MSE Seminar Thursday November 29, 2007

Integrated Nanowire Electronics and Sensors on Flexible Plastic Subtrates

Presented by

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ABSTRACT

The introduction of an ambient-temperature route for integrating high performance materials on flexible plastic substrates could enable exciting avenues in fundamental research, and innovative electronic and medical devices. However, the temperature constraints imposed by these substrates restrict the use of high carrier mobility materials, such as polycrystalline silicon, generally limiting these devices to the modest computational capabilities of amorphous silicon and organic semiconductor thin film transistors. The development of new materials and novel materials processes for overcoming this restriction could impact a broad spectrum of applications.

Semiconductor nanowires represent unique, high performance building blocks for electronic, photonic, and sensing devices. In this talk, I will present my work demonstrating that single-crystal nanowires can be hierarchically assembled onto flexible plastic substrates under ambient conditions to create multi-component, fully integrated devices, including field-effect transistors, light-emitting diodes, ring oscillators, and electronic noses. These devices all exhibit performance metrics which meet or exceed the state-of-the-art flexible electronics.

The key to our approach is the separation of the high-temperature synthesis of single-crystal nanowires from room temperature assembly, thus enabling fabrication of high-performance devices on virtually any substrate. Silicon nanowire field-effect transistors on plastic substrates display mobilities rivaling those of single-crystal silicon and exceeding those of amorphous silicon and organic transistors currently used for plastic electronics. Furthermore, we show that these systems can be integrated into ring oscillators on plastic which generate frequencies approaching the microwave, the highest observed frequencies for circuits based on nanoscale materials.

Finally, we exploit SiO_2 surface chemistries to construct a “nano-electronic nose” library, which can distinguish acetone and hexane vapors via distributed responses. We also demonstrate that amide coupling of theoretically tailored peptide sequences to the arrays allows for selective discrimination of chemicals often found in the breath of sick patients. This excellent sensing performance coupled with biocompatible plastic could open up far-reaching opportunities in mobile computing, lightweight display, or even implantable monitoring applications.

BIO

Dr. Michael C. McAlpine is a Postdoctoral Fellow at California Institute of Technology. He received a B.S with honors in Chemistry from Brown University, and a Master’s Degree and Ph.D. in Chemistry from Harvard University. His dissertation work at Harvard under Professor Charles M. Lieber involved the development of integrated, high performance, nanoelectronic systems on flexible plastic substrates. Mike’s current research interests at Caltech under Professor James R. Heath include nanotechnology-enabled sensors on plastic for medical applications. He was awarded a NSF Graduate Research Fellowship in 2000 and an Intelligence Community Postdoctoral Fellowship in 2006.

Hosted by
Professor Naresh Thadhani