**Week Three Assignment I:**

**Transmission Line Measurement (TLM)**

**Purpose:**

To determine the contact resistance between metal and semiconductor as well sheet resistance of the semiconductor layer.

*Sheet resistance* $R_s (\Omega/\square)$:

$$R = \rho \left( \frac{d_i}{A} \right)$$  

($R$: resistance measured between two contact pads, $L$: distance current travels, $A$: cross-section area, $\rho$: resistivity)

$$= \rho \left( \frac{d_i}{Zt} \right)$$  

($Z$: width, $t$: thickness)

$$= \left( \frac{\rho}{t} \right) \left( \frac{L}{Z} \right) = R_s \left( \frac{d_i}{Z} \right)$$

*Transfer resistance* $R_T (\Omega\text{-mm})$

*Specific contact resistance* $R_c (\Omega/\text{cm}^2)$

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The blue rectangular are ohmic metal contact pads. (length: $d_i$, width: $Z$)

The big white rectangular is the isolation mesa of the semiconductor layer.

**Way to measure:**

Contact two metal pads with probes, apply a current between the contact pads and measure the voltage drop at the same time.

Use $V = IR$, we can estimate the total resistance between two metal contacts at certain gap. By measuring of resistance between metal pads for a set of different gaps, the following figure can be obtained:
When \( d_i = 0 \), the intercept of the line at y axis is \( 2R_0 \). \( R_0 \) is the resistance between metal contact and the underlay semiconductor.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Derivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet resistance ( R_s )</td>
<td>( \Omega/) (ohm per square)</td>
<td>Slope ( \times Z )</td>
</tr>
<tr>
<td>Transfer resistance ( R_t )</td>
<td>( \Omega-\text{mm}(\text{ohm} \times \text{width}) )</td>
<td>( R_0 \times Z )</td>
</tr>
<tr>
<td>Specific contact Resistance ( R_c )</td>
<td>( \Omega-\text{cm}^2 ) (ohm-length(^2))</td>
<td>( (R_t)^2/R_s )</td>
</tr>
</tbody>
</table>

When \( R = 0 \), the intercept of the line in x-axis is \( 2L_T \) (Transfer length).

For example:
The TLM gap spacing are 5 \( \mu \)m, 10 \( \mu \)m, 20 \( \mu \)m, 40 \( \mu \)m and 80 \( \mu \)m
If \( Z = 100 \mu \)m, the slope = 2 ; \( R_0 = 13 \Omega \), what are \( R_s \), \( R_t \), and \( R_c \) ?
Answer:
\( R_s = 2 \times 100 \mu \)m = 200 (\( \Omega/\) )
\( R_t = 13 \Omega \times 0.1 \text{ mm} = 1.3 (\Omega-\text{mm}) \)
\( R_c = 1.3 \Omega-\text{mm} \times 1.3 \Omega-\text{mm} / 200 (\Omega/\) ) = 8.45 \times 10^{-3} (\Omega-\text{mm}^2) = 8.45 \times 10^{-5} (\Omega-\text{cm}^2) \)