Solution Processing of Semiconducting Organic Molecules for Tailored Charge Transport Properties

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We studied the charge transport characteristics of the organic semiconductor 6,13-bis(tri isopropyl silyl ethynyl) pentacene (TIPS-PEN) deposited by dip-coating of a solution in an azeotropic solvent mixture. Arrays of crystalline ribbons were obtained with a morphology controllable by variation of the coating speed U. The charge carrier mobility μ exhibited a systematic and reproducible dependence on the coating speed U and maximum values as high as $\mu \approx 1.0$ $cm^2/(V\ s)$. [1]

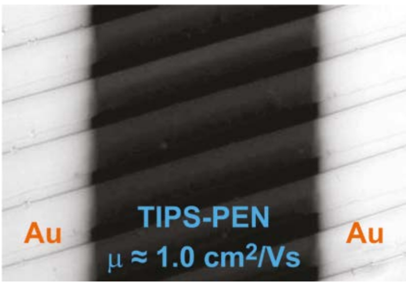

Fig. 1: Optical micrograph of TIPS-PEN crystal ribbons deposited on a Si substrate by means of solution crystallization. The white regions have increased reflectivity due to evaporated Au layers that form the source and drain contacts. Image width 200 μm.

We used isopropanol (IPA) and toluene, which exhibit a positive azeotropic point at a volume fraction (VF) of approximately 1/1. We typically use IPA/toluene VFs above 55/45, such that the vapor concentration of toluene exceeded its concentration in the liquid phase, which tends to enrich in IPA over time. The TIPS-PEN concentration was 1.5 wt%. In Fig. 2 we show the dependence of the average ribbon width <w> and the fill factor f that were extracted from the optical microscopy images. The ribbon width monotonically decreases with increasing dip-coating speed. The solid line corresponds to a power-law relation $\langle w\rangle = b(U/U_0)^{\alpha}$ with $U_0 = 0.12$ mm/s and fit parameters b = 5.5 μm and $\alpha = 0.94$. Figure 3 presents the dependence of the field effect mobility μ on the dip-coating speed. A very well-defined maximum of the carrier mobility $\mu_{max} \approx 0.75$ $cm^2/(V\ s)$ is observed in the vicinity of $U_{opt} = 0.02$ mm/s.

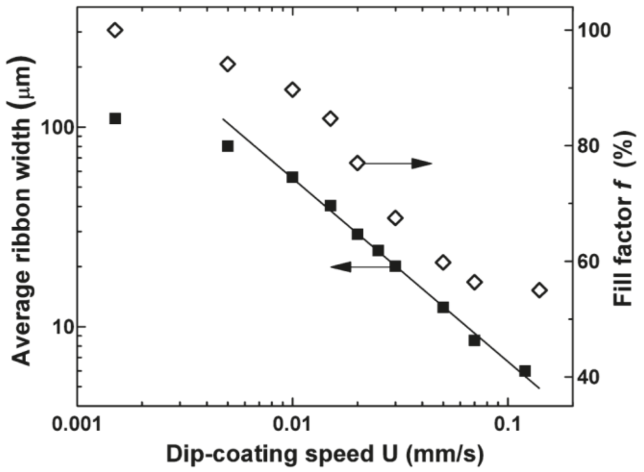

Fig. 2: Average TIPS-PEN ribbon width <w> and fill factor f as a function of U.

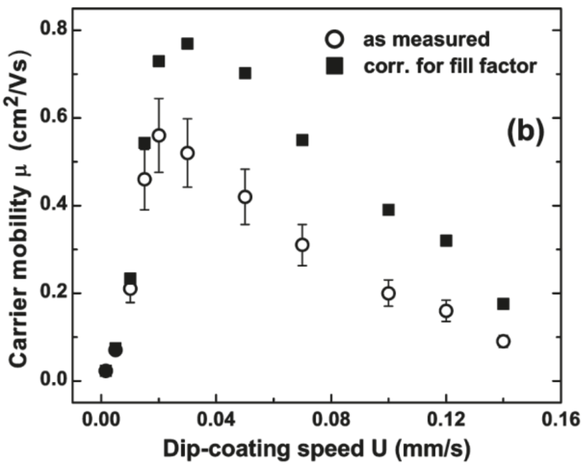

Fig. 3: Saturated carrier mobility μ vs U.

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References

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