Cross-field optoelectronic modulation *via* inter-coupled ferroelectricity in 2D In_2Se_3

Debopriya Dutta, Subhrajit Mukherjee, Michael Uzhansky, Elad Koren
Nanoscale Electronic Materials and Devices Laboratory, Faculty of Materials Science and Engineering, Technion - Israel Institute of Technology, Haifa, 3200003, Israel
debopriyad@campus.technion.ac.il

Abstract -
Ferroelectricity in two-dimensional (2D) materials has been at the forefront of recent research owing to its potential application in low powered non-volatile phase change memory, energy harvesting, strain tuned electronics, artificial brain and neuromorphic sensors. Among the 2D materials exhibiting ferroelectricity in room temperature, a-In_2Se_3 stands out owing to the presence of both in-plane (IP) and out-of-plane (OOP) dipole polarizations[1]. In addition, the ability to modulate IP by switching OOP and vice versa owing to their intercoupled nature makes it a promising material for multimodal memory and optoelectronic applications. Herein, we experimentally demonstrate the cross-field modulation of opto- and electronic properties in a-In_2Se_3 based field effect devices[2]. Gate dependent surface potential measurements using Kelvin Probe Force Microscopy (KPFM) were extensively used in In_2Se_3 based devices to directly reveal the bi-directional dipole modulation. Electric field calculations obtained from the surface potential studies also show hysteretic behavior of the dipoles following high gate voltage pulses. Also, to explore the consequence of the hysteretic change in the in-plane electrical field, photoresponse measurements following high gate pulses were performed exhibiting its functionality as a non-volatile memory switch. The multi-level photoresponse characteristics for different gate polarities in the fabricated photodetectors show a potential for their implementation and integration into non-volatile memory and electro-optical applications.

References

[1] Cui, C., Hu, W., Yan, X. et al. Nano Letters 18 (2018), 1253-1258.
[2] Dutta, D., Mukherjee, S., Uzhansky, M. et al. npj 2D Mater Appl 5 (2021), 81.

Figures

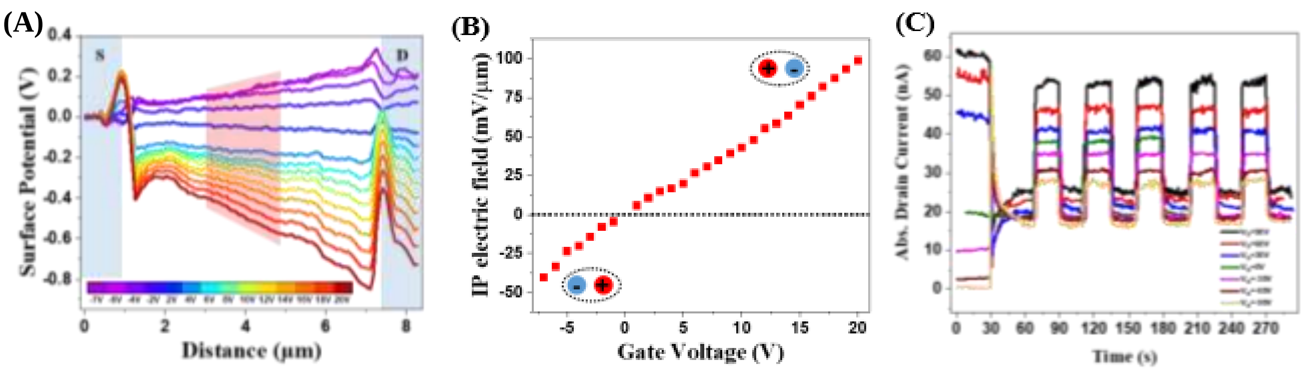

Figure 1: (A) Surface potential profiles across a-In_2Se_3 channel for various gate biases ranging from VG= -7 V to VG= 20 V. The semi-transparent blue boxes indicate the source and the drain positions. **(B)** Effective IP electric field calculated from a section of the line profiles away from electrodes (marked by semi-transparent red quadrilateral) in Fig. 1(A) as a function of applied gate voltage. **(C)** Temporal response of photocurrent in a-In_2Se_3 for various gate pulses. Gate pulses were applied for 30s after which the gate was withdrawn. The measurements were performed with zero applied gate potential and drain voltage of -2 V thereafter.