I-V characterization of Au/SWCNT/Au Schottky Junction fabricated using dry film photolithography

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MOTIVATION

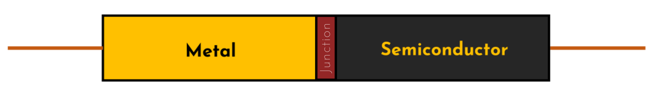
Single-Walled Carbon Nanotube (SWCNT)

- unique chirality and a one-dimensional structure that give them several advantageous electrical characteristics
- has significantly low carrier recombination, high carrier mobility, and low carrier scattering when compared to conventional materials [1]

Schottky Junction

- metal-semiconductor junction that can be a rectifying or non-rectifying (ohmic) contact
- Schottky diode as an application has high switching speed and low reverse recovery current [2]

Fabricated Schottky Junction



M-S Junction

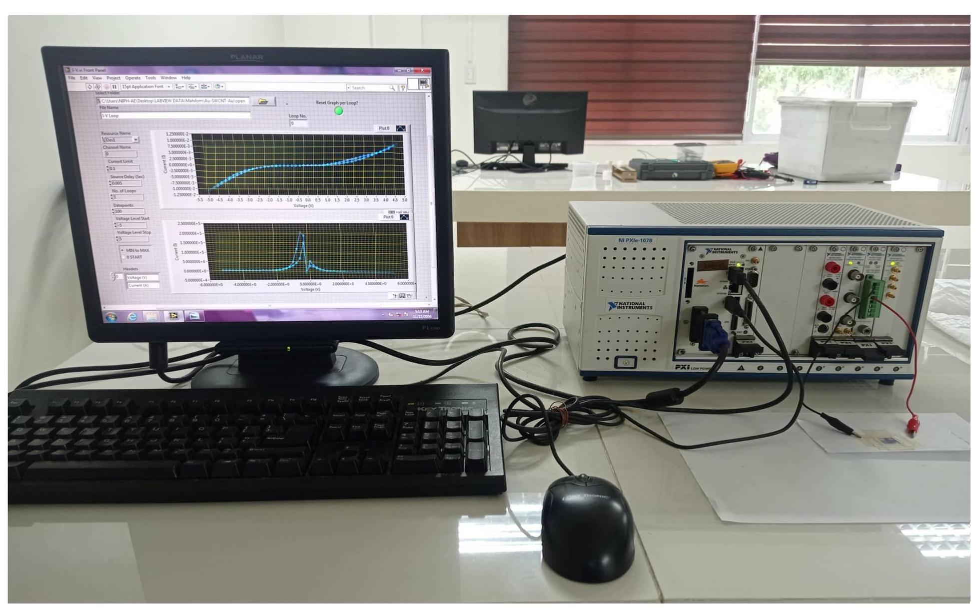
Dry Film Photoresist

- cheap and widely used pattern transfer mask in PCB printing and wet etching [3]

AIM: Investigate the properties and electrical performance of the fabricated Au/SWCNT/Au Schottky Junction using dry film photolithography via I-V characterization

METHODOLOGY

I-V Characterization Set-Up

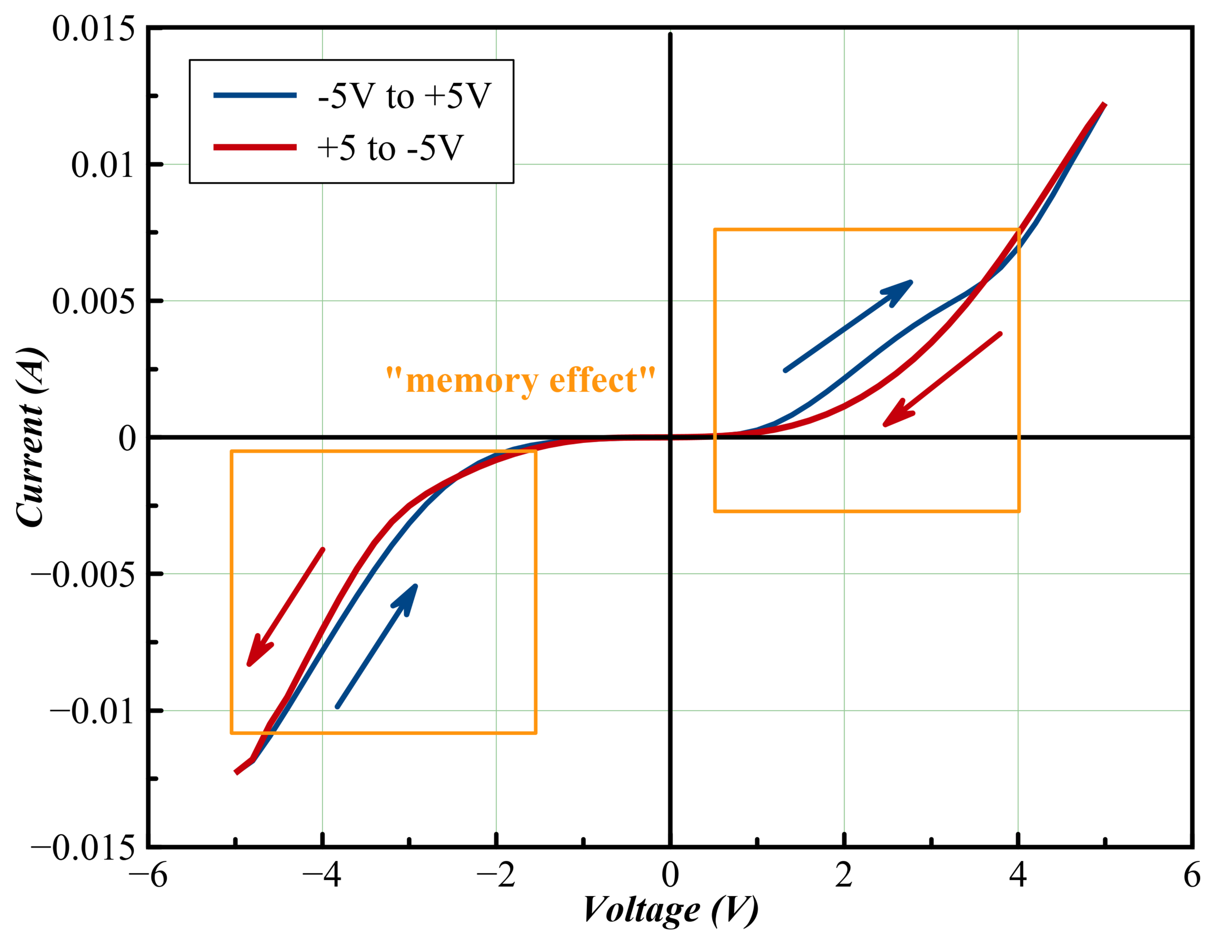


- **NI PXIe-1078** source/meter controlled by **Laboratory Virtual Instrument Engineering Workbench (LabVIEW)**

Scanning Parameters	
Voltage Range:	- 5V to +5V
Temperature:	Room Temperature
Current Limit:	0.1 A
Number of Loops:	1
Scanning Option:	minimum to maximum
Number of Data Points:	100

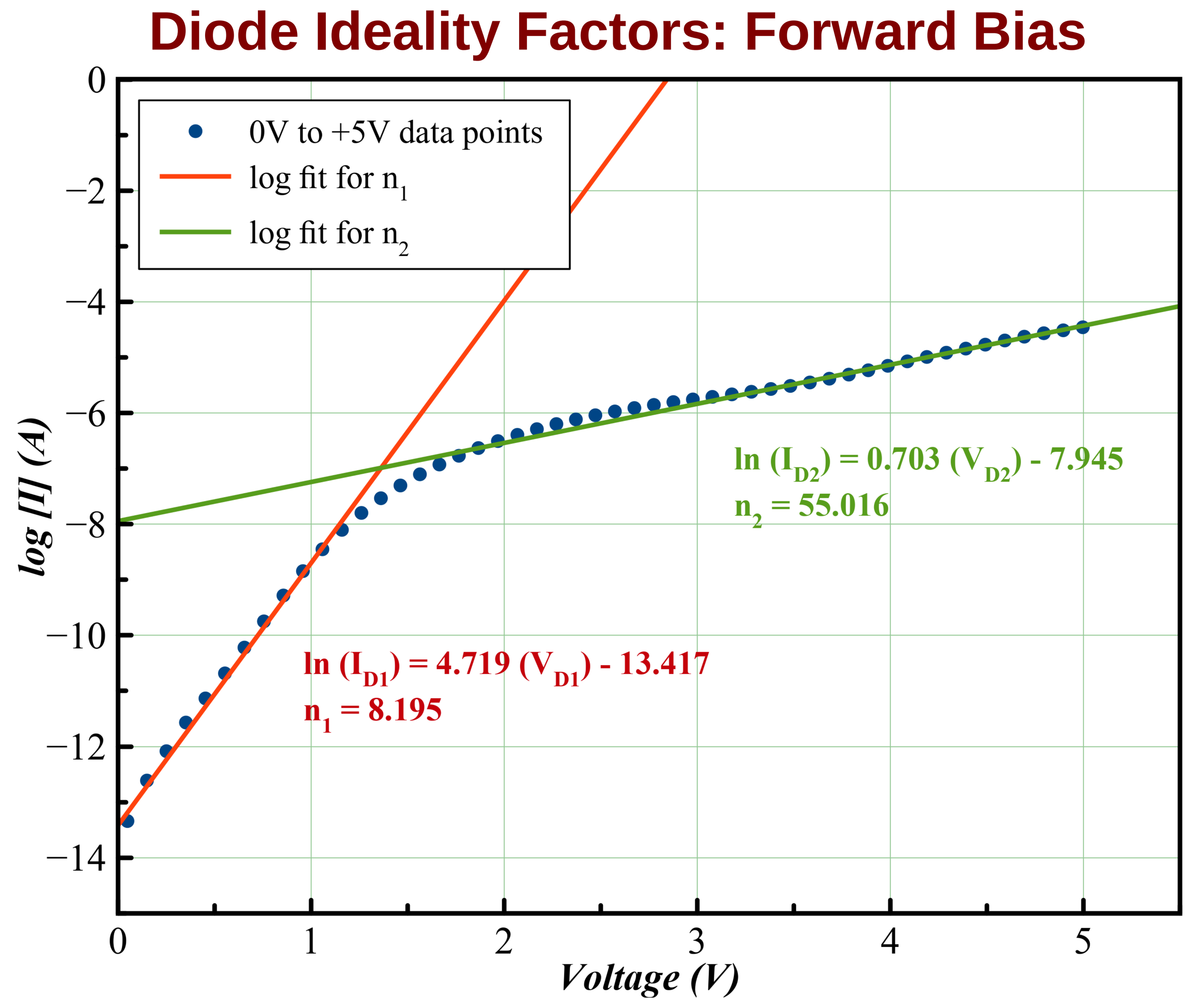
RESULTS and DISCUSSIONS

Current – Voltage (I-V) Loop

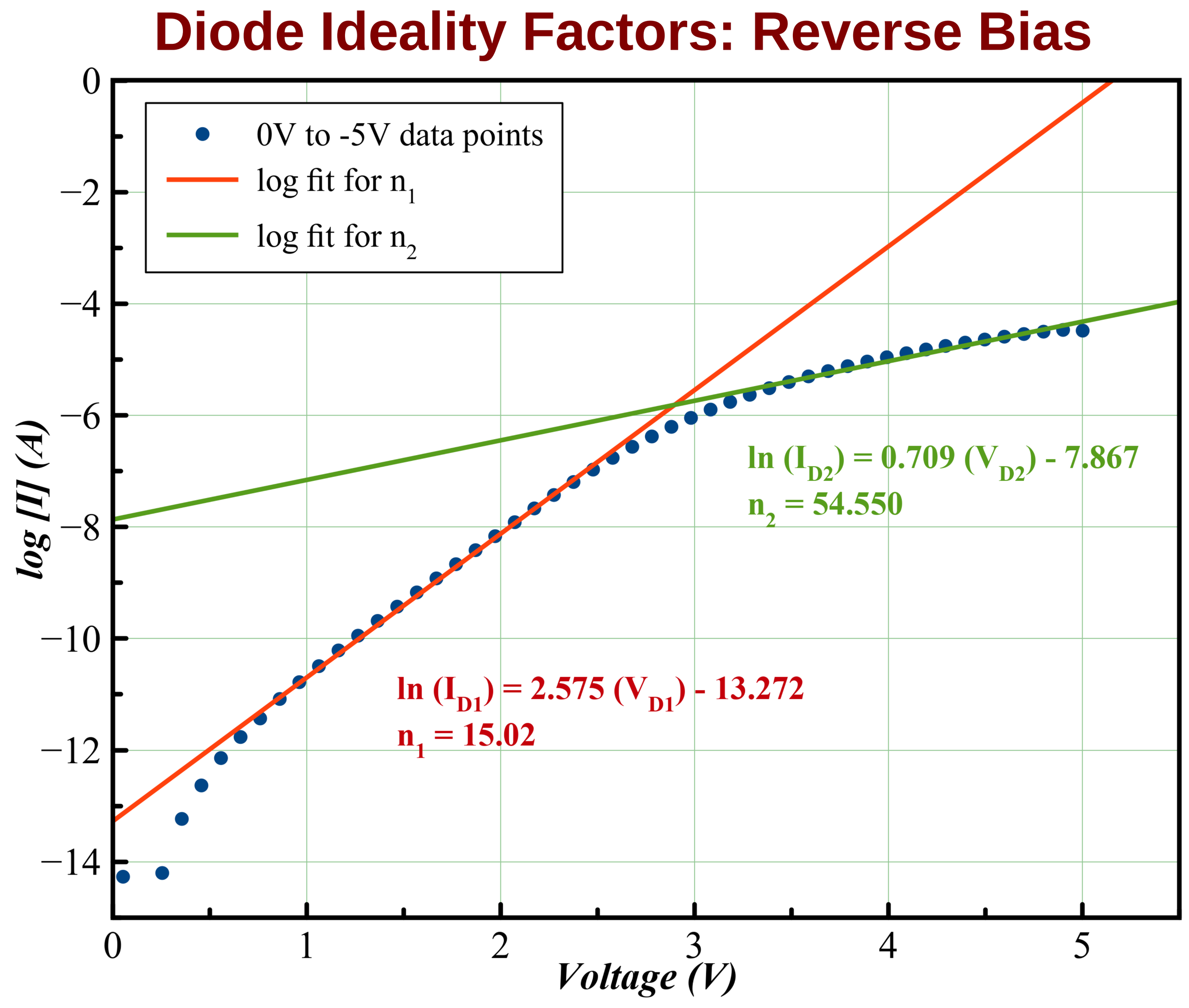


- The I-V loop exhibited **rectifying characteristics** implying a formation of **Schottky contact/barrier** with turn-on voltage of $V_T \cong \pm 2.75$ **V**
- Hysteretic behavior is observed revealing existence of electrical **memory effect.**
- Conduction of the SWCNT changes from a **low-resistance (ON) state** to **a high-resistance (OFF) state** in a voltage sweep of 0V→+5V→0V while behaving opposite in the 0V →-5V→ 0V voltage sweep showing similar behavior from previous study [4]
- The effect is probably due to the SWCNT charge trapping in the defects and charge transport behavior owing to an increased band asymmetry; **small barrier for hole injection in the ON-state** and **huge barrier for electron injection in the OFF state.** [5]

Diode Ideality Factors: Forward Bias



Diode Ideality Factors: Reverse Bias



Shockley Diode Equation

$$\ln(I) = \frac{q}{nkT} V_D + \ln(I_0)$$

- I_0 - saturation current
- q - electron charge
- k - Boltzmann constant
- T - temperature in Kelvin
- V_D - diode voltage
- n - diode ideality factor

- Log of current versus voltage plot shows two linear regions each fitted by the Shockley diode equation giving rise to two ideality factors $n_1^+ = 8.2$ and $n_2^+ = 55.0$ for the **forward bias**, and $n_1^- = 15.0$ and $n_2^- = 54.6$ for the **reverse bias**.
- Based on the obtained values of n, the diode is **non-ideal** having $n > 2$, which may be due to the non-homogeneous SWCNT powder used in the experiment.

SUMMARY

- Fabricated Au/SWCNT/Au Schottky Junction using a facile process via dry film photolithography has a rectifying characteristic similar to a typical diode.
- The stark difference of n_1 values comes from the electrical irreversibility of the sample which can be exploited for memory device applications.

References:
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[3] L. Zhang, W. Wang, X.-J. Ju, R. Xie, Z. Liua and L.-Y. Chu, "Fabrication of glass-based microfluidic device with dry film photoresists as pattern transfer masks for wet etching," RSC Adv., 2015, 5, 5638–5646, (2014), Doi:10.1039/c4ra15907a.
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[5]] M. Y. Chan, L. Wei, Y. Chen, L. Chan and P. S. Lee, "Charge-induced conductance modulation of carbon nanotube field effect transistor memory devices," doi:10.1016/j.carbon.2009.07.017.

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