Molecular Modification of CNT Junctions

Kari McLaughlin*
College of Arts and Sciences, Boise State University

Hanna Meinikheim*
College of Arts and Sciences, Boise State University

Angela "Nikki" Chang
College of Arts and Sciences, Boise State University
Towards Molecular Modification of Carbon Nanotube Junctions in Thin Film Transistors

Kari McLaughlin¹, Hannah Meinikheim², A. Nicole Chang¹, Jeunghoon Lee¹,², David Estrada¹
¹Department of Material Science & Engineering, ²Department of Chemistry
Boise State University Boise, ID 83725

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.
- A common problem of such TFTs is high electrical and thermal 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.

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 C60 and C70.
- QDs are made of semiconductor materials.
- Molecular modification of NJs can reduce the sheet resistance of conducting and transparent CNN electrodes.

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 using Ferritin catalysts.

Extracting Mobility

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

Reduction of Resistance at NJ

- Application of CdSe QDs, C60 or C70 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.

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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