DEPARTMENT OF
ELECTRICAL & COMPUTER
ENGINEERING

TEXAS TECH
Whitacre College of Engineering

TLM

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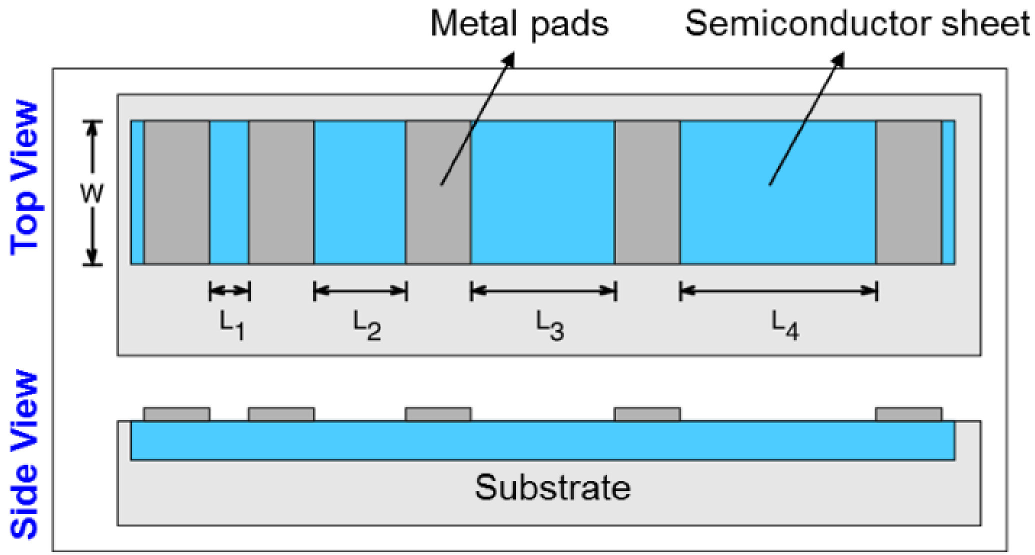
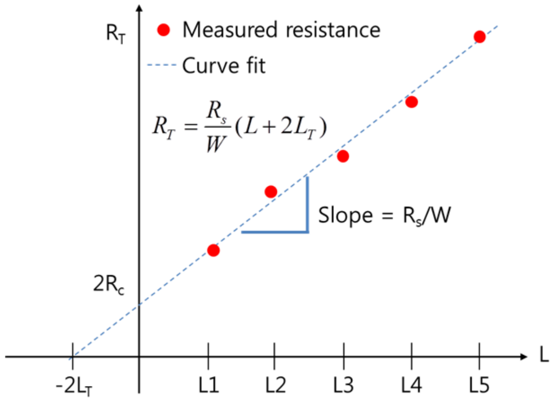
Transfer Length Method

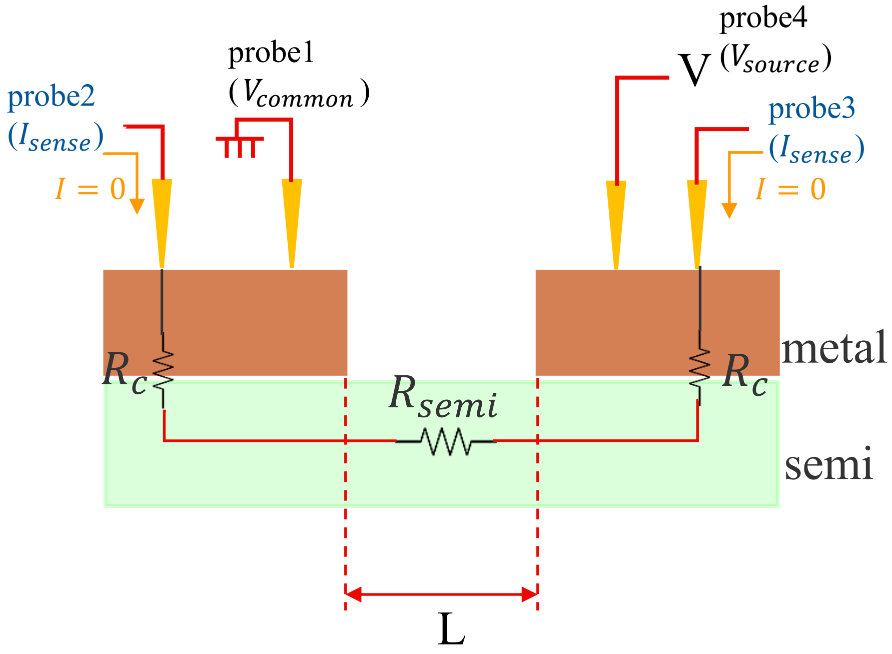
- Method to determine various resistances in passive semiconductor structures
  - Such as ohmic contact pads of various devices
- Most simple test structure allows for:
  - Contact resistance
  - Semiconductor sheet resistance
- Works by measuring several semiconductor lengths and extrapolating the desired data

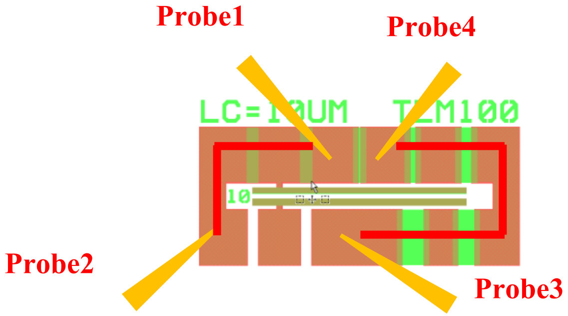




Measurement Methodology

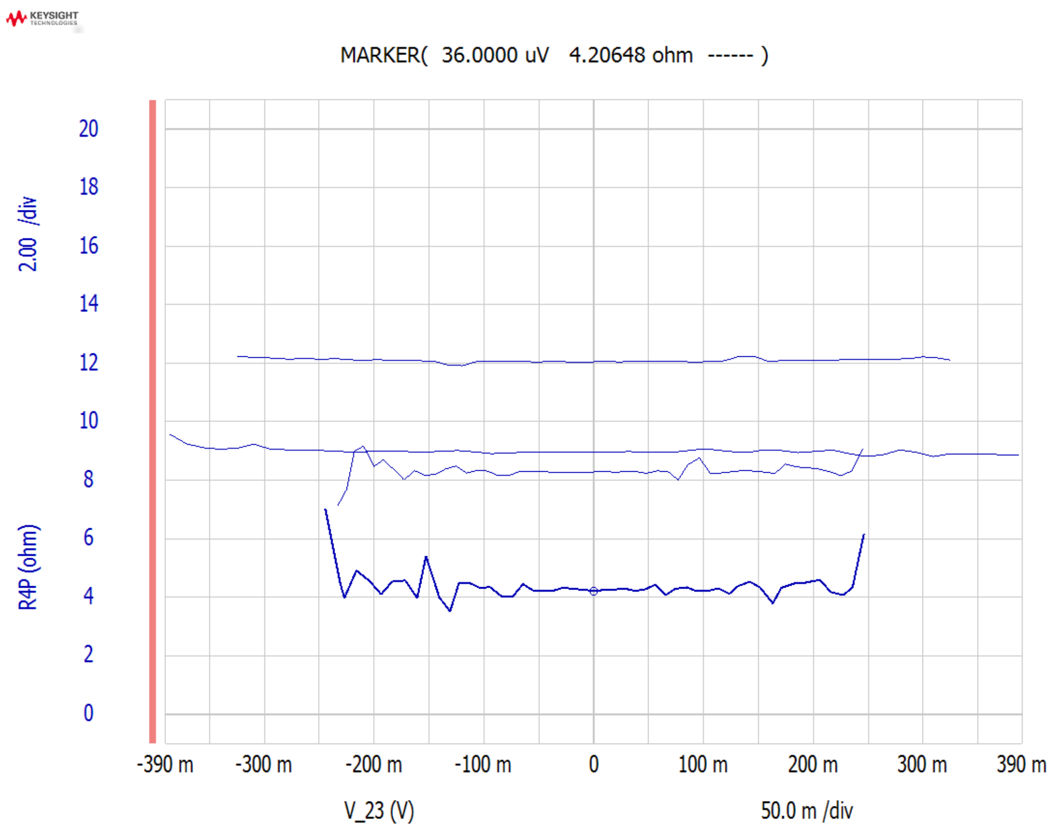
- Four measurement probes
  - Two for measuring
  - Two for biasing
- Voltage biasing probes
  - Apply linear voltage sweep
  - Thus, creating a current
- Voltage measuring probes
  - Are held at a constant current of 0 A
  - The two probes will sense a difference in voltage
- Sense and bias probes do not need to be on the same pad!





Measurement Output

- X-axis is V_2-V_3
- Y-axis is R
  - $R = (V_2-V_3)/I1$
- From here, we simply take the measurement at the Y-axis
- This is our R that we plot



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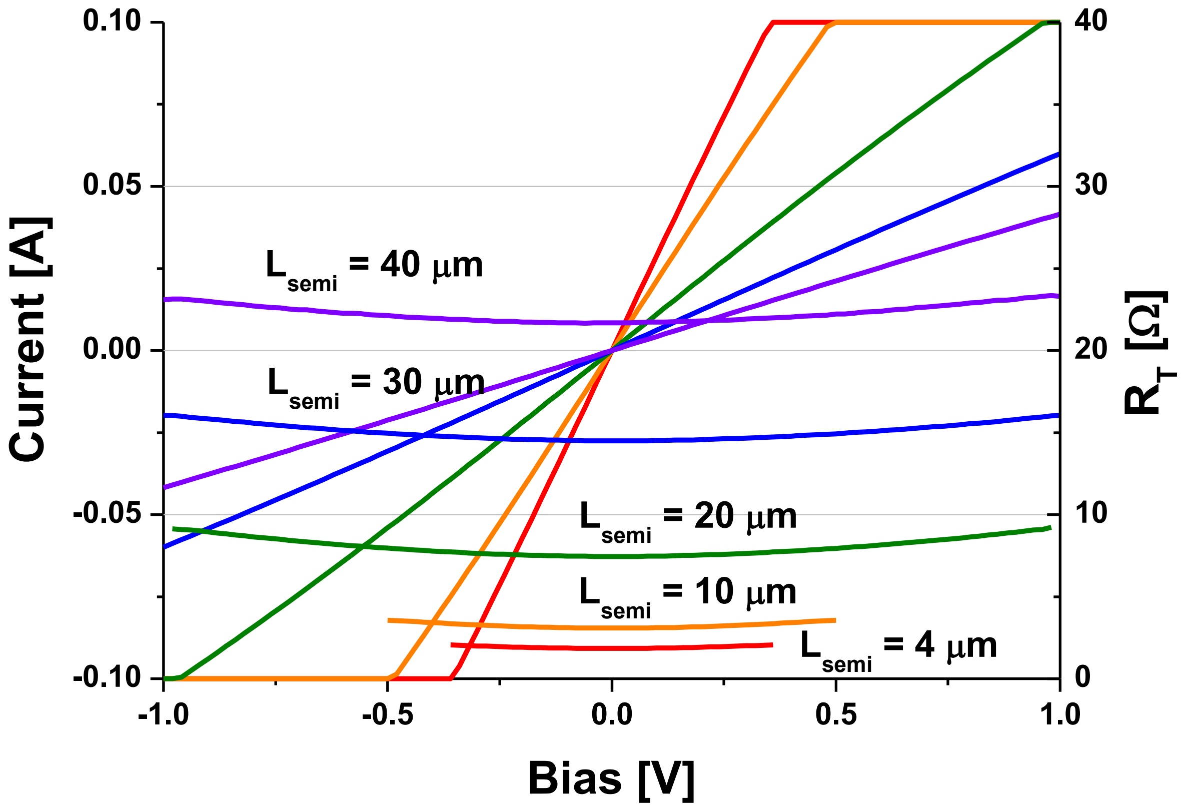
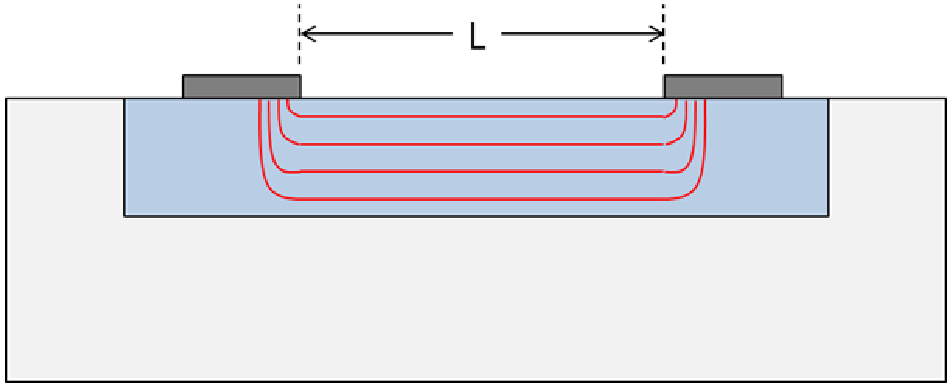


Current Crowding

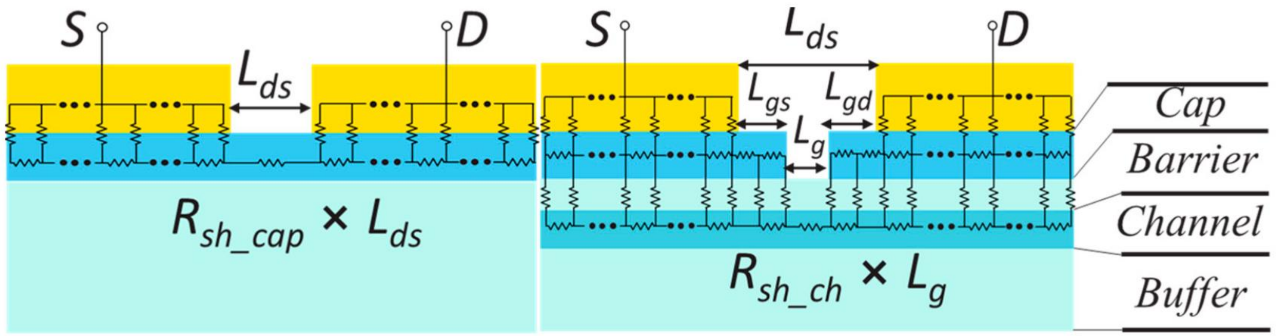
- The purpose of the “transfer length”
- The electron flow crowds at the nearest edges of each of the contacts
- This means that the contact’s area is not necessarily the actual contact area
  - Transfer length (x-intercept) is the average length along the contact that the electrons actually reach

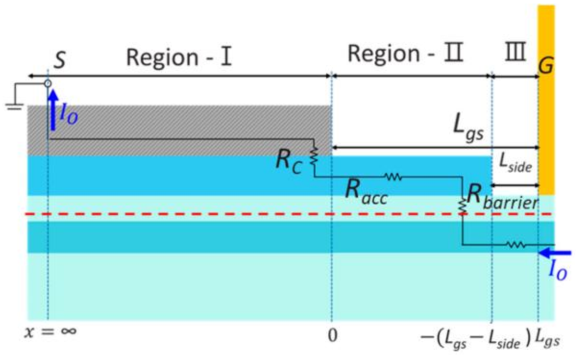


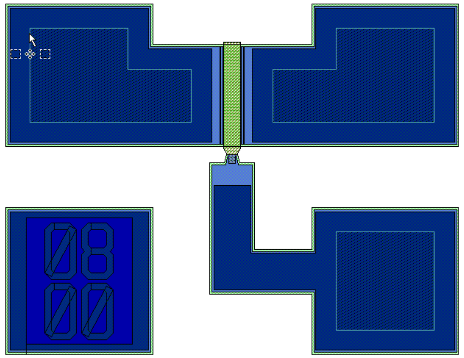
$$L_T = \sqrt{\frac{\rho_C}{R_{\text{sheet}}}}$$

Complex Structures – Barriers

- For MESFET/HEMT devices, special structures are made to properly de-embed the contact and access resistances
- Importantly, an inclusion of a barrier is present and a *recess* is made
- Furthermore, there is still some capped region to accurately model device



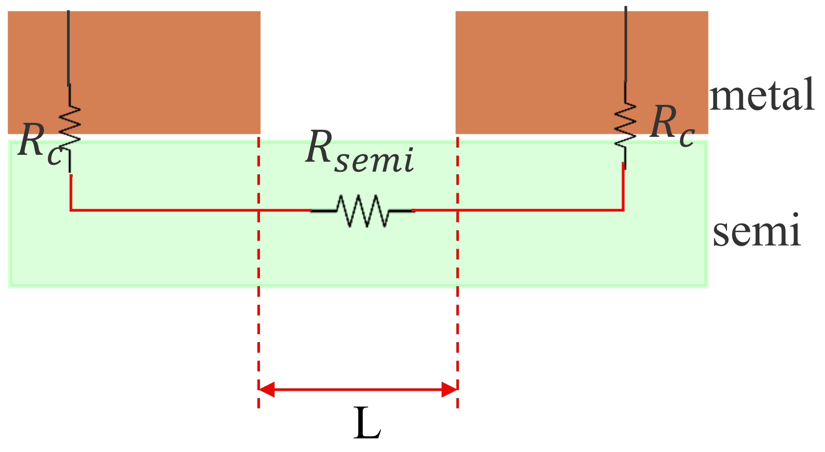




Practice

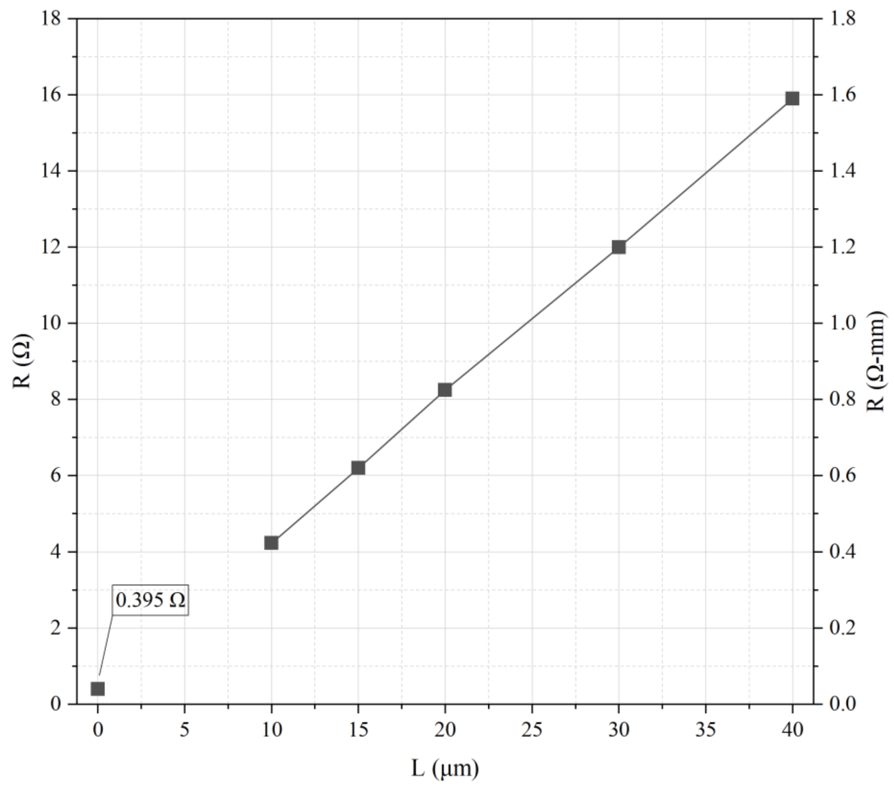
- Find the following information from the table for the simple structure pictured:
  - Contact resistance R_C
  - Transfer length L_T
  - Contact resistivity ρ_C
  - Semiconductor sheet resistance R_{Sh}
- The width of this is 100 µm
  - What is the effective contact area of this pattern?

L (µm)	R (Ω)
40	15.9
30	12.0
20	8.25
15	6.20
10	4.23



Answer

- $R_C = \frac{1}{2} \times 0.395\ \Omega$
- $L_T = 0.465\ \mu m$
- $\rho_C = 0.084\ \Omega \cdot \mu m$
- $R_{Sh} = 0.388\ \Omega/\square$
- Effective contact area = $46.5\ \mu m^2$



References

- TLM guide from Kyungpook National University
- Yoo, J.-H., Lee, I.-G., Tsutsumi, T., Sugiyama, H., Matsuzaki, H., Lee, J.-H., & Kim, D.-H. (2023). Analytical and Physical Investigation on Source Resistance in InxGa1−xAs Quantum-Well High-Electron-Mobility Transistors. Micromachines, 14(2), 439. https://doi.org/10.3390/mi14020439
- Honsberg, C., Bowden, S. TLM measurement. PVEducation.org. https://www.pveducation.org/pvcdrom/tlm-measurement?expr=30