Supplementary Information

A nanogrooves-guided slot-die coating for highly ordered polymer films and high-mobility transistors

Aung Ko Ko Kyaw,*[a] Lim Siew Lay,[a] Goh Wei Peng,[a] Jiang Changyun[a] and Zhang Jie*[a]

[a]Institute of Materials Research and Engineering, Agency for Science Technology and Research (A*STAR), 2 Fusionoloplis Way, Singapore 138634

Email: kyawakk@imre.a-star.edu.sg, zhangj@imre.a-star.edu.sg

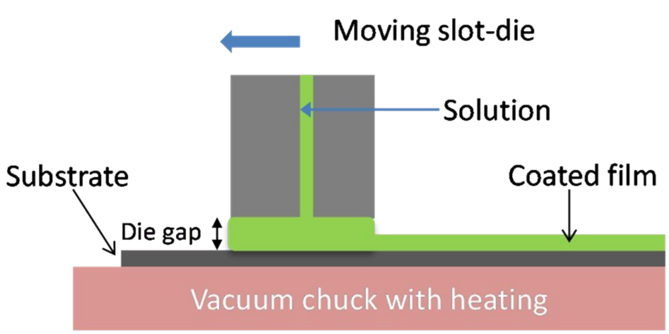


Figure S1. Illustration of slot-die coating used in this study.

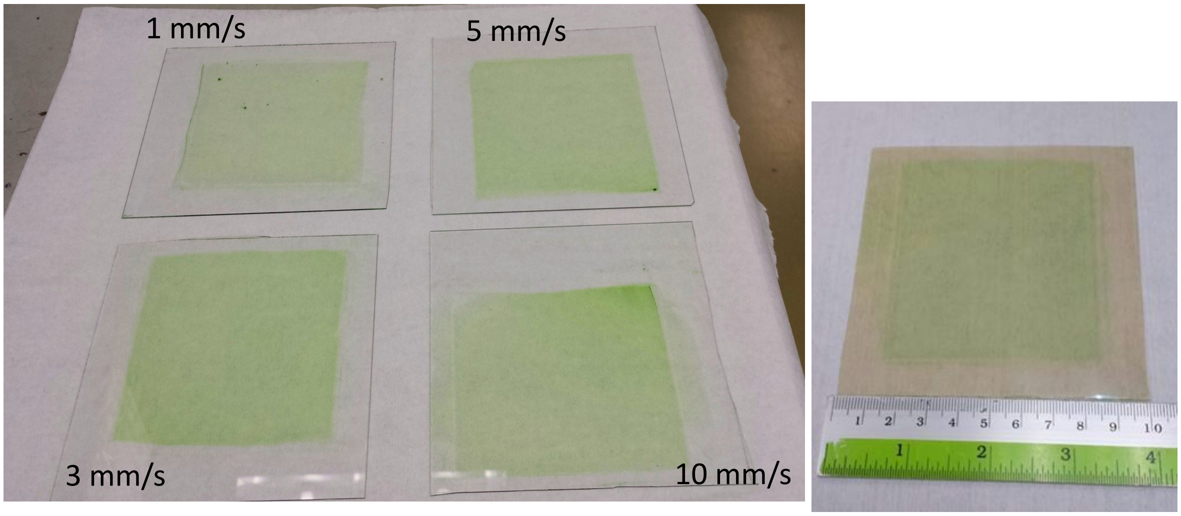
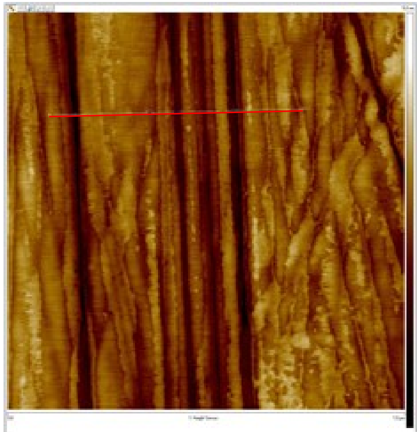


Figure S2. The comparison of PCDTPT films deposited on the glass substrates (10 cm x 10 cm) at various slot-die coating speeds (left). The PCDTPT film deposited on the ITO-coated-PET substrate (10 cm x 10 cm) at slot-die moving speed of 3 mm/s (right).

The moving speed of slot-die influences the thickness and uniformity of the coated film. The thickness of the films coated at 1 mm/s (~ 10 nm) and at 10 mm/s (~ 12-15 nm) are thinner than those coated at 3 mm/s and 5 mm/s (~ 20 nm). The coated film with excellent uniformity is obtained from the slot-die moving speed of 3 mm/s. Note: All the films shown in the figures are as cast condition after solvent drying, without annealing.



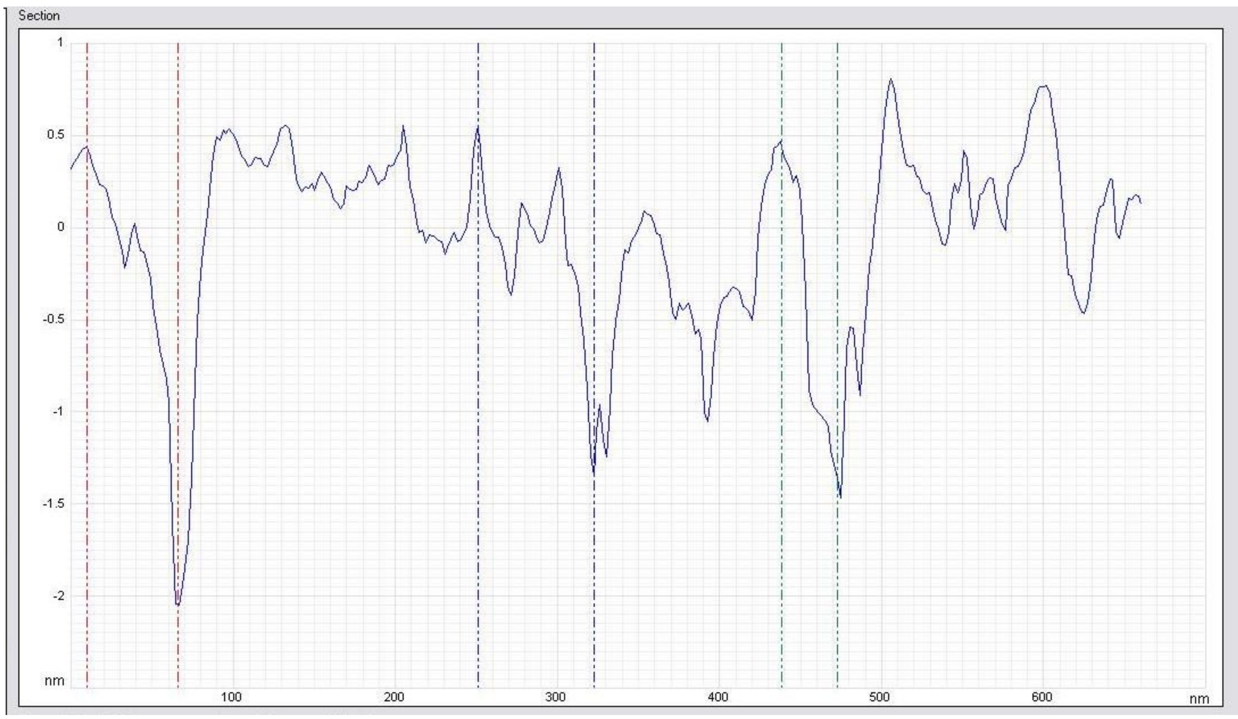


Figure S3. AFM topography of the nanogrooves fabricated on the SiO_2/Si substrate. The scan size is 1 µm x 1 µm (top). The cross-sectional depth profile of the nanogrooves along the red line in the AFM image (bottom) shows that the depth of nanogrooves is ~ 1-2 nm.

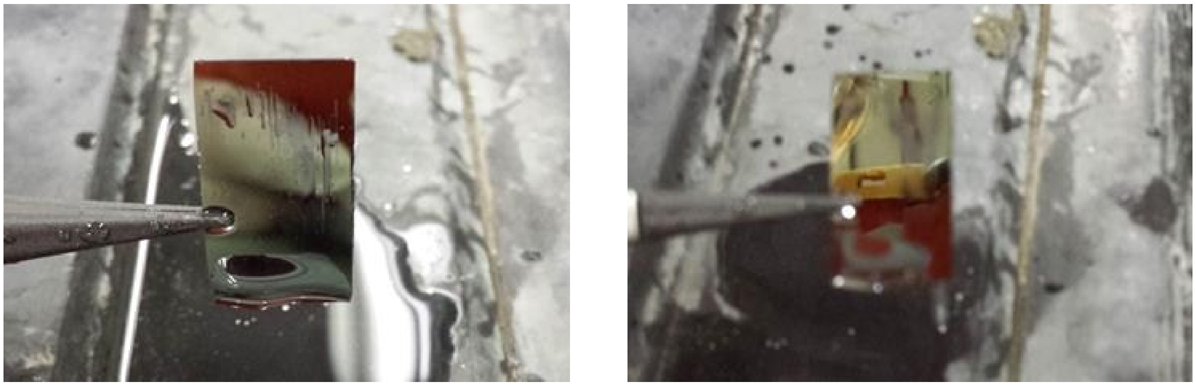


Figure S4. When the substrate was sprayed with deionized water and held in a vertical position, the flow of liquid is parallel with the scratching direction (nanogrooves) (left). However, the parallel flow of liquid was not seen on the bare SiO_2/Si substrate (right).

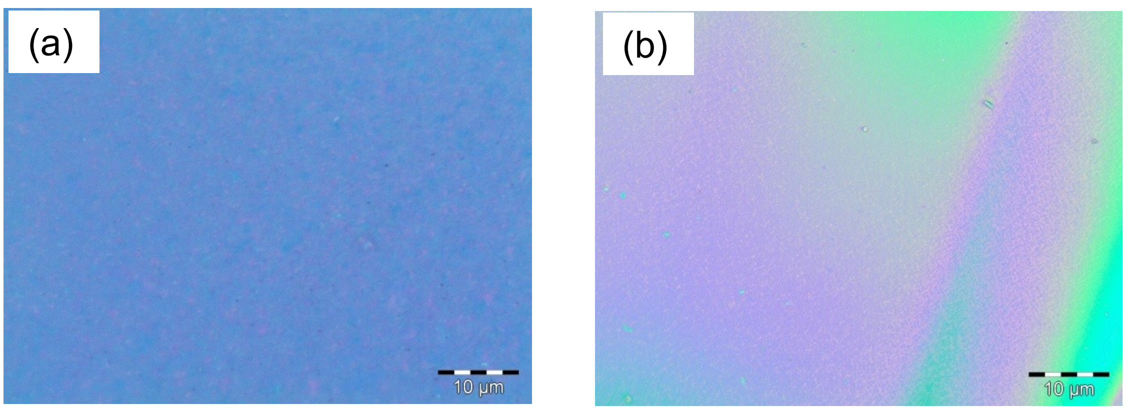


Figure S5. The bright field optical microscopic images of PCDTPT film deposited by spin coating (a) and nanogrooves-guided slot-die coating (b).

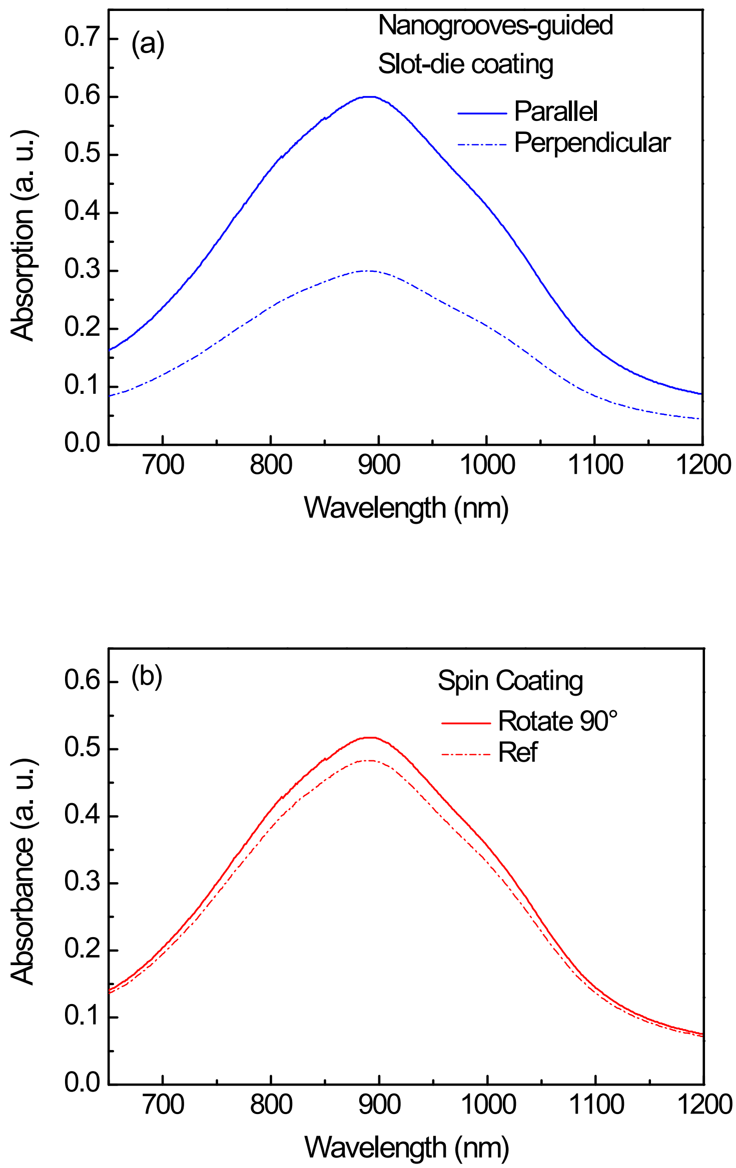


Figure S6. Polarized Vis-NIR absorption of PCDTPT film deposited by (a) nanogrooves-guided slot-die coating and (b) spin coating. In (a), the solid line and dotted line represent the absorption spectra of the PCDTPT film coated by nanogrooves-guided slot-die coating with the incident polarization parallel and perpendicular to the nanogrooves, respectively. In (b), an arbitrary polarization direction which gives the minimum absorption spectrum is assigned as a reference and then polarizer was rotated 90°.

The optical anisotropy parameter is determined by the ratio of the area under respective absorption curves.

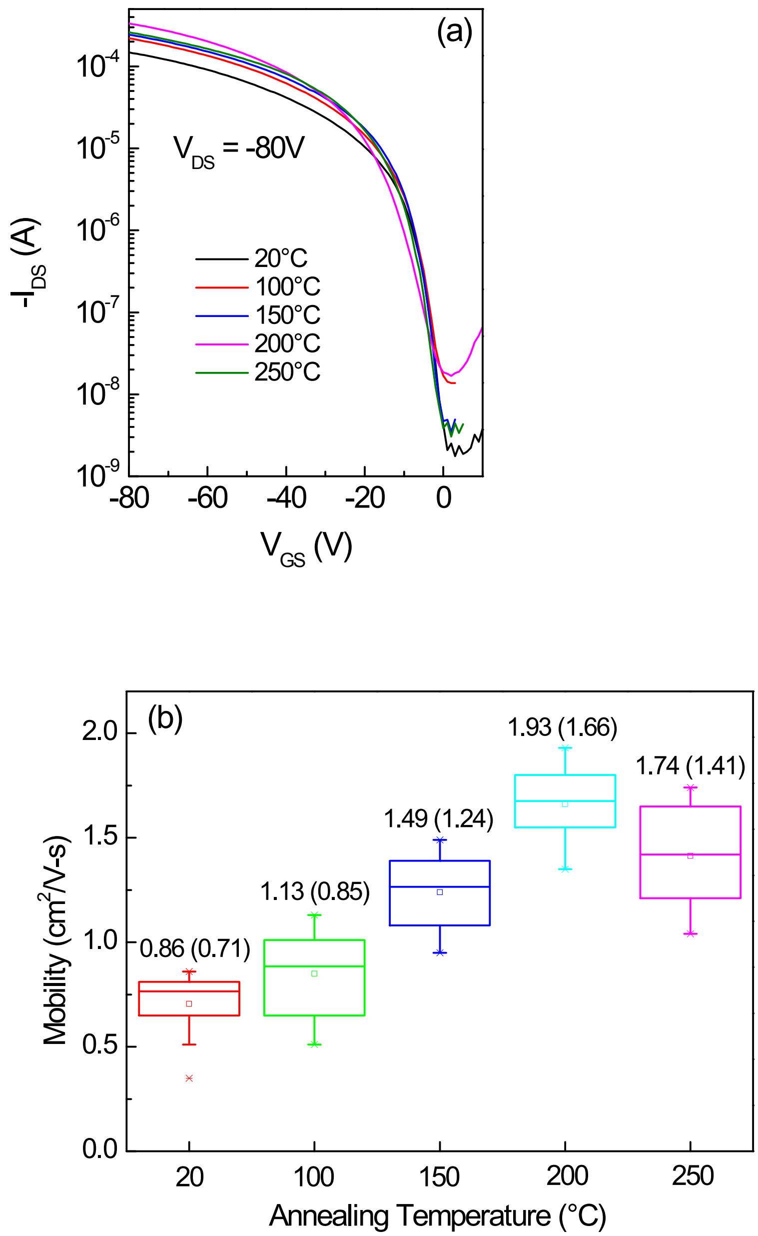


Figure S7. (a) The transfer characteristics of FETs in which PCDTPT films are spin coated and annealed at various temperatures. (b) Mobility of the FET at various annealing temperatures. The mobility value and the value in the parentheses represent the maximum and mean values, respectively. The horizontal lines in the box denote the 25^{th}, 50^{th} and 75^{th} percentile values and the error bars denote the 5^{th} and 95^{th} percentile values. The data are obtained from 10 devices for each temperature. The curves in (a) represent the champion devices of each category.

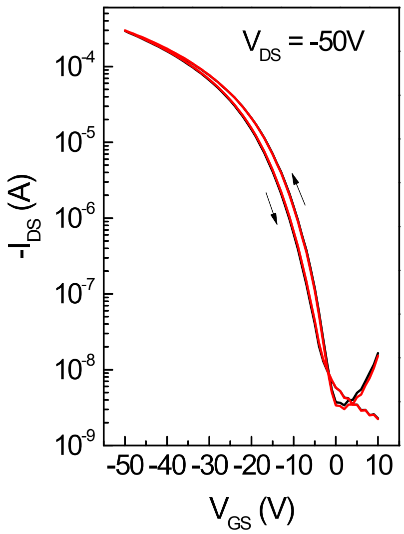


Figure S8. The hysteresis characterization with multi-cycles of sweeping of gate-source voltage for the FET fabricated by nanogrooves-guided slot-die coating

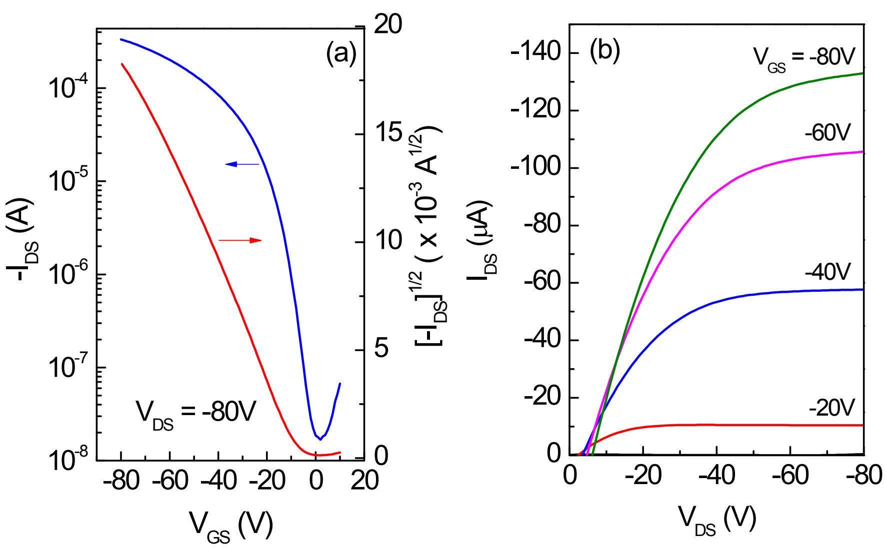


Figure S9. The transfer (a) and output (b) characteristics of FET device fabricated by spin coating showing the mobility of 1.9 $cm^2V^{-1}s^{-1}$, I_{on}/I_{off} ratio of 2 × 10^4 and a threshold voltage of -7.5 V.

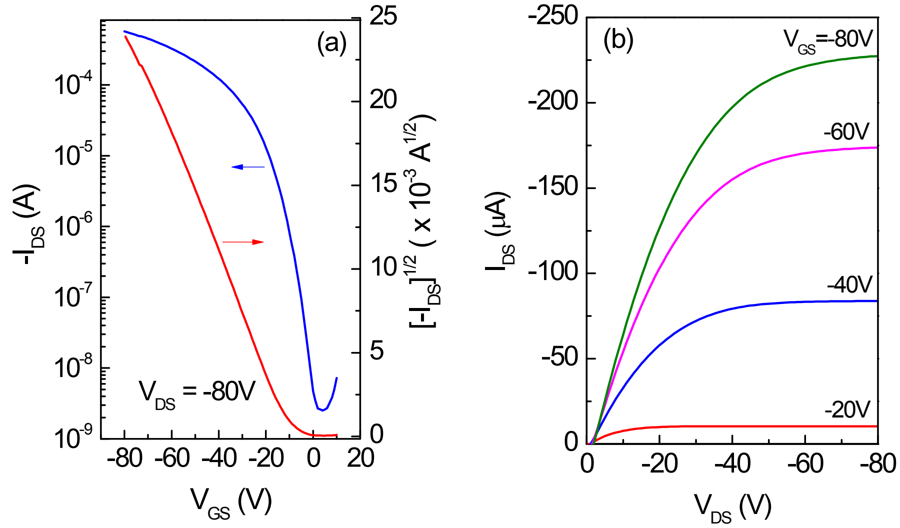


Figure S10. The transfer (a) and output (b) characteristics of FET device fabricated by conventional slot-die coating, showing the mobility of 2.6 $cm^2V^{-1}s^{-1}$, I_{on}/I_{off} ratio of 2.3×10^5 and a threshold voltage of -10 V.

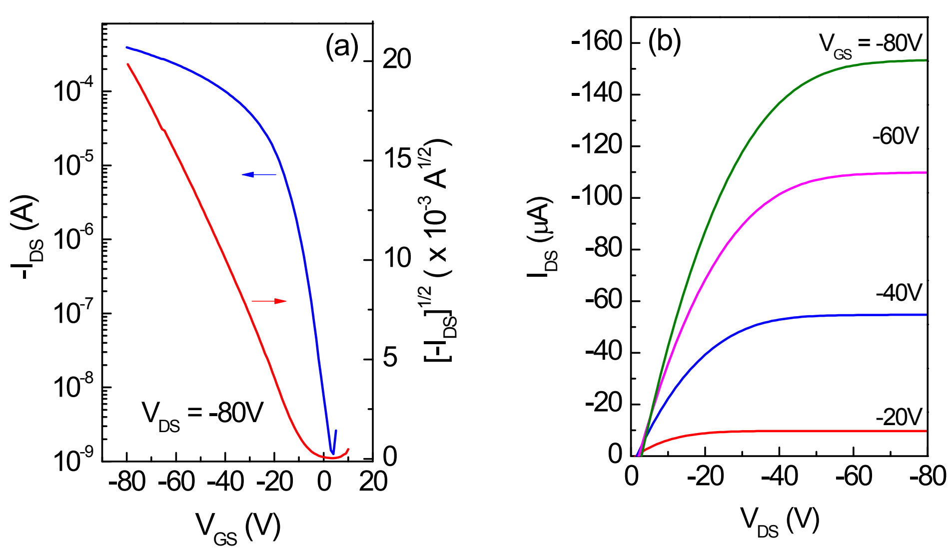


Figure S11. The transfer (a) and output (b) characteristics of FET device fabricated by nanogrooves-guided slot-die coating in which channel length is perpendicular to the nanogrooves and slot-die coating direction, showing the mobility of 2.35 $cm^2V^{-1}s^{-1}$, I_{on}/I_{off} ratio of 3.1×10^5 and a threshold voltage of -10 V.

Experimental Details

Imaging the bottom surface of PCDTPT film: In order to obtain the optical microscopic images and AFM images at the bottom surface, the films were first detached from SiO_2/Si substrate by immersing in Hydrofluoric acid (HF) solution. After HF solution completely etched the SiO_2, the PCDTPT film was separated from Si substrate and floated on the HF solution. The floated film was transferred to another Si substrate, facing down the top surface. The transferred film was characterized using cross-polarized spectroscopy and AFM.

Polarized Vis-NIR absorption spectrum: The PCDTPT films were deposited on the glass substrates by spin-coating and nanogrooves-guided slot-die coating. In the latter process, the nanogrooves were fabricated on the glass substrate by employing the same method used for SiO_2/Si substrate. The polarized Vis-NIR absorption spectra were recorded at room temperature using PerkinElmer (Lambda 750), with the incident light polarized along a certain direction by a high contrast IR polarizer (wavelength range 650-1700 nm, 25 mm diameter) from Edmund Optics. For the spin-coated film, an arbitrary polarization direction which gives the minimum absorption spectrum is assigned as a reference and then polarizer was rotated 90° to determine the optical anisotropy.