FUNDAMENTAL AND APPLIED ASPECTS OF ELECTRONICS BASED ON SINGLE-WALLED CARBON NANOTUBE THIN FILMS

Qing Cao, Ph.D.
Department of Chemistry
University of Illinois at Urbana-Champaign, 2009
John A. Rogers, Adviser

Ultrathin films of single-walled carbon nanotubes (SWNTs) represent an attractive, emerging class of material, with properties that can approach the exceptional electrical, mechanical, and optical characteristics of individual SWNTs, in a format that, unlike isolated tubes, is readily suitable for scalable integration into devices. These features suggest the potential for realistic applications as conducting or semiconducting layers in diverse types of electronic, optoelectronic and sensor systems.

In this dissertation I present a study on understanding the fundamental properties of such SWNT films and engineering aspects of implementation in electronic devices and circuits with various levels of complexity. We proposed a novel "striping" scheme, which allows us to achieve high device on/off without any pre-sorting step necessary. We then modeled our experimental results using a first principle stick percolation based transport model and established a design rule for this approach. The capacitance coupling between a SWNT submonolayer and a planar electrode was analyzed with both analytical model and finite-element simulation. Certain aspects of these calculations were verified through experiments.

To improve the performances of SWNT thin film transistors (TFTs), we adopted high capacitance gate dielectrics to reduce the device operation voltage from ~20 V to ~1 V and, in related work, the hysteresis has been reduced from levels so large that the transistors could be used effectively as memory devices to values that are nearly negligible. Not only *p*-channel but also and *n*-channel and ambipolar devices have been achieved by use of simple polymer coating strategies. Complex digital circuits composed of nearly 100 SWNT TFTs have also been successfully demonstrated. Finally, we demonstrated certain classes of optically transparent devices using SWNT films as electrically active material. These results represent important steps in the development of an SWNT based electronics technology that could find utility in areas such as flexible electronics and others that might complement the capabilities of established systems.