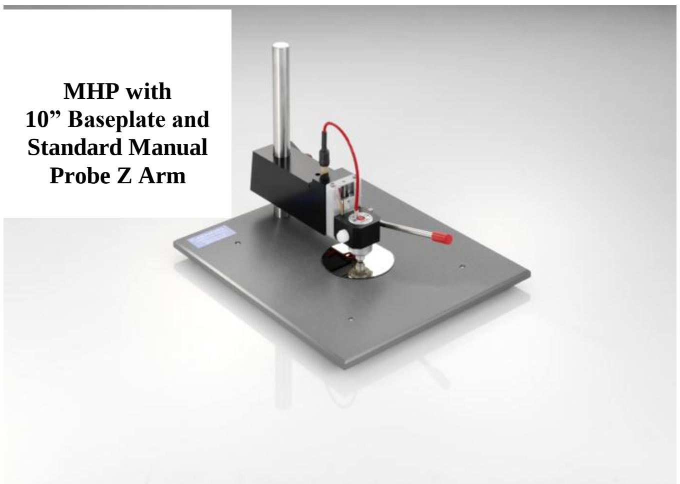
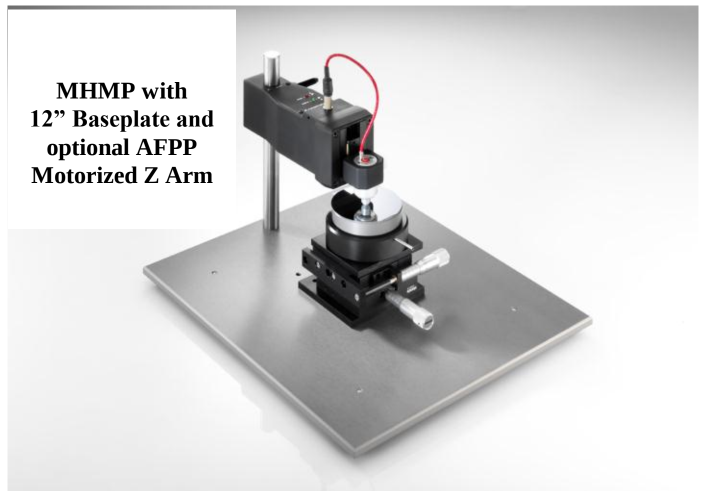
Maintenance and Use of the Jandel Engineering Ltd.

Multi Height Probe and Multi Height Microposition Probe



MHP with 10” Baseplate and Standard Manual Probe Z Arm



MHMP with 12” Baseplate and optional AFPP Motorized Z Arm

Application

Measurement of resistivity of samples by the four point technique using a Jandel four point probe head.

Principal Features

- Accomodates wafers up to 10" diameter and ingots up to 10" deep by 6" high. Width is limited only by need to support the ends. Optional 12” baseplate holds samples up to 12” x 12”. The 12” baseplate is required when used with the AFPP motoroized Z motion arm if the AFPP is to be centered on the baseplate.
- Lever operated probe with switched current leads to prevent arcing
- Simple height adjustment
- Precision low maintenance vertical slide

General Construction

The instrument comprises a hard anodised aluminium base 25cm wide, 29cm deep and 0.8cm thick. A 19mm diameter stainless steel column 20cm high screwed to the base supports the probe head raising and lowering mechanism incorporating the vertical slide, operating lever shaft, and micro-switch. The vertical slide carries the probe-head, secured by a clamp screw. The probe-head is positioned so that the micro-switch does not pass current until the probes have made contact, lost motion ensures that the current is switched off before the probes are raised.

Setting Up Instructions

- A dummy probe head is clamped in the mounting to assist in setting the height of the raising and lowering assembly - ensure its top is level with the probe head mounting block.

- Place the specimen to be measured on the base

- Slacken the clamp screw (at the rear of the R & L assembly)

- Lower the probe head slide fully until the microswitch operates

- Lower the whole assembly by sliding it down the column until the tip of the dummy probe head touches the specimen. Tighten the rear clamp hard. Raise the probe head slide with the long lever and unclamp the dummy probe head by the red thumb screw on the left of the head mounting block

- Insert the JANDEL cylindrical probe head so that its top is level with the top of the mounting block just as the dummy probe head

- Attach the connecting lead marked 4PL to the 9-way plug at the rear of the assembly and secure it by the locking screws

- Plug the lead into the RM3-AR .T.U. at the rear

The MULTI HEIGHT PROBE is now ready for use. Remember that different specimen heights require resetting the assembly on the column, use the dummy probe head as before to avoid the risk of breaking the probe head needles.

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.

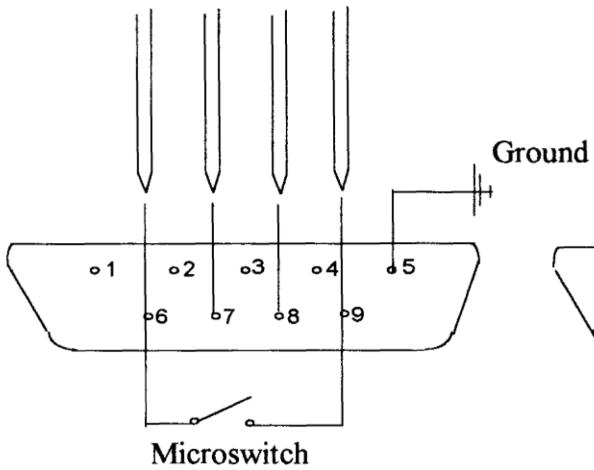
2. Check the micro-switch setting by pulling down the operating lever so that the slide is fully down, observe that the micro-switch has just operated, if not, correct by adjusting the screw and locking it.

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). Proceed as described in setting up instructions.

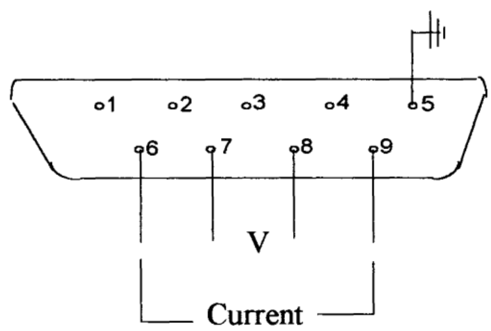
Multiheight Probe Wiring Details

(see diagram next page)

PLUG

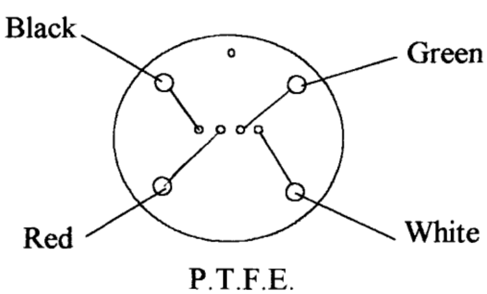


SOCKET

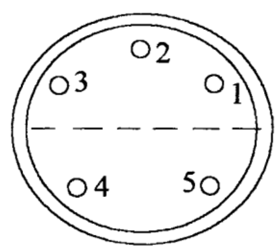


To lead with 180 ° DIN plug on Test Unit

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% of 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.