Hybrid Flexible and Monolithic Photo Sensor Arrays made by Solution-Processed Metal-Oxide and Organic TFTs

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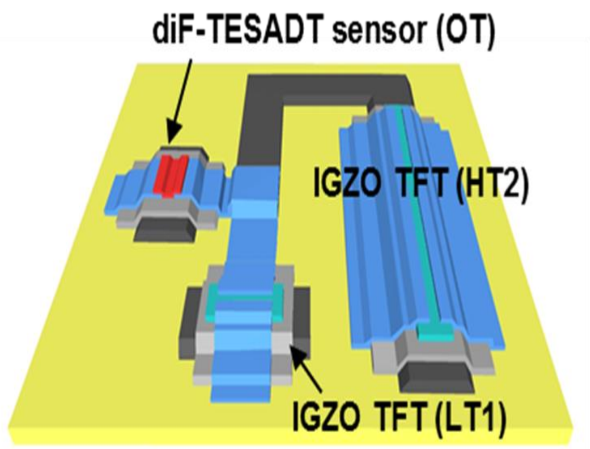
Low-temperature solution-processed semiconductors including organic and oxide materials represent a promising platform enabling low-cost fabrication of flexible devices. These two materials possess distinctive characteristics such as relative high performance for oxide semiconductors and abundance of functional materials for organic semiconductors. We believe that heterogeneous integration of these inherently different materials in a synergetic way opens new routes toward multifunctional flexible system. Here, we demonstrated monolithically integrated 13×13 oxide-organic semiconductor hybrid complementary photo-sensor array on a 3 μm-thick flexible film in which the optical response of 2,8-difluoro-5,11-bis(triethylsilylethynyl) anthradithiophene (diF-TESADT) organic material is transferred to InGaZnO thin film transistors for signal amplification.

For the solution-processed discrete organic and metal oxide TFTs on flexible polyimide substrates, we annealed IGZO semiconductor by deep-ultraviolet (DUV) process at 150℃, which is the highest process temperature for TFT fabrication. Our experiments shows that the transfer curves of discrete IGZO TFT exhibited almost minimal Vth or the threshold voltage shift by an exposure of halogen light while diF-TESADT showing the obvious Vth shift. Based on these individual TFTs, respectively, we constructed the hybrid circuits that have the discrete sensory and amplifying functions by virtue of organic and oxide TFTs performance. In other words, as shown in the figure 1 (left), we propose a simple voltage divider composed of two TFTs: one is organic TFT and the other is oxide TFT (LT1). So, V_{DD} is divided by two TFTs' resistance such that $V_O = V_{DD} \cdot R_{LT1} / (R_{LT1}+R_{org})$, and output voltage goes into another oxide TFT's (HT2) gate input voltage. Therefore we can amplify the organic TFT's small drain current by increasing a ratio of T1 and T2, as shown in the figure 1 (right). As a result, once the illumination intensity-dependent current from diF-TESADT OTFT is translated into the gate potential of HT2, the output current (I_{OUT}) of HT2 is modulated according to its transfer characteristics, resulting in about multiple orders of magnitude current amplification. It should be noted that IOUT of hybrid circuitry was increased only at illuminated condition while remained low in the dark condition.



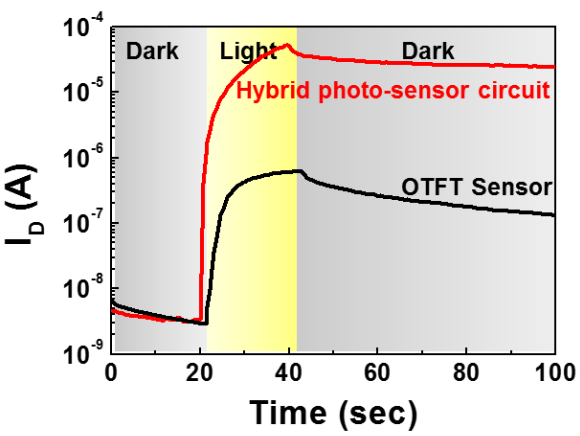


Fig. 1. Schematic illustration of hybrid photo-sensor circuitry (left) and temporal responses of diF-TESADT TFT and hybrid photo-sensor circuitry (right)

Referencess

1. S. K. Park et. al. Nature, vol. 489, no. 7414, pp. 128-32 (2012)
2. S, K. Park et. al. Org. Electron, vol 15, no. 9, pp. 2099-2106 (2014)