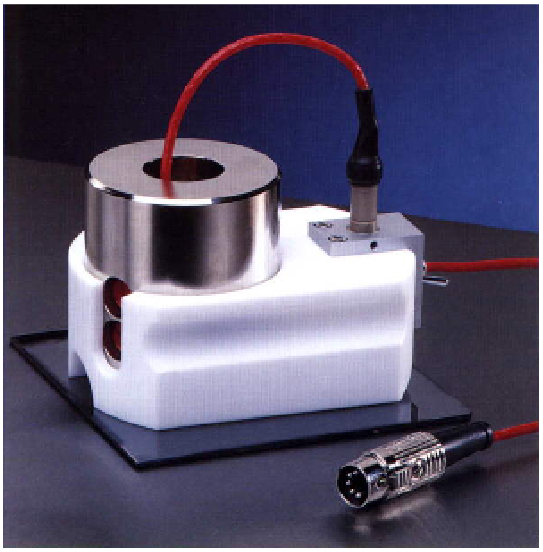
Hand Applied Probe

(Incorporating a 4-point cylindrical probe)



PRINCIPAL FEATURES

- ✓ Teflon body
- ✓ 4-point cylindrical probe head can be easily changed
- ✓ shorting switch to prevent sparking
- ✓ easy placement by hand

APPLICATION

1. Measurement of bulk resistivity of large ingots unable to be mounted on a normal probe station.
2. Measurement of sheet resistivity of very large wafers or deposited films on large substrates.

GENERAL DESCRIPTION

The unit comprises a Teflon body containing a cylindrical brass mass sufficient to cause the probe needles of the 4-point head (loaded up to 200g each) to be completely retracted. The Teflon body incorporates a lead about 1m long to connect to the associated electronic measuring equipment. There is a toggle switch marked 'S' (shorted) and 'R' (read) which permits the probe head to be raised off the sample, or placed on it, with no sparking. The current source is shorted at position 'S' on the hand applied probe independent of the FWD, SBY, REV switch on the power supply. Of course, when the probe head is in position the FWD/REV positions can be used in the usual way to observe forward and reverse readings.

OPERATION

The probe head should be installed so that its acrylic insulating pad (adjacent to the projecting probe needles) lies in the same plane as the lower Teflon surface. Rotate the probe head so that its needles lie at right angles to the longitudinal axis of the Teflon holder, and clamp firmly with the two red screws. To present the probe head to the specimen it is best to make contact with the rear end of the block (where the switch is) and rock the block downwards so that it effectively pivots about the rear. In this way the probe points will retract without scrubbing on the specimen surface. The actual position of the probe points can be seen via the cutaway.

SPECIFICATIONS

Dimensions:	Length:	approximately 125 mm front to rear
	Width:	75 mm
	Height:	approximately 80 mm (Wire from probe head projects additional 30mm upwards)
	Weight:	approximately 1.6kg
Downward force:	approximately 1.1 Kg (sufficient to retract 4 needles with 200g load easily)	
Material:	Virgin Teflon body with nickel plated brass weight to accept Jandel cylindrical probe Ø 25.4mm	
Electrical	4-point probe with Teflon screened lead and Lemo 5-way plug and socket. Toggle shorting	

Maintenance and Use of the Jandel Probe

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.