Development of anti-ambipolar transistors

Part V: Application to optically controllable ternary logic circuits

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Anti-ambipolar transistors (AATs) have attracted tremendous attention due to their potential application in multivalued logic circuits (MVLs) which can handle three or more number of logic states.[1,2] Here, organic semiconductors play a major role in such applications due their superior electrical and optical properties. In this work, we demonstrate an organic AAT based ternary inverter, in which the output logic states can be precisely controlled by proper optical signals.[3]

Figures 1 show molecular structures (PTCDI-C8 for n-type and α-6T for p-type channels) and a device geometry, in which the n-type and the AAT transistors are connected in series. Systematic investigation of the photoresponse revealed that the ternary logic states were optically controllable depending on light wavelength (UV or visible). Under visible light, the Λ-shaped transfer curve of the AAT experienced a broadening due to the optically induced threshold voltage shift in both PTCDI-C8 and α-6T controlled regions. Under ultraviolet (UV) light, the broadening was observed only towards α-6T side. These contrasting impacts of the UV/Vis light signals enabled us to fine-tune the widths of Logic 1 and Logic ½ state of the inverters as shown in Fig. 2. Moreover, the contrasting influence of visible and UV light signals on the drain current of PTCDI-C8 controlled regions allowed us to precisely control the voltage level of the logic states. Such optically controlled ternary inverters may bring broad prospects for next-generation opto-electronic logic electronics.

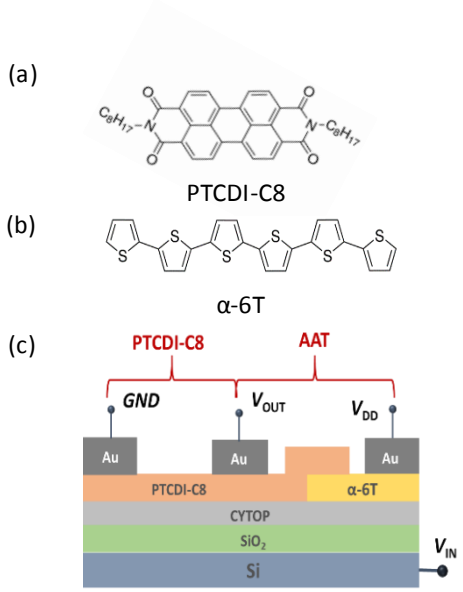

Fig. 1: Molecular structures and schematic illustration of the ternary inverter.

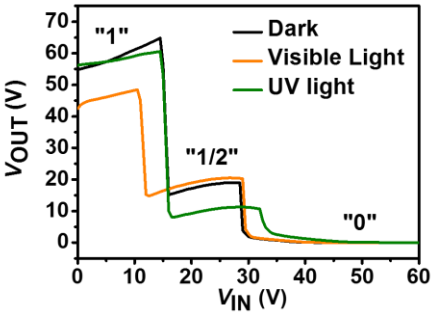

Fig. 2: Voltage transfer characteristics of the inverters under dark, visible light and UV light.

References:
1) K. Kobashi, R. Hayakawa, T. Chikyow, Y. Wakayama, Adv. Electron. Mater. 3, 1700106 (2017).
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3) D. Panigrahi, R. Hayakawa, K. Fuchii, Y. Yamada and Y. Wakayama, Adv. Electron. Mater. 7, 2000940 (2020).