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Molecular Modification of CNT Junctions

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Towards Molecular Modification of Carbon Nanotube Junctions in Thin Film Transistors

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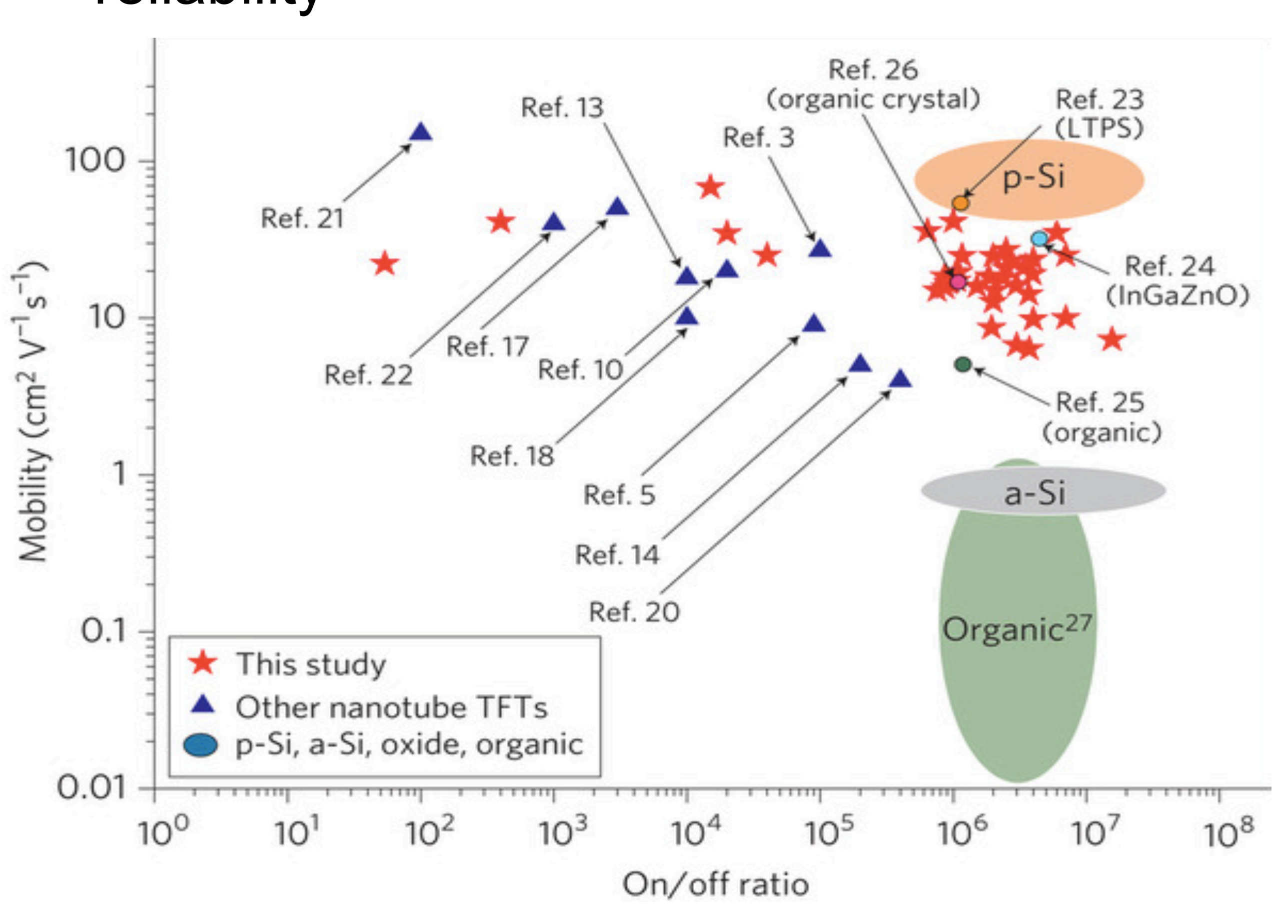
Background & Motivation

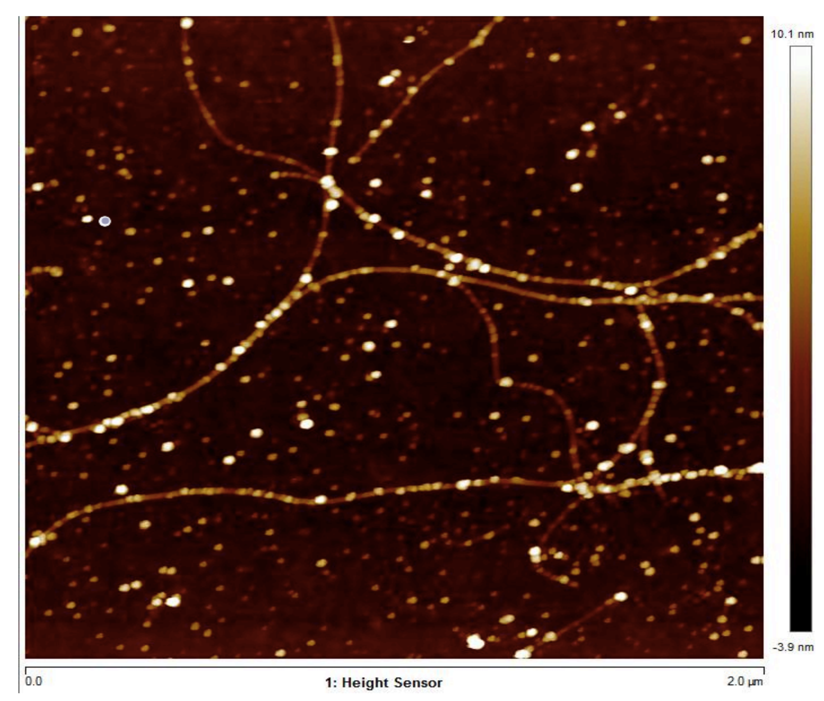
- Many applications that use thin film transistors (TFTs) such as integrated circuits and display drivers on flexible, transparent substrates are interested in carbon nanotube network (CNN) devices
- CNNs have demonstrated higher carrier mobility than amorphous silicon and organic TFTs[1,2]
- A common problem of such TFTs is high electrical[3-5] and thermal [6,7] resistances at individual nanotube junctions (NJs) limits the performance of CNN devices
- The resistances of the junctions are no less than an order of magnitude higher than those of individual carbon nanotubes (CNTs)
- This causes high power dissipation at the NJs. In the end this causes degradation of the overall device performance and reliability[3,4]



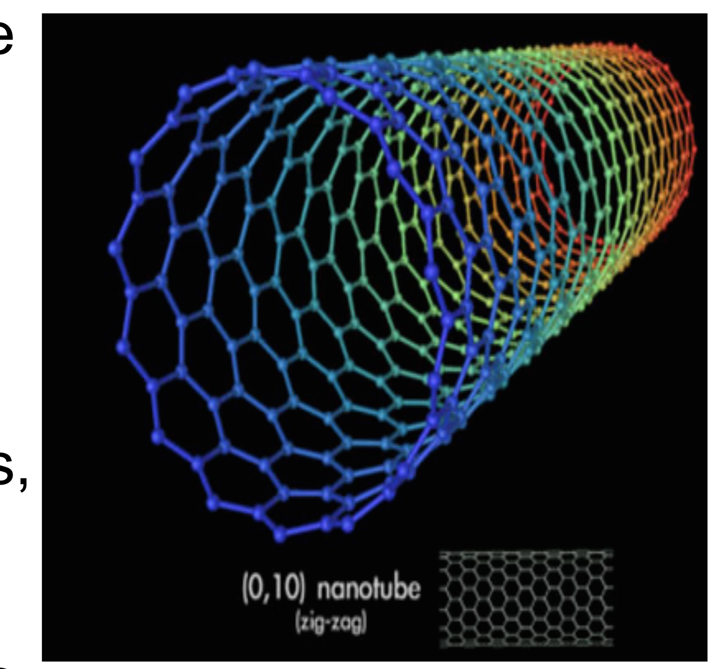
Carrier mobility vs. on/off ratio for various TFTs[1]

- We seek to show that carrier mobility for our CNNs will increase with the deposition of fullerenes and quantum dots
- We aim to produce TFTs that will supersede the benchmark of existing devices

Fullerenes, Carbon Nanotubes, & Quantum Dots

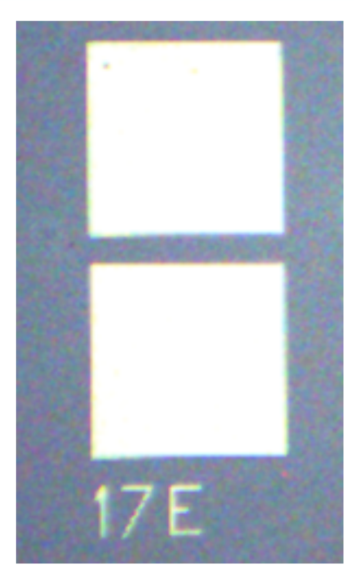


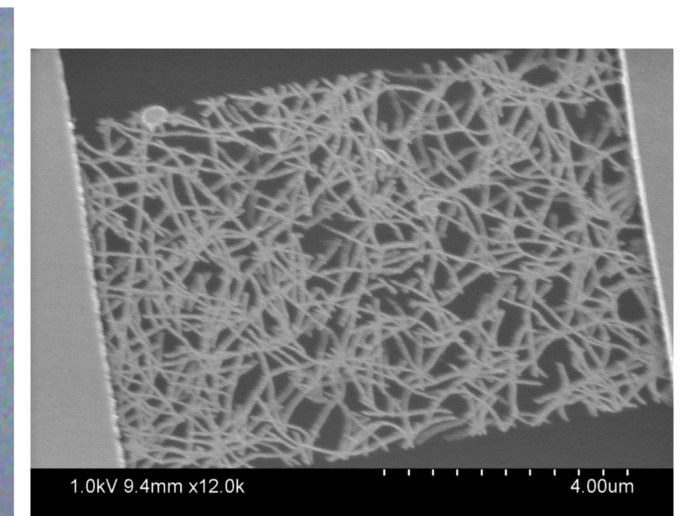
- A fullerene is a molecule made only of carbon
- Carbon nanotubes are cylindrical fullerenes
- Spherical fullerenes increase in size with the number of carbon atoms, such as C_{60} and C_{70}
- QDs are made of semiconductor materials



- Molecular modification of NJs can reduce the sheet resistance of conducting and transparent CNN electrodes[8]

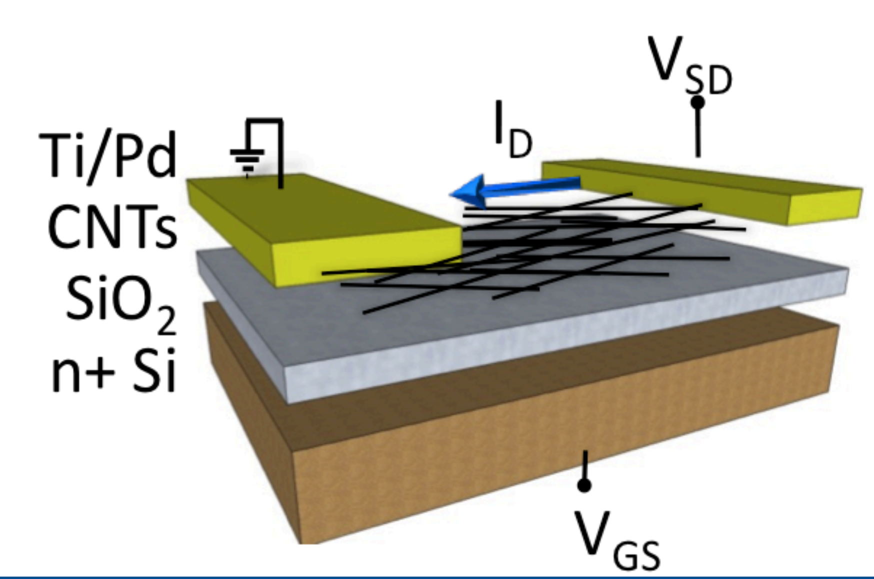
Device Structure & Experimental Setup



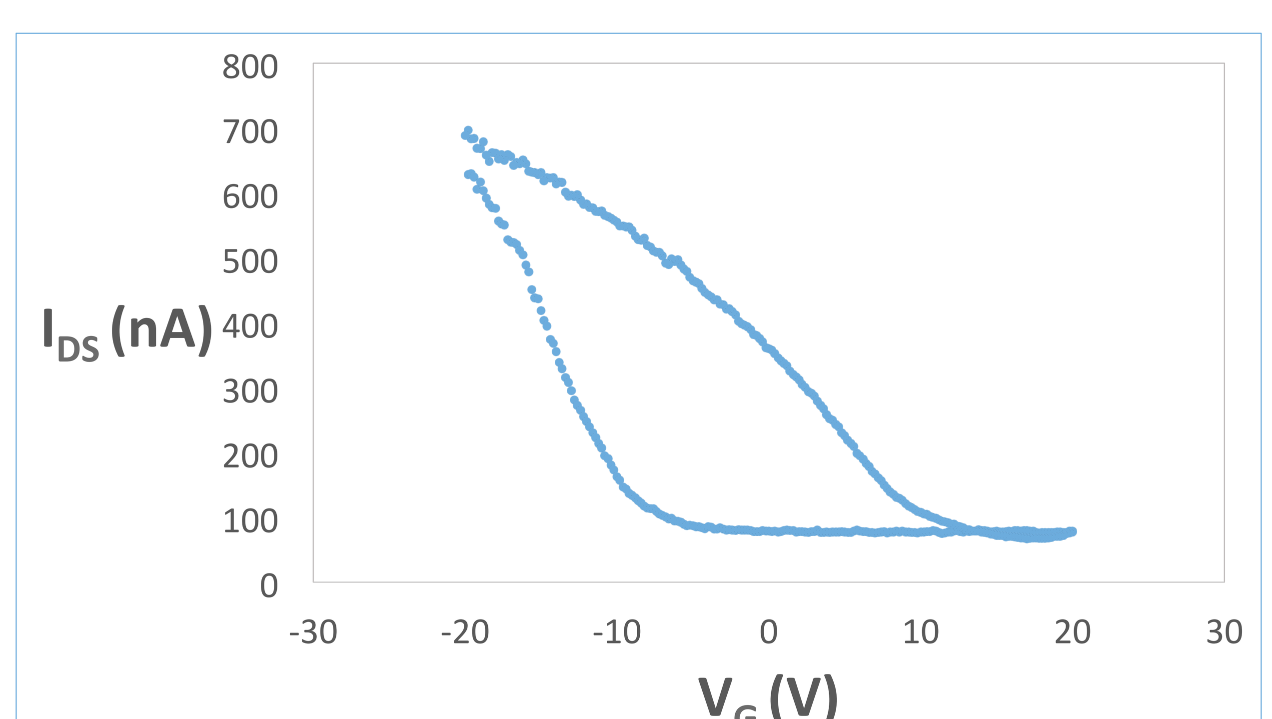


- 40 nm Pd contacts with 1 nm Ti adhesion layer
- 20 nm Au and 20 nm Pd contacts with 1 nm Ti adhesion layer
- Nanotubes are grown by CVD on SiO_2 using Ferritin catalysts

- V_{GS} is swept in order to extract the field-effect mobility
- V_{SD} is constant -1 V
- The Ion/Ioff ration and carrier mobility is extracted from the device transfer characteristics (I_D-V_{GS})



Extracting Mobility



Typical IV curve for CNN TFTs

- We can extract the mobility using:

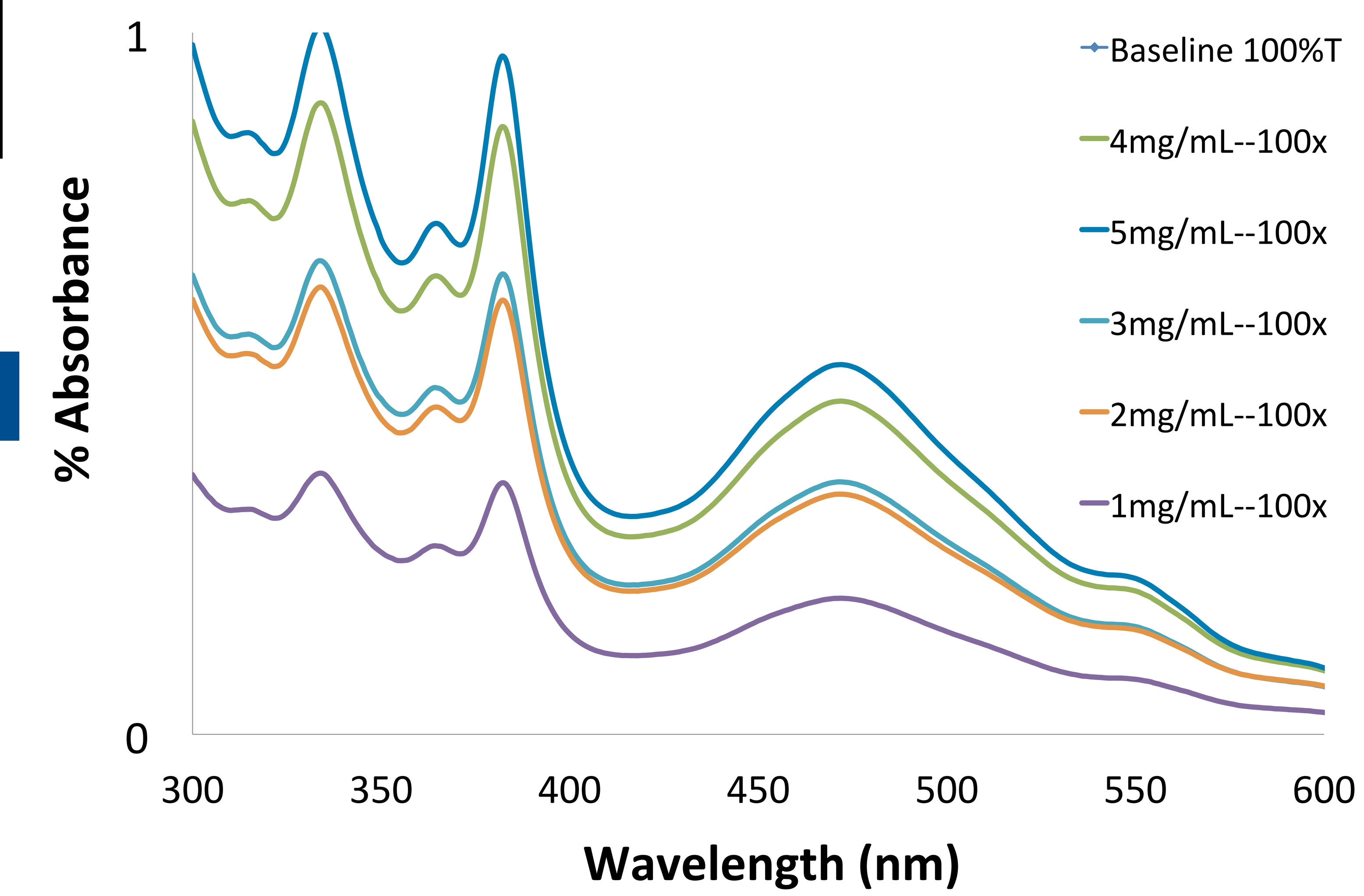
$$\mu_{FE} = \frac{dI_D}{dI_{GS}} \frac{L}{W} \frac{1}{C_{OX}} \frac{1}{V_{DS}}$$

- In calculating the on/off ratio, we used the equation:

$$\frac{I_{on}}{I_{off}} = \frac{I_{max,at-20V}}{I_{min}}$$

Reduction of Resistance at NJ

- Application of CdSe QDs, C_{60} or C_{70} onto the CNN device may yield high performance CNT TFTs
- Fullerenes or QDs will act as a nanosolder at NJs to reduce their electrical and thermal resistance by modifying Schottky barriers between metallic and semiconducting NJs and increasing the cross-sectional area for heat flow



Intensity of absorbance increases with concentration of C_{70}

Conclusion

- CNN devices are prized for their transparency and the application of fullerenes and QDs are not expected to significantly diminish transparency
- This doping of the CNN could also be applied to other devices where resistance of CNNs limits the overall reliability and performance of the device
- Future experiments include high-field measurements and varying temperature to determine effect on mobility

References

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