Orientation Characteristics of Large-area Thin Films of Conjugated Polymers Fabricated via ribbon-shaped FTM

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Organic semiconductor device using conjugated polymers (CPs) research has attracted a lot of attention in the past three decades due to their potential application in futuristic devices owing to their flexibility, biocompatibility. Many efforts have been made to understand and improve the charge transport in thin films of organic semiconductors by tuning their chemicals structures or by improving their film crystallinity. Solution processability of CPs and tailor-made synthetic versatility makes them a potential candidate for the active layer of organic field effect. The quasi-one-dimensional nature of polymer backbones offers increase in carrier transport when oriented along the channel direction of organic field effect transistors (OFETs). Many different methods have been reported in the recent past to orient the CPs uniaxially, however, most of them are either not suitable for large-area organic thin-film fabrication or not capable for multi-layered film fabrication due to chemical and mechanical damages [1]. Ribbon-shaped floating film transfer method (FTM) developed by Tripathi et al. for large-area film fabrication with oriented polymer chains offers various advances and can solve most of the issues that exist with other conventional techniques (2).

In this work, we successfully fabricated uniform and oriented large-area (>30 cm^2) floating film of poly (3, 3'''- dialkylquaterthiophene) (PQT C-12) using ribbon-shaped FTM. These films were successfully transferred on rigid/flexible substrates by simple stamping and were subjected to different thin film characterizations. It was observed that the films were highly uniform along the length and width of the spreading direction which was interpreted by the variation in peak intensity of non-polarized absorption spectra. The films were found to have high dichroic ratio (DR) > 10 and quite uniform at the center. The initial characterizations of polarized spectra revealed that orientations at the edge in these floating films were in different direction to that of center region. Polymer orientation direction at the edges shifts to several degrees with respect to center area due to the sheer force of liquid substrate which continuously acts on the films' edges while spreading the floating film.

These variations were measured with angle-dependent polarized absorption mapping for the entire region, and it was found that orientation intensities were similar everywhere, however, the direction of backbone orientation varied along the width, i.e., center, boundary, and most edges regions of the PQT C-12 ribbons. The variation in orientation direction was further confirmed by fabricating OFETs with the channels along the backbone orientation direction. It was found that the device for each area shows anisotropic characteristics. For devices in the central region, the maximum charge mobility was along the ribbon width whereas the devices fabricated from the boundary and edges of floating films show that the maximum charge mobility shifted from 0 deg. These results reinforced the results obtained through polarized absorbance spectroscopy. The results will be discussed further during the presentation.

References:

(1) M. Pandey et al. J. Mater. Chem. **7**, 13323 (2019).
(2) Tripathi et al. Appl. Phys. Lett. **112**, 123301 (2018).