Electronic Supplementary information

Ambient-protecting organic light transducer grown on pentacene-channel of photo-gating complementary inverter

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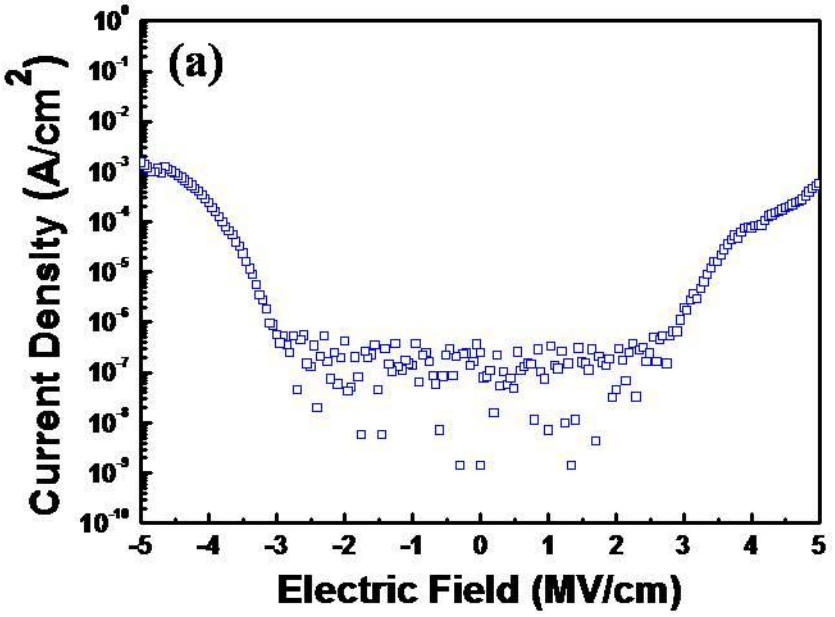


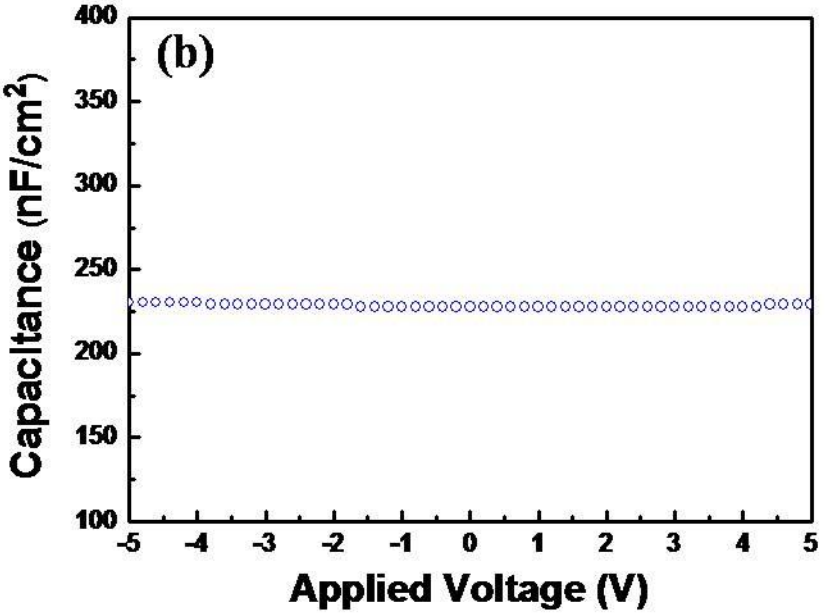


Fig. 1S. (a) The capacitance and (b) dielectric strength of our 30 nm-thin ALD Al_2O_3, respectively. We used 30 nm-thin oxide for dielectric that has ~230 nF/cm^2 and ~3 MV/cm as its capacitance and strength, respectively.

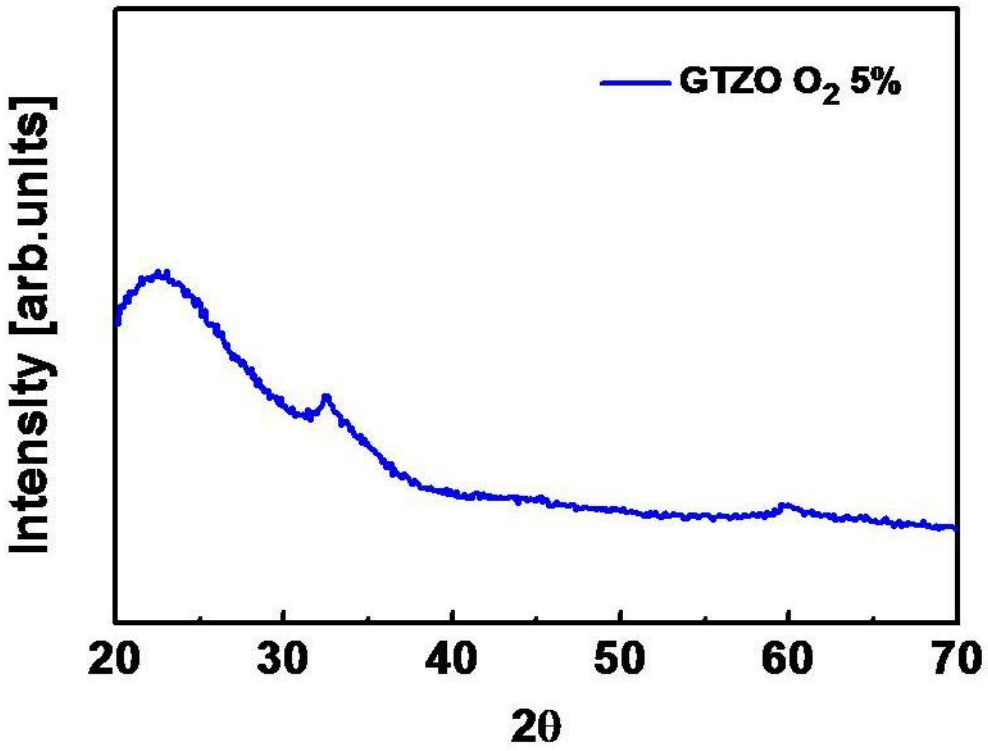


Fig. 2S. XRD spectra of 60 nm-thin GTZO film formed by co-sputtering of a Ga-doped ZnO (Ga_2O_3 5.7 wt%) and a SnO_2 target. The sputtering was performed in a working pressure of 5 mtorr with flowing Ar and O_2 mixed (5 %) gas and the deposition temperature was maintained at 100 ℃.

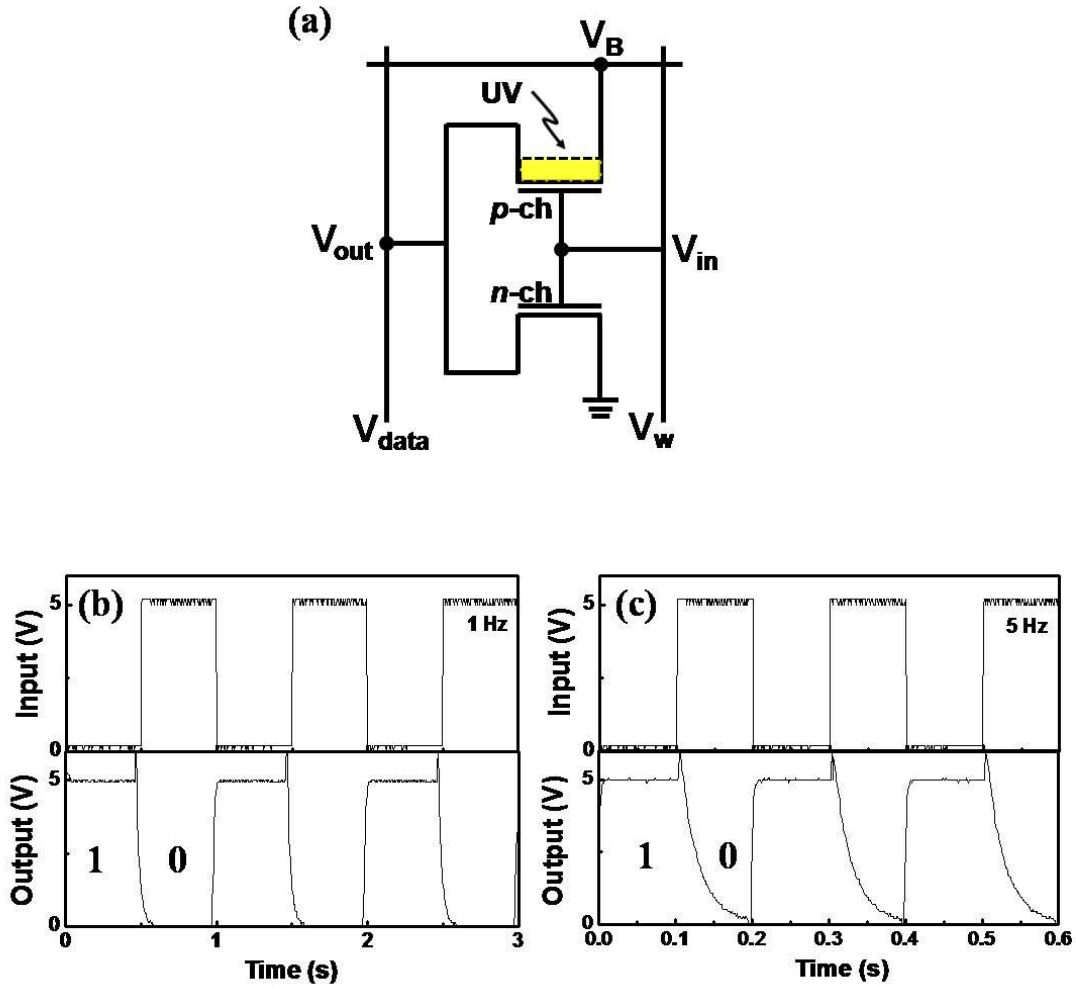


Fig. 3S. (a) Our inverter cell could be extended to a pixel array circuit with word, data and bit line as above. Input voltage is V_{word} (V_w), V_{out} is V_{data}, V_{DD} is V_{bit} (V_B) in the circuit. Dynamic gating (inverting) of our device under 5 V input pulses (b) at 1 Hz and (c) 5 Hz.

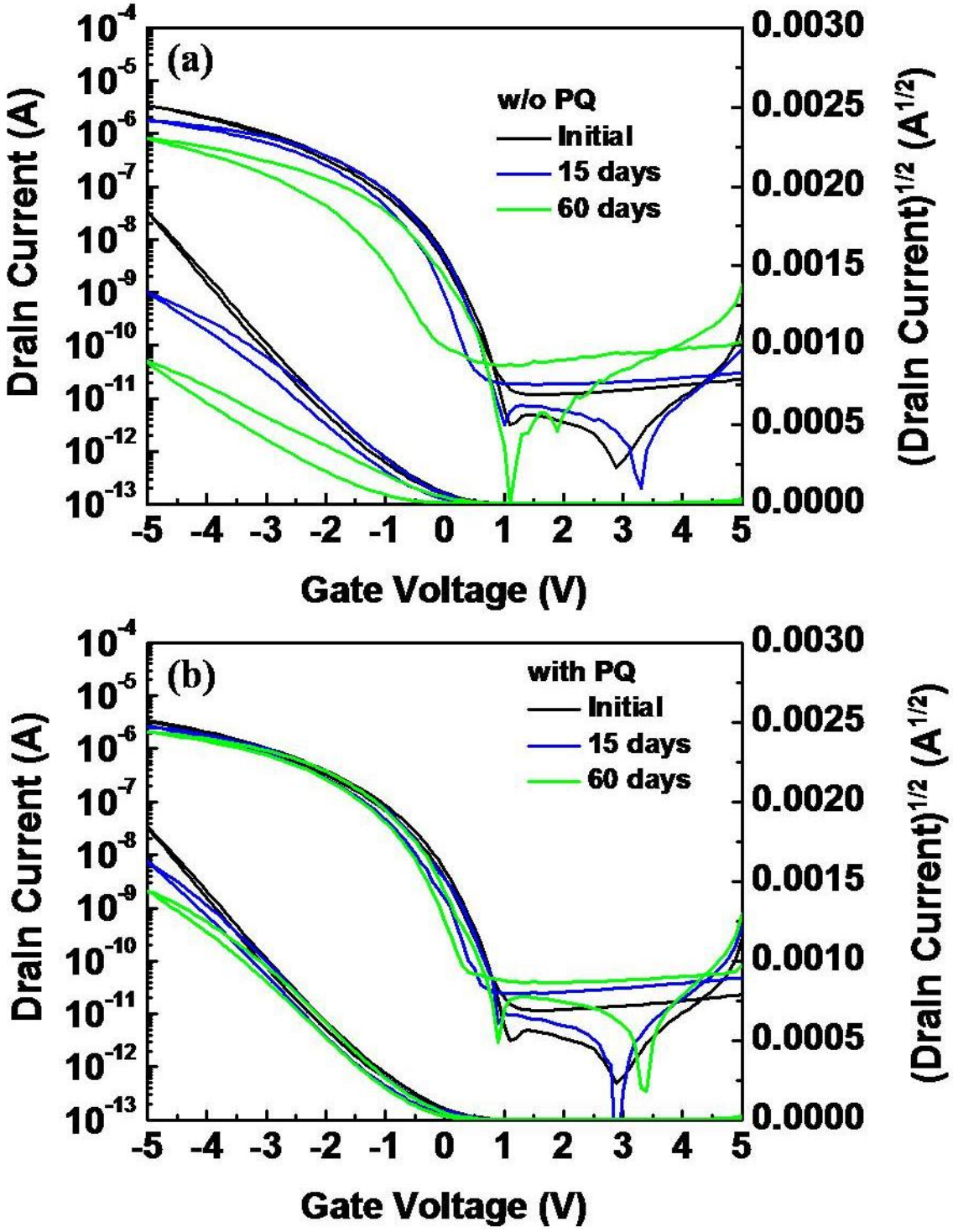
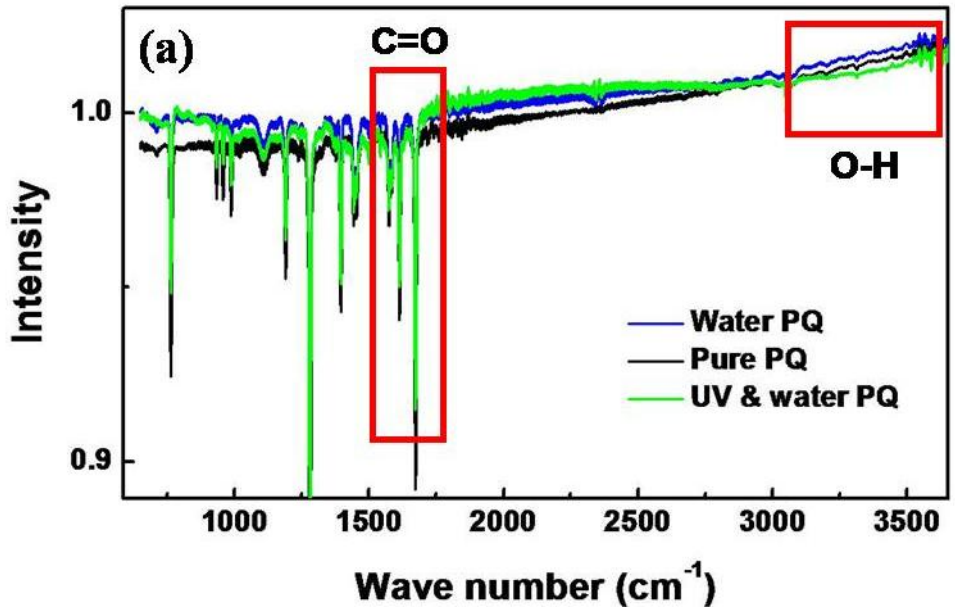


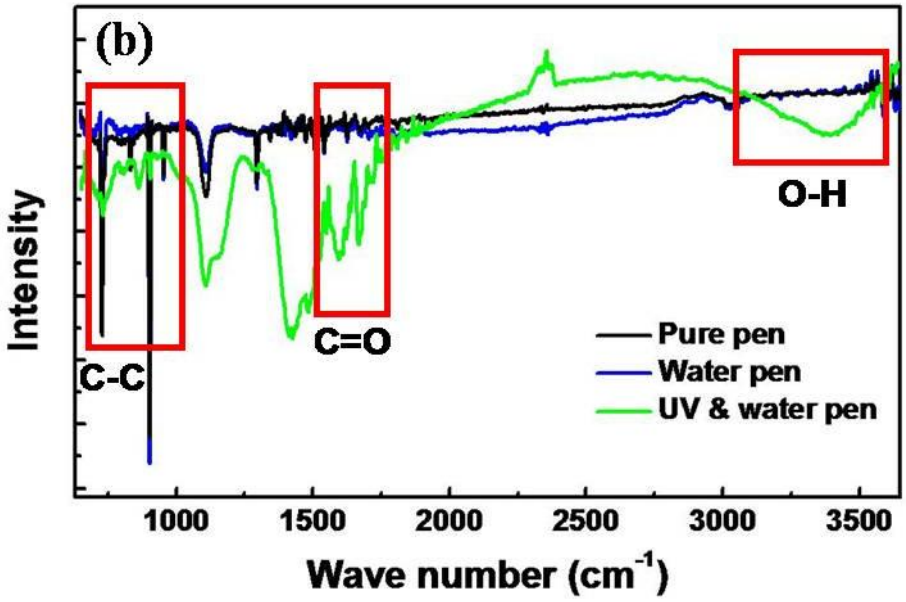
Fig. 4S. (a) Gate-bias hysteresis of 15 and 60 day-aged pentacene TFT without PQ layer and (b) that of the other cell with PQ.

Fig. 5S. In order to justify our conclusions on PQ as diffusion barrier against water and oxygen molecule, we implemented three types of experimentations and measurements as follows.

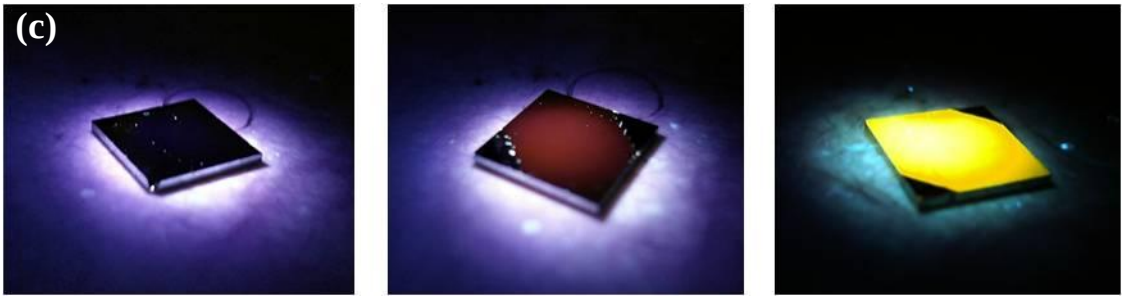
(a) We thermally evaporated 100 nm hydrophobic PQ layer on Si and then kept the sample in 90% relative humidity for 0.5 day under intense UV or under no UV before fourier transformed infrared (FTIR) spectroscopy measurements; no O-H bond vibration ($1/\lambda$~3500 cm^{-1}) was found in the three spectra from pure (as-deposited), water (90% humidity), and humidity plus UV samples and they were almost the same as shown below.



(b) We did the same processes with pentacene layer on Si: pure (as-depo), water (90% humidity), and humidity plus intense UV conditions. Neither O-H or C=O bond was found from the spectra of as-deposited and 90% humidity-ambient-treated pentacene. However, humidity plus intense UV condition results in noticeable O-H and C=O vibration peaks, damaging the initial pentacene with C-C bonds: original C-C bonds now becomes weak due to the damage.



(c) The UV-damaged sample emits weak but visible light PL under another UV probe, as a proof that the original pentacene changed to PQ-like molecules from the surface by UV (see photographs below).



Pure pentacene UV-damaged pentacene Pure PQ

In brief summary from (a), (b) and (c) experiments, we presume that the PQ and pentacene layers will not easily degrade with humidity. (Of course, some water molecule penetration would be expected as long time elapses under the same ambient). However, under the UV assistance our pentacene TFT can degrade, to be oxidized as any form of pentacene-quinone, while the PQ (already-oxidized form of pentacene) does not degrade even under UV. The

results from pentacene are particularly consistent with previous work by other groups. (Refs. 22-25) Since there would be even weak intensity of UV in normal air ambient light, such UV lights negatively influence on pentacene TFT in the long run (normal ambient light exposure for 60 days). That's why we deliberately introduced already-oxidized 6,13 PQ as ambient (molecule-diffusion and UV) protection barrier layer over pentacene channel; the PQ plays as UV-absorber and UV-to-visible transducer as well.

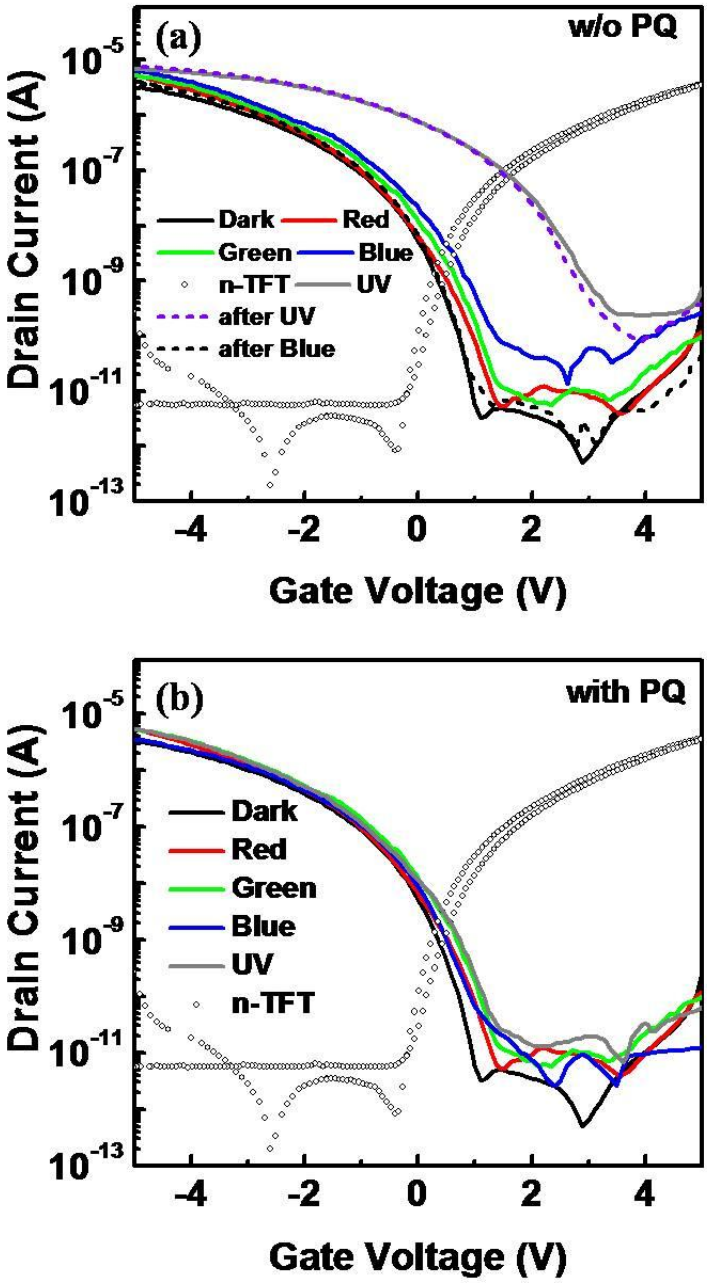


Fig. 6S. Photo-induced transfer curves of pentacene transistor (a) without PQ (b) with PQ. As shown in violet-dashed line of Fig. 6S(a), the transfer curve was hardly recovered after UV illumination. However, blue-light-induced transfer curve was fully recovered (black-dashed line). This means that UV-induced traps and damage are certainly introduced in pentacene channel, due to the UV energy, while the energies of visible range photons are not high enough to produce such damages.