Heterogeneous metal oxide channel structure for ultra-high sensitivity phototransistor with modulated operating conditions

National Sun Yat-Sen Univ [1], MSL Tokyo Tech [2], MDX Tokyo Tech [3] ○

Kuan-Ju Zhou [1], Keisuke Ide [2], Takayoshi Katase [2], Toshio Kamiya [2,3], Ting-Chang Chang [1]

E-mail: k-zhou@mces.titech.ac.jp

With the demand for high mobility materials, a heterogeneous channel structure and Sn-doped IGZO was introduced into oxide semiconductors to improve the electrical properties. In addition, the Sn-doped IGZO TFTs can effectively reduce localized states and deep-level traps in IGZO [1]. Moreover, buried channel designs are implemented using higher zinc content IGZO in the top and bottom channel layers to improve the overall electrical performance [2]. In this work, these designs for TFTs leads to high mobility and lower subthreshold swing (S.S.) properties.

Many studies have been conducted on the use of amorphous oxides as optical sensors, but achieving both sensing characteristics and device operation stability remains a challenge [3]. We propose a heterogeneous channel structure and then realize a phototransistor that operates stably even after 200 repeated measurements while improving the photoresponse on/off ratio by 4 orders of magnitude. Furthermore, we study the operating parameters such as voltage pulse width and voltage value in detail, demonstrate optimized operating conditions, and carefully discuss the operating mechanism and negative bias illumination stress (NBIS) degradation [4]. By improving the operation pulse modulation, the ultraviolet sensing ability is effectively improved, and the sensing on/off ratio of 4 orders of magnitude is still maintained after working for 10000 s. A high-sensitivity, ultra-high-endurance phototransistor has been developed, and the results show that it can effectively improve the reliability of ultraviolet sensing.

References [1] J. Wu. et al., *IEEE Transactions on Electron Devices*. 68, 6617-6622 (2021)., [2] Y. M. Kim. et al., *Applied Physics Letters*. 102, 173502 (2013)., [3] S. Cai. et al., *Adv. Mater.* 31, 1808138 (2019)., [4] B. Ryu. et al., *Appl. Phys. Lett.* 97, 022108 (2010)

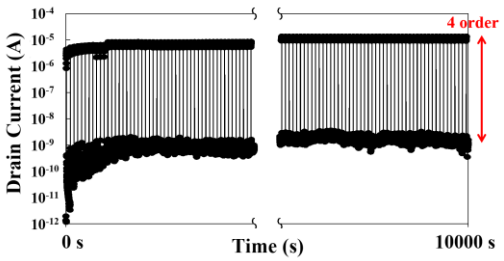

Figure: Sensing pulse with a fixed V_D = 10 V under illumination and a fixed V_D = 0.005 V under dark conditions. A difference of 4 orders was observed in the sensing on/off ratio after operating for 10,000 s.