New Materials and Processing Opportunities for Organic Electronics and Optoelectronics

Seth R. Marder
Georgia Institute of Technology

Organic electronics offer the chemist and materials scientist a broad range of opportunities to develop insulators, semiconductors, emitters, and sensitizers for devices including organic light-emitting diodes, photovoltaic cells, and organic field-effect transistors, and for systems based upon these devices. At Georgia Tech we have assembled a team of scientists and engineers enabling us to begin with the design of materials through first-principles quantum-chemical calculations, to proceed with the synthesis and processing of new materials and their patterning down to the nanoscale in two or three dimensions, and to continue to fabrication of devices based upon these materials. In this talk, I will highlight the work performed by researchers in Georgia Tech's Center for Organic Photonics and Electronics, emphasizing our interdisciplinary, collaborative approach.

In particular, I will discuss the development of polymeric and small-molecule (including liquid-crystalline) materials for electron- and hole-transport and their applications in devices such as OLEDs. I will also describe some new work on micro and nanolithography in two and three dimensions which could have potential impacts in organic optoelectronic applications. Specifically, I will discuss the application of two-photon 3D microfabrication of structures with feature sizes ranging from microns to below 100 nm. I will also discuss thermochemical nanolithography (TCNL), which has the potential for patterning of materials to sub-10-nm resolution. We have begun to examine the use of heated scanning-probe microscope (SPM) tips to induce thermochemical reactions on organic and hybrid organic/inorganic surfaces with resolution and heterogeneity to below 35 nm. Specifically we have begun to perform studies to utilize the diversity of chemical reactivity to impact chemically-distinct patterns that change the surface energies of materials and their ability to react further using thermally triggered chemical reactions at the nanoscale. Initial studies on macroscopic samples indicate that it is possible to switch a polymer between states by heating it; we have examined a film of a functional polymer at six different temperatures between 25 °C and 175 °C and monitored the IR spectrum as a function of temperature. The IR results suggest the possibility of creating a two-state chemically-addressable TCNL pattern, indicating the potential for switching from an initially hydrophobic state to a hydrophilic state at 120 °C. We have attempted to induce the same chemical reactions at the local scale in a polymer by means of a thermal cantilever and have shown that the friction force is higher on the thermally treated areas.

In each case the work involves several researchers from my group, along with the groups of Jean-Luc Brédas, Joseph Perry, Marcus Weck, Laren Tolbert, Bernard Kippelen, Elisa Riedo, and William King.

Keywords:

Organic transport material: Materials that in the presence of an applied electric field allows charge carriers (holes and electrons) to move through the material

Two-photon absorption: A process in which a molecule absorbs two photons of light simultaneously.

Thermochemical nanolithography: A process in which a resistively heated AFM tip causes a chemical change in a materials with sub 100 nm feature-size resolution.