Morphology Dependent Charge Transport in MEH-PPV Films

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Polymers with conjugated -electrons along the backbone play important roles in organic electronic applications because of their unique mechanical and electronic properties. Extensive studies have shown that electronic properties of conjugated polymers may depend on film-processing conditions such as the solvent used, the solution concentration, and methods/conditions of film preparation. On the whole, the fact that film morphology developed during processing bears significant effects on device performance is well-established. While the operation of devices such as light emitting diodes, solar cells, and field effect transistors involves various factors, charge carrier transport is one of the most important and yet least understood properties. Thus there is a need to establish correlations among processing methods, morphological characteristics, and resulting charge transport behavior.

X-ray reflectivity and scattering (performed at 17B1 & 17B3, NSRRC) were used to provide insight into the morphology of the films. While optical properties on both length scales were identical for the two films, mobilities were significantly different with the mobility anisotropy, defined by the ratio of horizontal and the vertical mobility, being higher for films spun from chlorobenzene than for those spun from toluene solutions. X-ray reflectivity and scattering indicated that films spun from the first solvent have a clearer layer structure parallel to the substrate.

These observations indicate that carrier transport is influenced by structure on two different length scales. The low mobility observed in spin-cast films is a direct result of global layered structure with characteristic thickness of ~4 nm: in the absence of this layered structure, drop-cast films with inherent nano-scale heterogeneities (~20 nm in size) exhibit much better hole mobility. Elimination of nanodomains via electric field alignment results in further improved charge mobility.

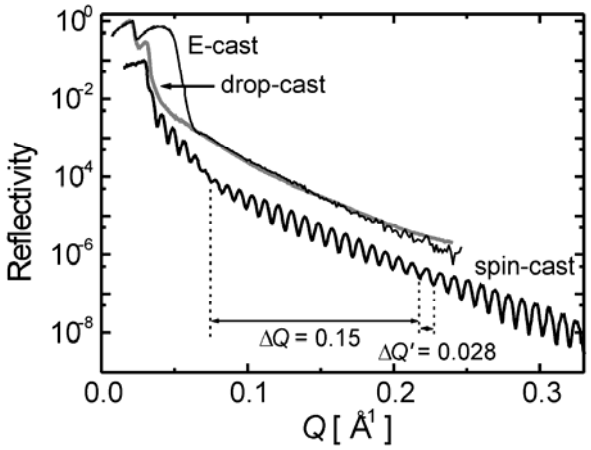

Figure 1. X-ray reflectivity profiles of drop-cast, E-cast, and spin-cast MEH-PPV films from chlorobenzene solutions, where *Q*' is for the period of Kiessig fringes whereas *Q* is the period of amplitude modulation in Kiessig fringes.

Figure 2. Charge transport paths in ITO/MEH-PPV/Al devices. Ordered domains (dark-grey) of high electron density are schematically shown as distributed within the lighter matrix of low electron density. Spatial distribution of ordered and disorder domains determines routes of holes (white crosses) traveling through the film.