivity Measuring With Jandel Equipment

General

Before attempting measurement one needs to know something of the sample or the wafer - is it silicon? (Germanium is easier to contact and measure). Metallic and other layers are also deposited on semiconductor, sapphire or ceramic wafers.

First, is the sample clean and fresh?
If the sample is old it may be etched, washed and dried which will remove oxide which can impede ohmic contact.

Secondly, is the sample homogenous i.e. is it uniformly doped or does it have a layer on its surface e.g. by epitaxy, diffusion, ion-implantation, or sputtering etc?

If the sample has a layer it must be of the opposite conductivity type to the substrate i.e. electrically insulated from the substrate. A layer of the same conductivity type cannot be measured by the four point method because the substrate offers an easier path for the current, and the measured resistivity is effectively that of the substrate.
If the layer is thin, meaning sub-micron, one must avoid puncturing the layer by excessive needle loading, by sharp or rough needle tips, or too rapid descent velocity of the probes, excessive current can also inject minority carriers.
All these effects cause some leakage into the substrate, so that the measuring current in the layer is reduced, and the resistivity measured is too low.

Limits of Measurement Capability

1. The material must be capable of being probed, i.e. the probes must be able to make ohmic contact with the material e.g. Germanium, Silicon and metals. Materials such as Gallium Arsenide cannot normally be probed unless it is doped and measured with special measuring techniques such as that in the Four Dimensions Inc. GaAs probe.

2. Very low resistivity material e.g. aluminium, gold, platinum may require the maximum current from the current source to achieve a readng on the digital voltage display.

Calculation of Resistivity

A selection of correction factors are published by various authorities, covering the modifications to be made according to the specimen size and shape being measured, we show two examples for measurement of circular samples in the centre with a linear probe of spacing 's'.

Basically, bulk resistivity (for a semi-infinite volume) = 2 x pi x s x (V/I) ohm.cm where s is the spacing of the probe in cm, I the test current, and V the measured voltage.

Sheet resistance for wafers and films R_S = 4.532 x V / I ohms per square.

Bulk resistivity for wafers and films q = R_S x t = 4.532 x V x t / I where t is the thickness in cm.

General Comments

1. Most wafers and films approximate to 'infinite sheets' at the present time, but if the thickness is greater than 5 % the probe spacing (normally 1.00mm) i.e. 5mm then the semi-infinite solid formula is within less than 1%.

2. From the other point of view a reasonable sized wafer may be measured with a four point probe using the above sheet resistance formula. Provided the wafer thickness does not exceed 0.625 of the probe spacing the calculation is within 1%.

Please see table below.

FPP Correction Factors for Sample Thickness t		**FPP Correction Factors for sample diameter d**	
t/s	**C_1 (t/s)**	**d/s**	**C_2 (d/s)**
0.3	1.0000	10	4.1712
0.4	0.9995	20	4.4364
0.5	0.9974	30	4.4892
0.6	0.9919	40	4.5080
0.7	0.9816	50	4.5167
0.8	0.9662	60	4.5215
0.9	0.9459	70	4.5244
1.0	0.9215	80	4.5262
1.2	0.8643	90	4.5275
1.4	0.8026	100	4.5284
1.6	0.7419	200	4.5314
1.8	0.6852	∞	4.5320
2.0	0.6337		

3. Remember that other geometrical effects affect the result if the wafer is not measured at the centre because the number of possible current paths is limited.

We recommend study of the following original papers:

a) Linear Array Probes

Circular wafers at centre:
1. D. E. Vaughan, Br.J. Appl. Phys., 12, 414 (1961)
2. M. A. Logan, Bell Sys. Tech. J., 40, 885 (1961)
Off centre but on radius:
3. L. J. Swartzendruber, National Bureau of Standards Technical Note 199 (1964)

Perpendicular to radius:
4. M. P. Albert and J. F. Combs, IEEE Trans. Electron Devices, ED-11, 148 (1964)
5. L. J. Swartzendruber, Solid State Electronics, 7, 413 (1964)
Rectangular sample at centre and off centre:

6. M. A. Logan, Bell Sys. Tech. J., 46, 2277 (1967)
Half cylinder:
7. E. B. Hansen, Appl. Sci. Res., 8B, 93 (1960)
Circular rod:
8. H. H. Gegenwarth, Solid State Electronics, 11, 787 (1968)
Rectangular bar:
9. A. Marcus and J. J. Oberly, IEEE Trans. Electron. Devices, ED-3, 161 (1956)

Note: All the foregoing is based on measurement using a four point linear probe, the current being passed between the outer probes and the voltage measured across the inner two probes.

b) Square Array Probes

Small slice at centre:
as 9 above
Small slice along a radius:
as 3 above
Square sample:
10. M. G. Buehler, Solid State Electronics, 10, 801 (1967)
Thick sample near boundary:
11. S. B. Catalano, IEEE Trans. Electron. Devices, ED-10, 185 (1963)
thin infinite sheet:
as 10 above

Note: Square array probes have the current passed between two adjacent probes and the voltage measured across the two opposite when used for resistivity measurement.