MASTER'S THESIS

Growth and characterization of organic/inorganic thin films for photonic device applications

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Abstract

Thin film transistors (TFTs) can be used to determine the bulk-like mobilities of amorphous semiconductors. Different organic hole transporters (HTs) are under investigation including spiro-TPD, 2TNATA, NPB and TPD which are commonly used in organic light-emitting diodes (OLEDs). In addition, we also measure the TFT hole mobilities of two iridium phosphors: $Ir(ppy)_3$ and $Ir(piq)_3$. These materials were grown on two different gate dielectric surfaces which were SiO_2 and polystyrene (PS). On SiO_2, the TFT mobilities are found to be 1-2 orders smaller than the bulk hole mobilities as evaluated independently by time-of-flight (TOF) technique. On the other hand, on PS gate dielectric layer, the TFT mobilities of these hole transporters are found to be in good agreement with TOF data. A thickness dependence measurement was carried out on TFT with PS. We found that only 10nm of organic semiconductor is sufficient for TFTs to achieve TOF mobilities. We further investigate why organic semiconductors on SiO_2 have such huge reduction of mobilities. Temperature dependent mobility measurements were carried out and the data were analyzed by the Gaussian Disorder Model (GDM). We found that on SiO_2 surface, when compared to the bulk values, the energetic disorders (σ) of the HTs increase and simultaneously, the high temperature limits (μ_∞) of the carrier mobilities decrease. Both σ and μ_∞ contribute to the reduction of the carrier mobility. The increase in σ is related to the presence of randomly oriented polar Si-O bonds. The reduction of μ_∞ is topological in origin and is related to the orientations of the more planar molecules on SiO_2. The more planar molecules tend to lie horizontally on the surface and such orientation is unfavorable for charge transport in TFT configuration.

Hybrid organic/inorganic perovskites have emerged as an outstanding material for photovoltaic cells. In the second part of this work, we setup a repeatable

perovskite recipe and optimized the system under different conditions. Under certain circumstances, a perovskite solar cell with power conversion efficiency ~9% can be achieved with PEDOT:PSS as hole transporting layer with the conventional structure.

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