# Electronic Supplementary Information

## Low-voltage-driven organic phototransistors based on a solution-processed organic semiconductor channel and high *k* hybrid gate dielectric

Bo-Yi Jiang,[a] Sureshraju Vegiraju,[b] Anthony Shiaw-Tseh Chiang,[a] Ming-Chou Chen*[b] and Cheng-Liang Liu*[a]

[a]Department of Chemical and Materials Engineering, National Central University, Taoyuan, 32001 Taiwan

[b]Department of Chemistry, National Central University, Taoyuan 32001, Taiwan. E-mail: mcchen@ncu.edu.tw

*E-mail: mcchen@ncu.edu.tw, clliu@ncu.edu.tw

## Experimental

### Materials

All the solvents and reagents were purchased from Sigma-Aldrich, Merck and Alfa Aesar and used without further purification. The preparation of *h*TSO sol precursor and **DDTT-SBT-14** organic semiconductors was according to the pervious literature.[1,2]

### Characterization

Film thickness was measured with DEKTAK 150 Surface Profilometer (Veeco). Polarized optical micrographs were obtained by Leica 2700M. UV-Vis spectrum was characterized by JASCO V-670 UV-Vis spectrophotometer. The atomic force microscope (AFM, Seiko SPA400) was operated under tapping mode at room temperature to investigate the surface roughness. Etched silicon tips with a typical resonant frequency of 160 kHz were employed.

### Device fabrication and measurement

Heavily doped n-type Si wafer was diced and cleaned in sulfuric acid/hydrogen peroxide (7:3 v/v) at 110 $^{o}$C for 40 min, rinsed thoroughly with DI water, dried under nitrogen and used immediately. The *h*TSO dielectric films were deposited by spin-coating the precursor sol onto cleaned Si substrate (6000 rpm, 60 s), then cured under ultraviolet light and baked at 400 $^{o}$C for 1 h before cooled to room temperature. The as-fabricated *h*TSO films were then immersed in a (2-phenylethyl)trichlorosilane (PETS) solution (5 mM in toluene) at 55 $^{o}$C for 1 h, followed by rinsing with toluene and blow dried with nitrogen. Solution-shearing organic semiconductors thin films developed by Bao's group[3] were prepared through customized

shearing machine where the upper shearing plate (modified with n-octadecyltrichlorosilane (ODTS)) dragged the placed solution (~20 μl) on a heated substrate (50~55 $^{o}$C) at a controlled shearing rate of 15 μm $s^{-1}$. Following that, source and drain electrodes were defined on top of the organic semiconducting layer by evaporating a 50 nm thick gold film at 0.5 Å $s^{-1}$ through a shadow mask. The channel width ($W$) and length ($L$) are 25 μm and 1500 μm, respectively. The capacitance per area ($C$) of $h$TSO gate dielectric was obtained by measuring capacitance-voltage properties of Si/$h$TSO/Au with Agilent E4980A LCR meter. The saturated field effect mobility ($\mu$) and threshold voltage ($V_{th}$) was estimated in the saturation region from the slope and x-intercept, respectively, of the linear fit of $(-I_d)^{1/2}$ versus $V_g$ data, using the following Eq. (S1):

$$I_d = \frac{W}{2L} C\mu \left(V_g - V_{th}\right)^2 \tag{S1}$$

The subthreshold swing ($SS$) is calculated by taking the inverse slope of a plot of logarithmic $I_d$ versus $V_g$ in field effect transistor operating region. The blue LED was directly used for irradiation. Two important parameters for organic transistor, namely, photoresponsibility (R) and photosensitivity ($P$), based on following fundamental equation.

$$R = \frac{I_{ill} - I_{dark}}{P_{ill}} \tag{S2}$$

$$P = \frac{I_{ill} - I_{dark}}{I_{dark}} \tag{S3}$$

$I_{ill}$ : the drain current with illumination (A)

$I_{dark}$ : the drain current in darkness (A)

$P_{ill}$ : the incident power (W)

1. B.-X. Yang, C.-Y. Tseng, A. S.-T. Chiang and C.-L. Liu, *J. Mater. Chem. C*, 2015, **3**, 968-972.
2. S. Vegiraju, B.-C. Chang, P. Priyanka, D.-Y. Huang, K.-Y. Wu, L.-H. Li, W.-C. Chang, Y.-Y. Lai, S.-H. Hung, B.-C. Yu, C.-L. Wang, W.-J. Chang, C.-L. Liu, M.-C. Chen and A. Facchetti, *Adv. Mater.*, DOI: 10.1002/adma.201702414, 1702414.
3. G. Giri, E. Verploegen, S. C. B. Mannsfeld, S. Atahan-Evrenk, D. H. Kim, S. Y. Lee, H. A. Becerril, A. Aspuru-Guzik, M. F. Toney and Z. Bao, *Nature*, 2011, **480**, 504-508.

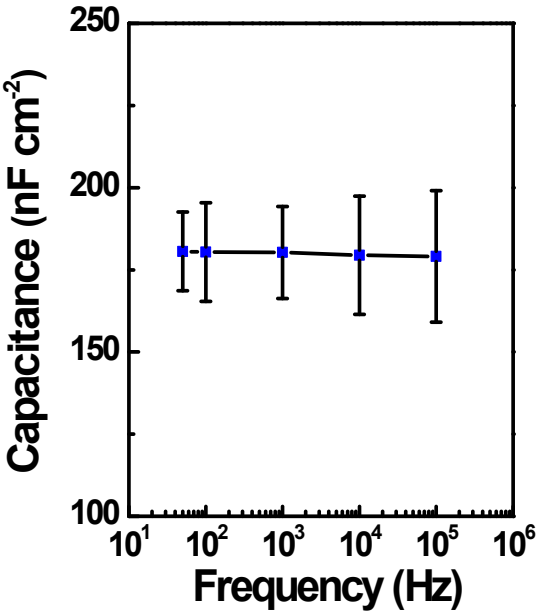


**Fig. S1** Areal capacitance versus frequency of *h*TSO dielectric film.

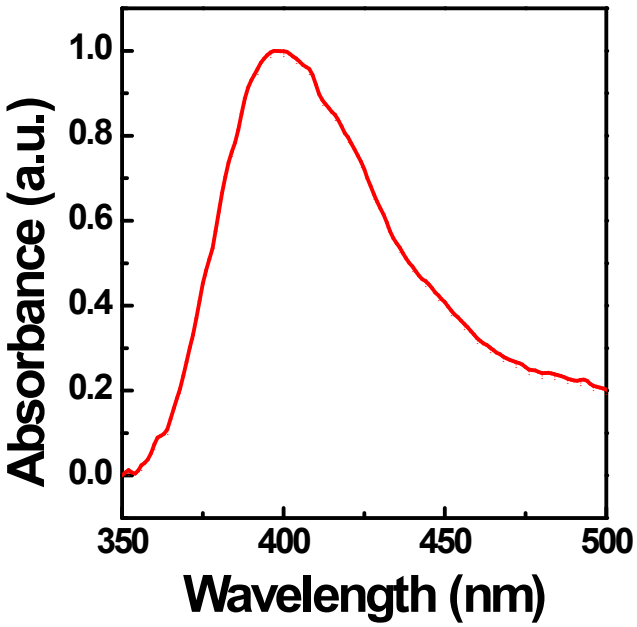


**Fig. S2** UV-Vis spectrum of solution-sheared **DDTT-SBT-14** thin film.

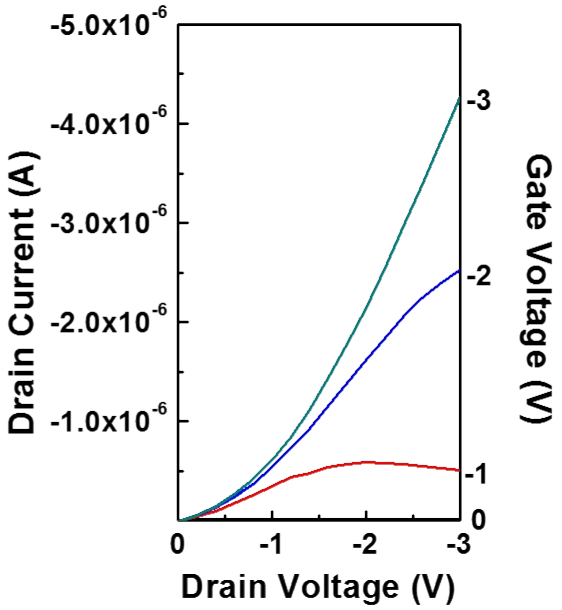


**Fig. S3** Output characteristics of **DDTT-SBT-14** based organic transistor in dark.

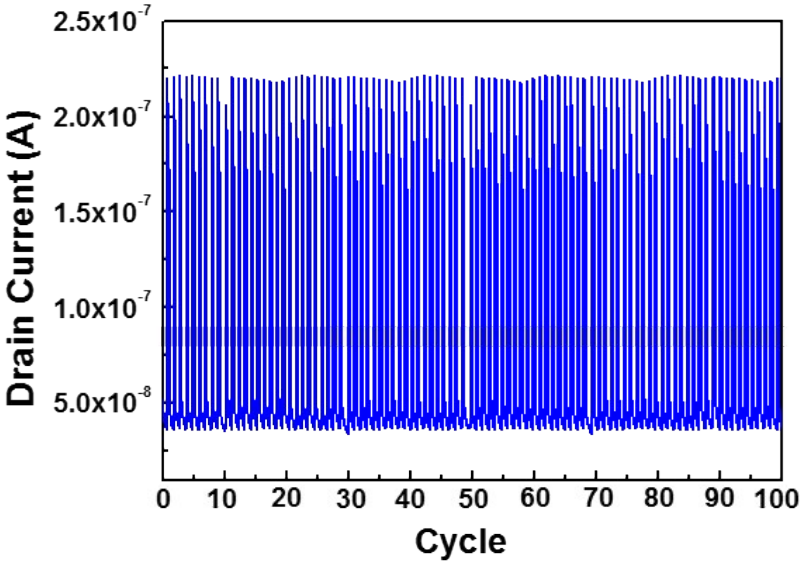


**Fig. S4** ON/OFF cycles test of **DDTT-SBT-14** based organic phototransistor.