

CONTROLLING MORPHOLOGY AND INTERFACE STRUCTURE TO OPTIMISE THE PERFORMANCE OF POLYMER ELECTRONIC DEVICES

Richard A. L. Jones, Simon Martin, Mark Geoghegan, Anthony Higgins,
James Sharp and Paul Jukes

Dept of Physics and Astronomy, University of Sheffield, UK.

The performance of electronic and optoelectronic devices made from semi-conducting polymers depends crucially on the structure of their internal interfaces and on the morphology of the films. I will review some of our recent results from studies of the polymer physics which underlies polymer electronic device structure and performance.

In polymer light emitting diodes, achieving balanced charged injection is crucial for efficient performance. Poly(3,4 ethylenedioxythiophene) (PEDOT) doped with polystyrene sulphonate (PSS) is a popular choice as an anode material, as it can be applied by a simple spin-coating step and is thus consistent with the goal of all-polymer structures. Using neutron reflectivity on samples containing deuterium labelled PSS we have found that substantial concentration gradients can be induced near the surface of thin PSS/PEDOT films by simple thermal treatments. As the length-scale characterising this composition variation is commensurate with the relevant carrier-hopping length-scale we expect this to result in layers with graded electronic properties.

Improvements in efficiency can be found in both light emitting diodes and photovoltaics if the active layer is made from a blend. Here the length scale and connectivity of the phase separated domains are crucial in determining the performance of the device, but our understanding of how the process history affects these parameters is still not well developed. The processes that go on when immiscible polymers are spun-cast from a common solvent are complicated, but we are beginning to get some insight into the kinetics of phase separation during spin-casting using fast light scattering studies of the spin-coating process.

Finally, in polymer field effect transistors performance, and in particular carrier mobility depends both on the roughness of the interface between the gate dielectric and the channel and the degree of molecular order in the first few molecular layers of semi-conducting polymer adjacent to the interface with the gate dielectric. I will describe neutron reflectivity data indicating how the roughness of this interface is correlated with the degree of molecular order of the semiconducting polymer.