



Nadine Tchamba Yimga

EHF – Organic and Hybrid Photovoltaics

Controlling the electronic properties in liquid crystal conjugated small molecules for application in electronics

Organic semiconductors offer numerous advantages for electronic and opto-electronic applications such as chemical flexibility, good optical properties, low material usage, low cost processing via solution processing. However, carrier mobilities in organic semiconductors are generally orders of magnitude lower than those in inorganic semiconductors. This is a major bottle neck for increasing device efficiency. The electrical properties are additionally strongly dependent on thin film structure and morphology which is challenging to control in solution deposited films.

In this talk we study structure-function relationships in a novel small molecule which demonstrates liquid crystal properties. The molecular films demonstrate phase changes from the crystalline to nematic to isotropic phases at temperatures of 140 C, 165 C and 250 C, respectively. By controlled film preparation we can manipulate the film crystallinity and thereby influence the electrical and optical properties. We demonstrate the influence of temperature on the structural properties of solution processed films with cross polarized microscope (CPM) and X-ray diffraction (XRD). Electrical measurements were performed on single carrier devices using current-voltage measurements and impedance spectroscopy. We found that after annealing the films to temperatures above the crystalline – nematic phase change and subsequently cooled, the mobility can be increased from $10^{-5} \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ (as prepared) to $10^{-3} \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$. We investigated the electric field dependence of the mobility on the dispersion of the carrier transport and demonstrated that controlled structural manipulation of the film can be used to reduce electronic disorder. These results demonstrate the potential of liquid crystal conjugated materials in organic electronic applications.

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