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Structural Effects on the Performance of Polymeric Thin Film Transistors

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Semiconducting polymers are currently being researched for use in thin-film transistors (TFTs) in large-area electronic devices such as displays. Most high performance semiconducting polymers form semicrystalline thin films, but the details of the connection between their structure and the field-effect mobility of charge carriers in these materials in TFTs are poorly understood. We have used a variety of techniques to reveal the connection between the microstructure of semiconducting polymers and their electrical performance. We have used synchrotron x-ray scattering to determine the molecular ordering in thin films of several high-performance poly(thiophene)-based semiconducting polymers including poly[5,5'-bis(3-dodecyl-2-thienyl)-2,2'-bithiophene], known as PQT-12, and poly(2,5-bis(3-alkylthiophen-2-yl)thieno[3,2-*b*]thiophene). These materials show evidence of thermotropic liquid crystalline phases that can be used to improve the ordering in the films. We have used a delamination technique to transfer these films between substrates without substantially perturbing their structure to help disaggregate the contributions of film structure and of interfacial structure to device characteristics. Using films of constant morphology, we have found that chemically modified dielectrics can have a strong influence on the threshold voltage of TFTs, but have little impact on mobility. These results suggest that the field-effect mobility is mainly controlled by the structure of the first few molecular layers of the semiconducting films at the interface with the gate dielectric.