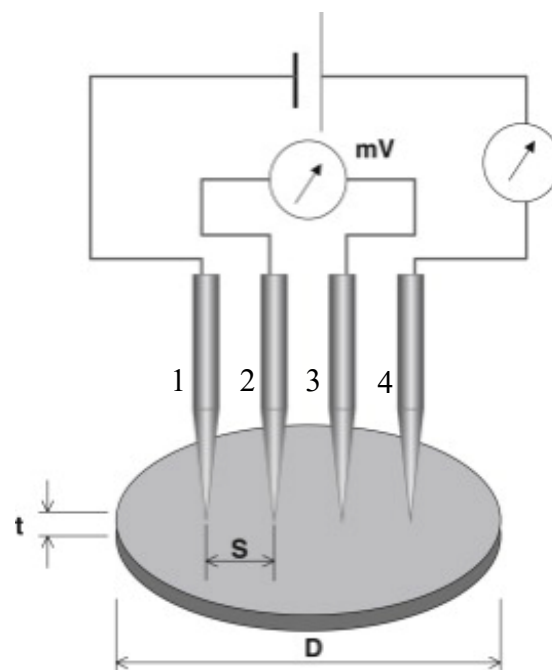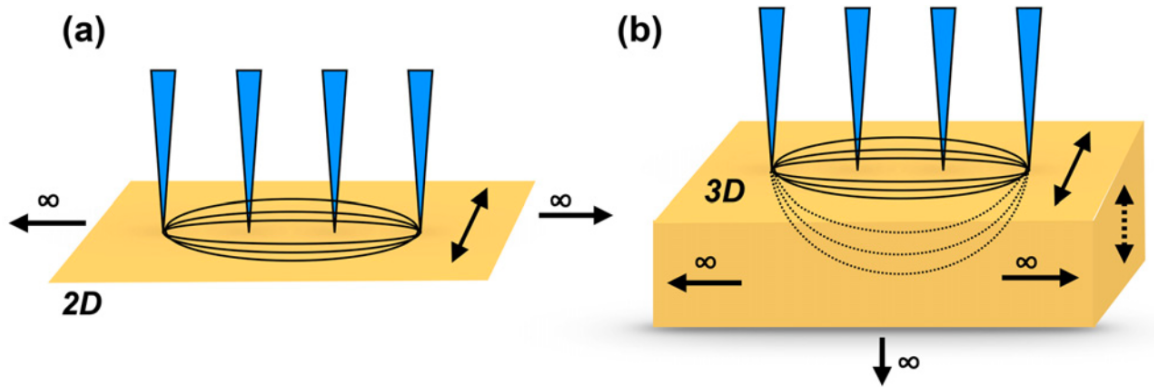# 4 Point Probe resistivity theory

The 4 points are aligned with a constant spacing (s). In the classical measurement, Current (I) passes through the two extreme probes (1 and 4) and voltage (V) is measured between the two central probes (2 and 3).

(a) 2D

(b) 3D

Above are the diagrams of the flow lines.

The current flowing and the voltage measured are related to Rs in accordance with the Maxwell's field equations.

In the ideal case with :

1. The sample size is > 10 x the spacing of the probes (s)

2. The thickness is < 0.4 x the spacing of the probes (s)

4. The measurement temperature is 23°C

5. The probe spacing (s) is constant

In these conditions the current and voltage are related to the average resistance by a special solution to the equations.

$$Rs = \pi/\ln(2) \times V/I = 4.532 \times V/I \text{ (ohms/sq)}$$

AND

$$\text{Resistivity} = Rs \times t \text{ (ohm.cm)}$$

Therefore, the resistivity may be calculated from the measurements of V and I and film thickness (t).

Conversely if the resistivity of the material is known, the thickness may be calculated from:

**t = resistivity / Rs (cm)**

Correction Factors :

As a practical consideration the conditions for this particular solution are not usually in force.

However, the four-point probe technology is useful for process control.

If an accuracy approaching 0.5% is desired, geometry and thickness correction factors can be applied as follow :

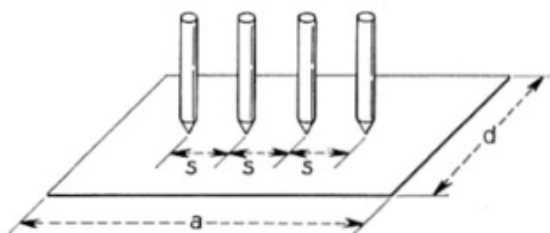**Rs = 4.532 x Geometry CF x Thickness CF x (V/I)**

Case of a wafer (or circular sample) :
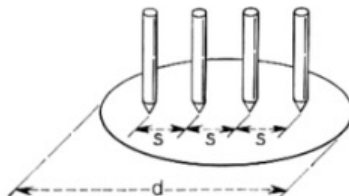
Geometry CF :

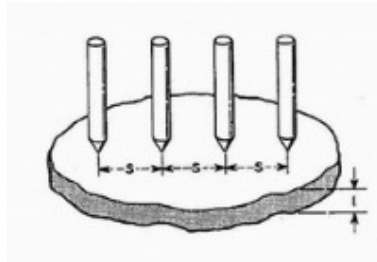| d/s	Correction factor (CF)
3	0.5
4	0.646209
5	0.741882
7.5	0.866526
10	0.920312
15	0.96295
20	0.978818
40	0.994619
∞	1

Case of a rectangle :

Geometry CF :

d/s	Correction factor a/d = 1	Correction factor a/d = 2
1.5	x	0.3264
1.75	x	0.3796
2	x	0.4294
2.5	x	0.5592
3	0.541919	0.5960
4	0.686934	0.7118
5	0.774376	0.7891
7.5	0.884503	0.8909
10	0.931261	0.9350
15	0.968109	0.9701
20	0.981779	0.9835
40	0.995375	0.9962
∞	1	1

Thickness CF :

t/s	Correction factor (CF)
< 0.4	1
0.4	0.972135
0.5	0.957281
0.6	0.939876
0.7	0.920287
0.8	0.898906
0.9	0.876122
1	0.852305
1.5	0.72854478
2	0.615077
3	0.4476