Charge Transport Anisotropy of Oriented Semiconducting Polymer Films Grown at Liquid/Air Interfaces

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Semiconducting Polymers (SCPs) are emerging as material for the active layer of organic field-effect transistors (OFETs) for printed and flexible electronics. Various methods have been proposed to orient SCPs as the field-effect mobility, μ, in OFETs can be improved by aligning the backbone along the current direction [1]. However, difficulty in multilayer film coating by various methods to orient polymer is still a major limitation because of the unavailability of orthogonal solvents for a majority of the SCPs [1]. The unidirectional floating film transfer method (UFTM) is an efficient film fabrication technique to prepare oriented film [2]. In UFTM, film preparation is isolated from the device substrate; therefore, structural order and thickness can be independently controlled [2].

Most of the reports in UFTM and related method utilizes polarized UV-vis absorption spectroscopy to evaluate the dichroic ratio (DR) and air interface of the films are transferred at the dielectric interface of bottom-gated top-contact (BGTC) OFETs. Optical anisotropy is not surface sensitive and probes the absorbance throughout the bulk (including liquid and air interface). Since the orientation in UFTM is supposed to occur due to frictional force arising from the viscous liquid substrate, it is important to investigate charge transport anisotropy, $\mu_{\parallel}/\mu_{\perp}$, at both the interfaces as the structural order of the SCPs can change through the thickness direction.

The orientation of SCPs results in a large $\mu_{\parallel}/\mu_{\perp}$ of which value is determined within a few nm of the thin film of SCP near the dielectric interface. Therefore, we examined $\mu_{\parallel}/\mu_{\perp}$ in UFTM films by different OFET geometry and SCP thickness utilizing different interfaces of UFTM films, as shown in Fig. 1. Thin films of SCP, Poly(3,3‴-didodecyl-quaterthiophene) (PQT) were prepared by UFTM as described in the literature [2]. Film thickness was increased by changing the PQT concentration in anhydrous $CHCl_3$.

Fig. 1 shows the $\mu_{\parallel}$ and $\mu_{\perp}$ at both the interfaces. High $\mu_{\parallel}/\mu_{\perp}$ can be confirmed at both the interfaces even when the thickness changes from 5.5 nm to 30 nm. These results suggest that the orientation distribution of SCPs in UFTM is almost uniform throughout film thickness. Slight variations of overall and $\mu_{\parallel}/\mu_{\perp}$ in TGBC and BGTC at different thicknesses resulted from several variations in the films and OFET geometry. The optical and morphological changes with polymer thickness will be presented in detail. The effect of DR, contact resistance and OFET geometry on overall μ and $\mu_{\parallel}/\mu_{\perp}$ will also be discussed.

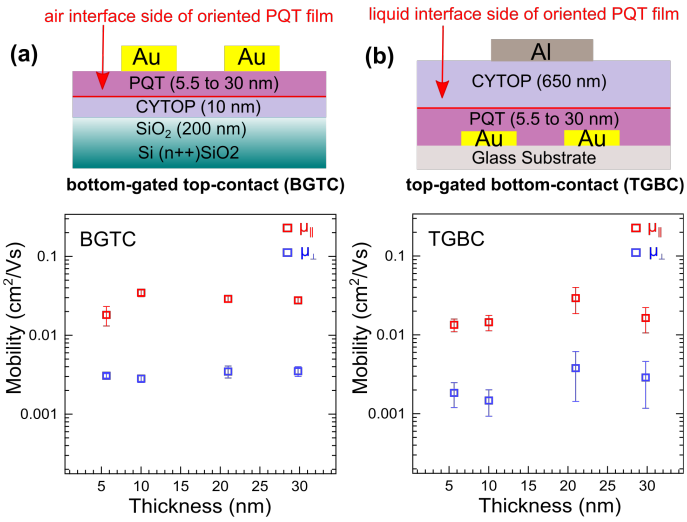

Fig.1. OFETs schematics and evolution of saturation field-effect mobility along the parallel and perpendicular direction increasing SCP thickness. (a) BGTC OFETs. (b) TGBC OFETs

References:
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[2] M. Pandey et al., ACS Appl. Mater. Interfaces **2021**, *13*, 38534.