Semiconductor Process (EB68684)

Appendix 2: Derivation of Sheet Resistance from Four Point Probe Method

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■ **Derivation for t<<s :**

Staring with the Ohm's law,

$J = \sigma E = \frac{E}{\rho}$ (1)

Here, J is defined at a certain distance from the source current (I) with a ground at infinity, as follows,

$J = \frac{I}{2\pi rt}$ (2)

Here, we assumed that the cylindrical current flowing since t<<s.

And the E-field intensity can be independently connected with potential (V) through the gradient,

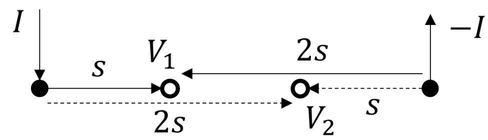
$E = -\frac{dV}{dr}$ (3)

From Equations (1) to (3), we get the equation as follows,

$dV = -\left(\frac{I\rho}{2\pi t}\right)\left(\frac{1}{r}\right) dr$ (4)

By integrating Equation (4), we get

$V = -\left(\frac{I\rho}{2\pi t}\right)(\ln r + C)$ (5)



Now, looking at the figure above, we assuming that measuring point 1 is at r=s from the source current (I), Eq.(5) becomes,

$V_{source} = -\left(\frac{I\rho}{2\pi t}\right)(\ln s + C)$ (6)

Since we have the sink current (-I) and the measuring point 1 is at r=2s from it, Eq.(5) becomes,

$V_{sink} = +\left(\frac{I\rho}{2\pi t}\right)(\ln 2s + C)$ (7)

Thus, the total potential at this measuring point 1 is given by the sum of Eqs.(6) and (7) by the superposition principle,

$V_1 = V_{source} + V_{sink} = \left(\frac{I\rho}{2\pi t}\right)(\ln 2s - \ln s)$ (8)

Similarly, the total potential at another measuring point 2 is given by superposition principle,

$V_2 = V_{source} + V_{sink} = \left(\frac{I\rho}{2\pi t}\right)(\ln s - \ln 2s)$ (9)

Finally, the voltage drop across the point 1 and point 2 is given as,

$V = V_1 - V_2 = \left(\frac{I\rho}{2\pi t}\right)(2\ln 2s - 2\ln s) = \left(\frac{I\rho}{\pi t}\right)\ln 2$ (10)

So, the sheet resistance is derived from Eq.(10),

$R_{sheet} = \frac{\rho}{t} = \frac{V}{I}\frac{\pi}{\ln 2}$ (11)