Wettability Control of Interfaces for High-Performance Organic Thin-Film Transistors by Soluble Insulating Polymer Films

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ABSTRACT: Organic small-molecule semiconductors have higher carrier mobility compared to polymer semiconductors, while the actual performances of these materials are susceptible to morphological defects and misalignment of crystalline grains. Here, a new strategy is explored to control the crystallization and morphologies of a solution-processed organic small-molecule semiconductor 2,7-dioctyl[1]benzothieno[3,2-b][1]benzo thiophene (C8-BTBT) using soluble polymer films to control the wettability of substrates. Different from the traditional surface modification method, the polymer layer as a modification layer is soluble in the semiconductor solution during the fabrication of organic thin-film transistors (OTFTs). The dissolved polymer alters the state of the semiconductor solution, which in turn, changes the crystallographic morphologies of the semiconductor films. By controlling the solubility and thickness of the polymer modification layers, it is possible to regulate the grain boundary and domain size of C8-BTBT films, which determine the performances of OTFTs. The bottom-gate transistors modified by a thick PS layer exhibit a mobility of >7 cm²/Vs and an on/off ratio of >10⁵. It is expected that this new modification method will be applicable to high-performance OTFTs based on other small molecular semiconductors and dielectrics.

INTRODUCTION

Organic thin-film transistors (OTFTs) have received much attention due to their solution-processable and low-temperature processes.¹⁻⁶ Among the solution-processable organic semiconductors, small molecules usually possess higher field-effect mobilities compared to polymers.⁷⁻⁹ However, the strong π−π interactions between small molecules and the low viscosity of the solutions often lead to inhomogeneous nucleation and dewetting of films from substrates.¹⁰⁻¹² Recently, blending a small molecular semiconductor with an insulating polymer has successfully been realized as an effective way to solve this problem.¹³⁻¹⁸ The addition of the polymer can increase the uniformity of the films and induce spontaneous vertical phase separation, which results in efficient charge transport.¹⁹⁻²¹ The microstructures of the blend films are easily affected by various interactions such as solute–substrate, solute–solvent, and solute–solute interactions during the solvent evaporation.¹¹,²²⁻²⁶ To further develop polymer–small molecule blended OTFTs with desired properties, much effort has been devoted to engineering interfaces to control the crystallographic morphologies and phase-separated structures of blend films. Self-assembled monolayers (SAMs),²⁷⁻²⁹ UV–ozone interface modification,³⁰ and selective-dewetting pattern³¹,³² were the commonly used methods to improve the qualities of blend films. These methods were committed to change the surface energy of the interface. However, commonly used SAMs, such as OTS and HMDS, have low surface energies, which prevented the wetting of the solution on the substrate.

Another kind of modification method to control the crystallization of small molecules is to engineer the surface with soluble polymer films. In 2010, Kjellander et al. first introduced the concept of soluble polymer films and successfully fabricated a semiconductor film with the large grains by printing TIPS-PEN on a thin soluble layer of P3HT.³³ Later, Qiu et al. controlled the morphologies of a printed small molecule semiconductor film by modifying the printed surfaces with polymer brushes. The TIPS-PEN molecules became more aligned and crystallized more rapidly to form a larger crystal.³⁴ However, soluble polymer films are usually used to modulate the crystallization of small molecules in the inkjet-printing method, which requires much more complex instruments and device-to-device variation that limit the practical application. Few studies have considered the impact of soluble polymer films on spin-coated small-molecule semiconductor films. Spin-coated blend semiconductor films with the modification of soluble polymer films have not been
reported till now. In this modification method, the blend solution was spin-coated on the soluble polymer film, and then the droplet locally dissolved the polymer layer. The crystallization and morphology of the films were thereby effectively controlled by the addition of a soluble polymer in the solution.

In this work, we introduce a soluble insulating polymer film to control the crystallinities and morphologies of spin-coated blend films. A SiO₂ gate dielectric was modified with different polymer films, which can be dissolved in the solvent of a blend solution. The small molecule, 2,7-diocyl[1]benzothieno[3,2-\(b\)][1]benzothiophene (C₈-BTBT), which has a high solubility, good environmental stability, and high charge transport mobility,\(^{35-38}\) was mixed with common poly(methyl methacrylate) (PMMA) in chlorobenzene as the blend solution. The morphology, crystallization, and electrical properties of the C₈-BTBT/PMMA blend films were investigated when different soluble insulating polymer films were used. Large self-assembled crystals with uniform structures were obtained by exploiting a thick polystyrene (PS) modification layer and the resulting devices demonstrated a high field-effect mobility of \(>7 \text{ cm}^2/\text{V} \cdot \text{s}\) without obvious hysteresis.

**RESULTS AND DISCUSSION**

Figure 1a shows the schematic diagram of our experimental system, which describes the formation process of an organic small molecular semiconductor thin film. C₈-BTBT and PMMA with a weight ratio of 5:1 were dissolved in chlorobenzene solvent. Then the mixture solution was spin-coated onto the polymer film. We expect that the polymer layer is dissolved by the organic solvent within a few seconds after the mixture solution is dropped on it (Figure 1a, step A). After starting the spinning, the relatively hydrophobic C₈-BTBT molecules tend to deposit toward the top layer of the blend film and a vertical phase-separated structure is formed as the solvent evaporates (Figure 1a, step B). We further provide evidence to confirm the phase-separated structure of the blend film by measuring water contact angles. C₈-BTBT in the chlorobenzene solvent and PMMA in the butanone solvent were respectively spin-coated onto the SiO₂ substrates. The mixture of C₈-BTBT and PMMA in the chlorobenzene solvent was spin-coated onto the substrate with PS modification. The water contact angles of these films are shown in Figure 1b. The water contact angle of the blend film resembles that of the as-spun C₈-BTBT film (∼108°). This indicates that the vertical
Table 1. Electrical Properties of Transistors Based on the C8-BTBT/PMMA Film Deposited by Spin-Coating on Different Polymer Modification Layers at 2000 rpm

| dielectric | $C_i$ (nF/cm²) | $V_{th}$ (V) | $I_{on}/I_{off}$ | SS (V/decade) | $N_{tr}$ (cm⁻² eV⁻¹) | average mobility (cm²/V·s) |
|------------|----------------|-------------|-----------------|---------------|-------------------|--------------------------|
| SiO₂       | 11.4           | −47.7 ± 4.5 | $10^5$−$10^6$   | 8.2 ± 0.4     | $(9.8 \pm 0.5) \times 10^{12}$ | 0.12 ± 0.09 |
| PMMA/SiO₂  | 10.2           | −42.3 ± 4.2 | $10^5$−$10^6$   | 6.3 ± 0.3     | $(7.5 \pm 0.3) \times 10^{12}$ | 0.65 ± 0.25 |
| PS/SiO₂    | 11.3           | −33.5 ± 3.9 | $>10^7$         | 4.7 ± 0.3     | $(5.6 \pm 0.3) \times 10^{12}$ | 1.86 ± 1.02 |

Figure 3. Optical microscopy images and polarized optical microscopy images (inset) of C8-BTBT/PMMA blend films on (a) SiO₂, (d) PMMA/SiO₂, and (g) PS/SiO₂ substrates. The corresponding transfer characteristics (b), (e), and (h) and output characteristics (c), (f), and (i) of C8-BTBT/PMMA blend films. All of the blend films were spin-coated on the substrates at 5000 rpm.

segregation of blend films occurs after spin-coating with the structure of the top-C8-BTBT and the bottom-PMMA.

The crystallographic morphologies of blend films are found to be strongly influenced by the modification layer of soluble polymer films. PS and PMMA were, respectively, dissolved in butanone to obtain a 5 mg/mL solution. They were spin-coated on Si/SiO₂ substrates to modify the interface. AFM images of the modified layer of PS and PMMA are shown in Figure S1. The grain boundary is the junction of grains with different orientations. The junction is sensitive to many factors such as the amount of polymer and the solvent evaporation rate. Figure S2 shows the AFM image of C8-BTBT/PMMA blend films spin-coated on SiO₂ substrates at 2000 rpm. The junction is wide and rough, restricting the effective transport of charge carriers. Figure 2a–c shows polarized optical microscopy images of devices obtained by spin-coating a C8-BTBT/PMMA blend solution onto a SiO₂ layer and different thin polymer layers at 2000 rpm. As shown in Figure 2a, the C8-BTBT film on the SiO₂ substrate shows a wide grain boundary, which limits the efficient transfer of carriers. Interestingly, the crystallization of C8-BTBT molecules is improved on soluble polymer-based films. The film on the PMMA/SiO₂ substrate exhibits larger polycrystals and the wide grain boundaries still exist, as shown in Figure 2b. In Figure 2c, the crystallization of the film on PS/SiO₂ is totally different and the wide grain boundaries in the film disappear. Actually, the polymer usually possesses a lower surface free energy compared to inorganic SiO₂. The surface free energies of SiO₂, PMMA, and PS are calculated in Table S1. The lower surface energy of the interface may weaken the aggregation of C8-BTBT. The different crystallographic morphologies in Figure 2a–c are not only attributed to the lower surface energy of the polymer films, which results in the smaller affinity of C8-BTBT molecules to the substrate surface. More importantly, the dissolution of polymer films will cause a change of the blend solution, affecting the crystallization of small molecules during solvent evaporation. The bottom soluble polymer will hinder the aggregation of C8-BTBT and provide a platform for C8-BTBT to crystallize. To prove whether the polymer film is dissolved in the organic solvent during the spin-coating process, the capacitances of polymer films are measured before and after the dissolution of the modification polymer. A change in capacitance means a change in the thickness of the soluble insulating polymers. Figure S3a is the schematic of the used metal–insulator–metal capacitor structure. A 60 mg/mL PMMA solution and 120 mg/mL PS solution in butanone were spin-coated as the dielectric. Then the C8-BTBT/PMMA blend solution was spin-coated on this polymer dielectric as the control group. Figure S3b shows the measured specific capacitances of the PMMA film before and after spin-coating the C8-BTBT/PMMA blend solution. The capacitance of the film shows a slight increase, implying a small amount of PMMA is dissolved. However, the capacitance of the PS film increases by more than ten times after spin-coating the C8-BTBT/PMMA blend, as shown in Figure S3c. This implies that a majority of the PS film is dissolved when the C8-BTBT/PMMA solution is spin-coated on it. Our main focus is not the difference between PS and PMMA, but that the dissolution of the polymer film can affect the microstructure of the small molecule, C8-BTBT, because in a practical film fabrication process, the small molecular film is sensitive to the substrate properties such as the surface energy and roughness. The
polymers usually have excellent solution processability, which can make them adapt well to different substrates. So, we can fabricate high-performance OFETs on a paper substrate and many other complex substrates by introducing a soluble polymer film.

Figure 2d,e shows the transfer and output characteristic of C8-BTBT/PMMA blend OTFTs with different soluble insulating polymer modifications. The devices were operated with the gate voltage varying from 0 to −80 V and the source/drain voltage fixed at −80 V. The representative parameters of OTFTs with different polymer modifications, including the capacitance (C), threshold voltage (Vth), on/off ratio, subthreshold swing (SS), upper limit of the trapped charges (Nmax), and saturation mobility are summarized in Table 1. Here, all capacitances of films with polymer modification have been measured for the extraction of the carrier mobility.

As shown in Table 1, the average mobilities of C8-BTBT/PMMA blend OTFTs increased from 0.1 to 1.8 cm²/V·s when PS is used to modify the SiO2 substrate. The improved performances of OTFTs are not only due to the better crystallization of small molecular films under PS modification, but also a better interface between C8-BTBT molecules and the dielectric. It is clear that the Vth of the device shifts toward 0 V after PS or PMMA modification. Generally, Vth increases with an increase of the trap-state density at the interface of the semiconductor and dielectric. We also calculated the upper limit of the trapped charges at the interface by

\[ N_{\text{trap}} \approx \frac{qS \log(e)}{k_BT} - 1 \left( \frac{C_i}{q} \right) \]

where q is the electronic charge, S is the subthreshold slope, C_i is the capacitance of the dielectric, and k_B is the Boltzmann constant. The smaller value of N_{\text{trap}} with polymer modification also indicates a better interface is formed between C8-BTBT and the dielectric. The increased mobility is attributed to the reduced trap density of the interface, which improves the charge transport. Therefore, the C8-BTBT/dielectric interface modified by the soluble insulating polymer films can effectively improve the crystallization state of the small molecule and improve the performances.

The solvent evaporation rate is another important factor for the grain boundary width. The C8-BTBT molecule will have enough time to aggregate when the evaporation rate is low, leading to a wide grain boundary. Figure 3a,d,g shows the optical microscopy images of C8-BTBT/PMMA blend films (a) SiO2, (d) PMMA/SiO2, and (g) PS/SiO2 substrates. All films were prepared by spin-coating the precursor solution at 5000 rpm. It is quite different from the blend film spin-coated at 2000 rpm. The C8-BTBT molecule does not have enough time to aggregate under high speed. It can be seen that the surface of the blend film becomes smoother when PMMA or PS modifies the surface of SiO2. Furthermore, the surfaces of blend films on PS/SiO2 substrates are smoother than those of films on PMMA/SiO2 substrates. To provide additional proof, AFM morphology images of C8-BTBT films on different substrates were characterized and are shown in Figure S4. The C8-BTBT/PMMA blend films on the PS/SiO2 substrate show smaller roughness. The possible reason is that the PS polymer with high solubility is beneficial to the crystallization of C8-BTBT molecules. The corresponding polarized images of blend films are shown in the insets of Figure 3a,d,g. Interestingly, under this high-speed spin-coating condition, all C8-BTBT/PMMA blend films do not exist as wide grain boundaries, which is totally different from the crystallographic morphologies of the blend films under a low-speed spin-coating condition, as shown in Figure 2. This is because the evaporation rate of the solvent at a high spinning speed is faster than that at a low spinning speed, resulting in the change of molecular crystallization. Further, the electrical properties of blend film OTFTs have been investigated. Figure 3b,f,h show the corresponding transfer and output characteristics of OTFTs based on SiO2, PMMA/SiO2, and PS/SiO2 substrates. The electrical parameters of transistors based on C8-BTBT/PMMA blend films on different substrates have been extracted from their transfer curves, as listed in Table 2. It is clear that the OTFTs with blend films fabricated at a high spin-coating speed show superior performances compared to the devices fabricated at a low spin-coating speed.

On the other hand, it is seen that the C8-BTBT/PMMA blend OTFTs with soluble PS layer modification show better performances compared to devices modified with less soluble

| dielectric | C_i (nF/cm²) | Vth (V) | Ion/Ioff | SS (V/decade) | N_{\text{trap}} (cm⁻³ eV⁻¹) | average mobility (cm²/V·s) |
|------------|-------------|--------|--------|-------------|-------------------|-----------------|
| SiO2       | 11.4        | −45.6 ± 4.8 | >10⁷  | 3.9 ± 0.3    | (4.6 ± 0.4) × 10¹² | 1.85 ± 0.68     |
| PMMA/SiO2  | 10.0        | −40.5 ± 4.2 | >10⁷  | 3.8 ± 0.2    | (4.5 ± 0.2) × 10¹² | 2.24 ± 0.75     |
| PS/SiO2    | 11.3        | −41.2 ± 3.5 | >10⁷  | 3.4 ± 0.2    | (3.7 ± 0.2) × 10¹² | 3.16 ± 1.24     |

Table 2. Electrical Properties of Transistors Based on the C8-BTBT/PMMA Blend Film Spin-Cast on Different Polymer Modification Layers
PMMA. It is consistent with the results of the optical microscopy image of blend films with different substrates. Further, the impacts of the thickness of the PS film on the performances of devices have been explored. PS films of different thicknesses were obtained by spin-coating different concentrations of the PS solution (10, 30, 60, 90, 120, 150 mg/mL) on SiO2 substrates. Then, the C8-BTBT/PMMA blend solution was spin-coated on these PS films at 5000 rpm. To investigate the dissolution of the PS films of different thicknesses and calculate the mobilities of the devices, the capacitances of PS/SiO2 were measured before and after spin-coating the C8-BTBT/PMMA blend solution.

Figure 4a shows the measured specific capacitances of PS/SiO2 as a function of frequency. It is seen that the capacitances of PS/SiO2 bilayer films decrease with the increase of PS thickness. However, as shown in Figure 4b, the capacitances of PS/SiO2 bilayer films do not exhibit a large change for modification with PS of different thicknesses on the SiO2 substrate after spin-coating semiconductor blends. This is because the PS film can be easily dissolved by the solvent in the C8-BTBT/PMMA blend solution. To further explore the dissolution of PS films, the thickness of PS films has been calculated before and after dissolution by equation $C_i = \frac{\varepsilon_i}{4\pi\varepsilon_0kd}$ and equation $\frac{1}{C_{\text{total}}} = \frac{1}{C_{\text{SiO2}}} + \frac{1}{C_{\text{PS}}}$, where $C_i$ is the capacitance of the dielectric, $\varepsilon_i$ is the static dielectric constant, $k$ is the Boltzmann constant, $d$ is the thickness of the dielectric, $C_{\text{total}}$ is the capacitance of the PS/SiO2 bilayer film, $C_{\text{SiO2}}$ is the capacitance of the SiO2 layer, and $C_{\text{PS}}$ is the capacitance. Figure 4c shows the calculated thickness of the modified PS layer deposited with different concentrations of the PS solution on the SiO2 substrate after spin-coating the C8-BTBT/PMMA blend solution. Interestingly, due to the dissolution of PS, the resulting thickness of the PS layer exhibits a small change when the PS concentration is below 120 mg/mL, which implies that the majority of the PS film has dissolved.

Figure 5a shows the polarized optical microscopy images of films fabricated by spin-coating the C8-BTBT/PMMA blend solution on the PS layer with different thicknesses. It is found that the domain size becomes larger when the thickness of the PS modification layer increases. When the concentration of the PS solution exceeds 120 mg/mL, the polarized optical contrast of C8-BTBT films becomes weak. Figure 5b,c shows the histograms of mobility and threshold voltage of devices modified with PS films of different thicknesses. The mobilities of the devices increase when the concentration of the PS film is above 120 mg/mL.
solution is not higher than 120 mg/mL. However, the mobilities of devices start to decrease when the concentration of the PS solution exceeds 120 mg/mL. When the concentration of the PS solution exceeds 120 mg/mL, an average mobility of >4 cm²/V·s and the highest mobility of >7 cm²/V·s are obtained, which are comparable with those of devices with solution-processed polycrystalline C8-BTBT films and other organic small molecular semiconductors. The deviation in mobility values is slightly large. The possible reason is the defects in C8-BTBT films, different from OTFTs based on polymer semiconductors. The crystallization of the C8-BTBT film is uniform overall, but there are more or less differences in the channel of each device. It can also be seen that the threshold voltages of devices fabricated with PS solutions of different concentrations demonstrate small changes. It is speculated that the thickness of the PS modification layer has little influence on the interface of the semiconductor C8-BTBT and dielectric, but a large influence on the crystallization of C8-BTBT molecules.

Figure 6a shows the schematic diagram of the top-contact bottom-gate OFETs with soluble PS layer modification. The threshold voltage is related to materials (semiconductor and dielectric) and traps of the interface of the semiconductor and dielectric. The relatively high threshold may be related to traps resulting from the exposure of the organic semiconductor and/or the organic semiconductor/dielectric interface to the ambient environment in our case. The typical transfer and output characteristics of the device with 120 mg/mL PS modification are shown in Figure 6bc. The corresponding dependence of mobility on the gate voltage is shown in Figure S5. The optimized device exhibits a high mobility of 7.01 cm²/V·s and a high on/off ratio of >10⁷. More importantly, devices also demonstrate little hysteresis during the double sweep of the gate voltage. The recently reported characteristics of BG-OFETs based on blends of C8-BTBT and insulating polymers are summarized in Table S2. Although the mobility exceeds 10 cm²/V·s in some OTFTs based on oriented films or single crystals, our devices provide higher competitiveness in C8-BTBT OTFTs based on uniform and isotropous semiconducting films.

To further understand the influence of soluble insulating polymer modification on the crystallization of C8-BTBT molecules, we also carried out XRD measurements of the C8-BTBT/PMMA blend layer coated on the PS/SiO₂ substrate with different thicknesses of PS films. As shown in Figure 7, three characteristic peaks of the (001), (002), and (003) reflections were observed for the films fabricated on the SiO₂ substrate with the modification of different thicknesses of PS films. It is clear that the thickness of the PS modification layer largely affects the crystallinity of the C8-BTBT thin film. As is known, the full width at half-maximum (FWHM) of XRD patterns depends on the crystallization of films. The FWHM values of peaks in XRD patterns for the films with the interface modification of PS are extracted. The extracted FWHM values are shown in Table 3. The crystallization of C8-BTBT films will be affected by the dissolved PS modification layer. The dissolved PS amount increases accordingly with the thickness of the PS modification layer. The dissolved bottom PS hinders the aggregation of C8-BTBT, leading to a narrower grain boundary. However, when the dissolved PS amount is very high, C8-BTBT separates to some extent and is hard to concentrate. So, the crystallization of C8-BTBT is weak when 150 mg/mL PS is used, with a correspondingly increased FWHM. The diffraction (001) peak of the film deposited on the substrate with 120 mg/mL PS modification exhibits the smallest FWHM of 0.16°, which implies better crystallization of the C8-BTBT film. This result is consistent with the polarized optical images in Figure 5a. The good crystallization of the C8-BTBT film is attributed to the interface modification of the soluble insulating polymer, which induces the crystallization of C8-BTBT molecules at the soluble polymer interface.

CONCLUSIONS

In summary, a new method is provided for improving the performances of solution-processed C8-BTBT OTFTs. Highly crystalline, uniform, and isotropic thin films of C8-BTBT were formed by spin-coating a C8-BTBT/PMMA mixture on a substrate with the modification of a soluble polymer film. The excellent crystallization of the semiconductor films is attributed to the interface modification of the soluble insulating polymer, which is beneficial to the crystallization of the small-molecule semiconductor at the interface. As a result, the charge transport is improved and the grain boundary and the domain size of C8-BTBT films are well controlled by adjusting the solubility and thickness of the polymer modification layers. An optimized C8-BTBT OFET with a mobility of >7 cm²/V·s and an on/off ratio of >10⁷ is achieved. Our findings provide a simple and efficient way to modify a small-molecule semiconductor/dielectric interface and to fabricate high-performance OTFTs.

EXPERIMENTAL SECTION

Materials. The small molecular semiconductor C8-BTBT was purchased from Sigma-Aldrich. Polystyrene (PS, Mₙ = 3.5 kDa) and poly(methyl methacrylate) (PMMA, Mₙ = 996 kDa) were purchased from Sigma-Aldrich. Chlorobenzene and butanone solvents were purchased from Sigma-Aldrich. All materials were used as received without further purification.

Preparation of Soluble Polymer Films. Heavily doped p-type silicon wafers with 300 nm-thick SiO₂ layers were used as substrates. The Si wafer was used as the gate electrode and the SiO₂ layer as the gate insulator. The substrates were ultrasonically cleaned for 15 min with acetone, isopropanol, and DI water. After cleaning, the substrates were placed in an air oven for 30 min at 80 °C to remove residual water. The PS and PMMA solutions with different concentrations in butanone were spin-coated at 3000 rpm for 60 s on SiO₂ substrates as the soluble modification layer. The treated wafers were then baked on a 70 °C hot plate for 2 h to remove the residual solvent.
Fabrication of the OFET Devices. C8-BTBT/PMMA blends were prepared by mixing the two components in a 5:1 weight ratio and were dissolved in chlorobenzene to obtain 6 mg/mL solutions. The solutions were further stirred for 1 day to mix completely. The prepared solutions were spin-coated onto soluble polymer films at different speeds in an air environment. Finally, 40 nm-thick Au was deposited to fabricate source and drain electrodes through a metal shadow mask using a thermal evaporator. The channel width/length ($W/L$) was 2 mm/130 μm.

Characterization. The electrical characteristics of OTFTs were measured using a Keithley 4200 semiconductor analyzer, and the capacitance of soluble polymer films was characterized on an Agilent 4294A. Polarized optical micrographs of C8-BTBT-based films were obtained using a CPV-900 reflectance polarizing microscope. The contact angle of the surface was measured with a video-based automatic contact angle measuring instrument (OCA1S, Data Physics). X-ray diffraction (XRD) patterns (2θ scans) were obtained using a Bruker Advanced D8 X-ray diffractometer using Cu Kα (λ = 0.154 nm) radiation.

**ASSOCIATED CONTENT**

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acsomega.0c00548.

AFM images, surface free energy, measured capacitance, the dependence of mobility on gate voltage, and a summary of previously reported work (PDF)

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**Author Contributions**

This paper was written through the contributions of all authors. All authors have given approval to the final version of the paper.

**Notes**

The authors declare no competing financial interest.

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**Table 3. FWHM Values of C8-BTBT/PMMA Blend Films Deposited on the PS/SiO$_2$ Substrate with Different Thicknesses of PS Films**

| PS thickness | 10 mg/mL | 30 mg/mL | 60 mg/mL | 90 mg/mL | 120 mg/mL | 150 mg/mL |
|--------------|----------|----------|----------|----------|----------|----------|
| FWHM         | 0.33°    | 0.32°    | 0.22°    | 0.25°    | 0.16°    | 0.29°    |
Key Points for High-Mobility Organic Field-Effect Transistors: the path beyond amorphous silicon.

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