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Voltage induced phase engineering in MoS_2/GFNO heterostructure

Owing to the nature of the metal/TMD interface, the contact geometry and energy level permutation play a key role in determining metal/TMD resistance [1][2]. Although the simulation shows zero Schottky barrier contacts with the 2H-1T' phase engineering [3], phase transition in MoS_2 have been only induced by thermal or chemical doping [4] [5][6]. It still lacks reliable methods to control the phase transition of MoS_2. In this work, we come across the idea using ferroelectric-driven phase transition on the MoS_2/GFNO heterostructures (Figure.1). We find that the 2H-1T' phase transition shows a reversible and hysteretic loop in Raman spectra during electrical manipulation (Figure 2). we distinguish the vacancy and structure transition by Scanning Photoelectron Microscopy (SPEM) and μ-PES (Figure 3, Figure 4), the shift only happened in Mo 3d spectrum suggest the sulfur vacancy generate during annealing process; in addition, the surface potential of GFNO will be controlled after pulse-voltage applying, therefor, the binding energy (Mo 3d, S 2p, Gd 4f) shift simultaneously which is due to the different symmetric of d-orbital splitting in 2H and 1T'phase. The vacancy and ferroelectric induced phase transition were investigated by the core-level shift via scanning photoelectron microscopy. The ferroelectric control on the structural phase transition opens up possibilities for developing ferroelectric based devices such as 2D non-volatile memory devices or 2D NCFET devices. This work was financially supported by the “Center for the Semiconductor Technology Research” from The Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education (MOE) in Taiwan. Also supported in part by the Ministry of Science and Technology, Taiwan, under Grant MOST-107-3017-F-009-002.

References

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Figures

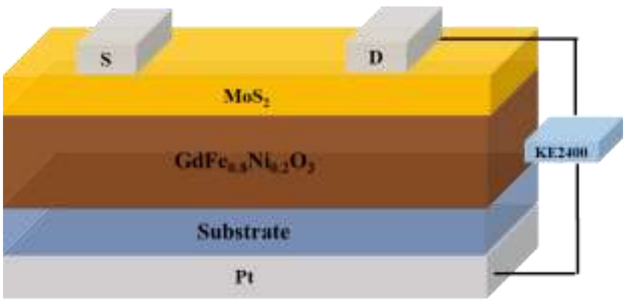

Figure 1: Device schematic of the 2D MoS_2/$GdFeNiO_3$ heterostructure

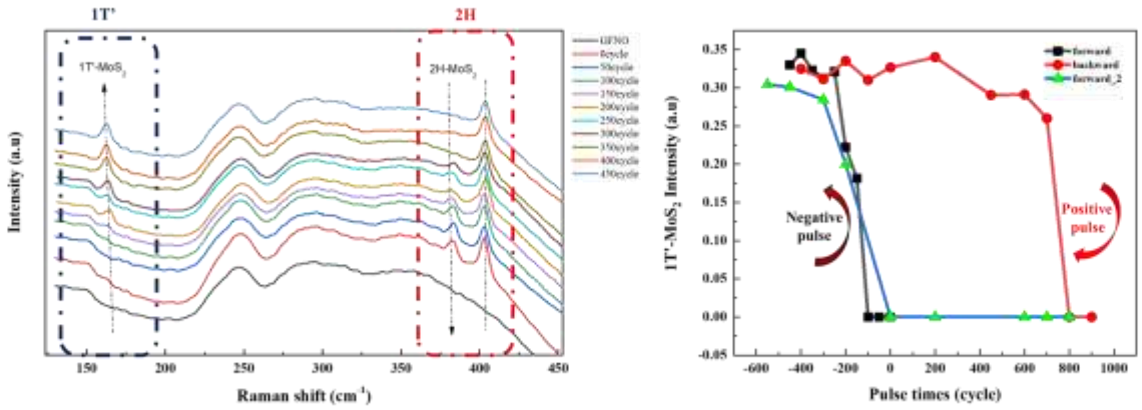

Figure 2: (Left) In-situ bias depend Raman spectrum (Right) Intensity ratio of 1T' Raman spectrum

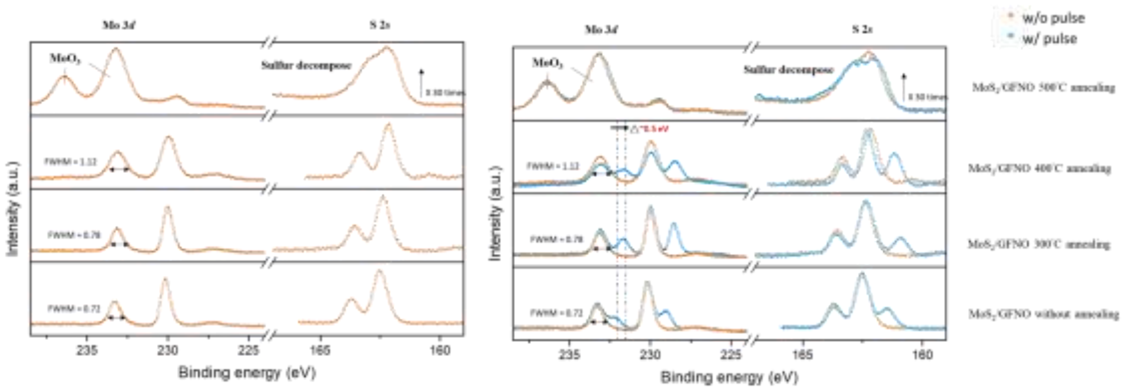

Figure 3: X-ray photoemission spectra of Mo 3*d*, S 2*s*, and S 2*p* core-level. (left) For MoS_2 on GFNO film annealed at various temperatures; (right) ex-situ pulse voltage applied after annealing.

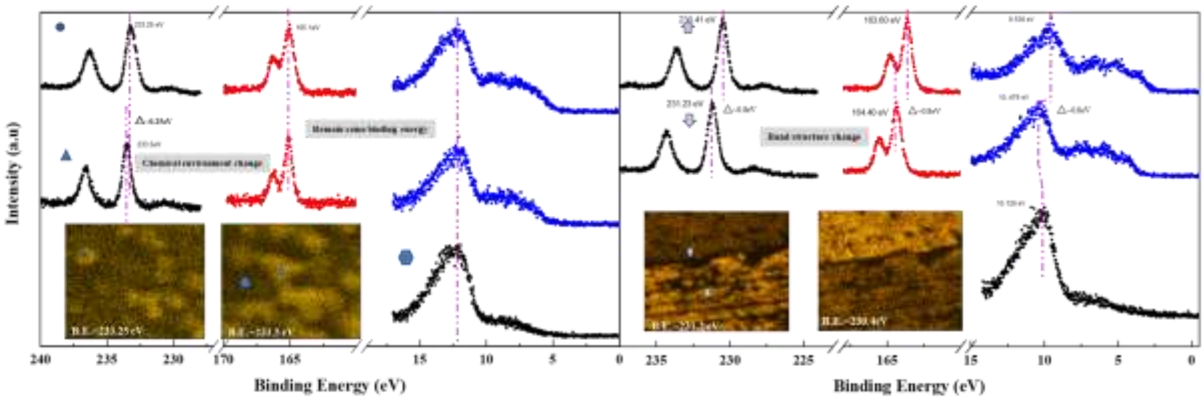

Figure 4: SPEM images and μ-PES measurements on the MoS_2/GFNO homojunction. Mo 3d, S 2s, S 2p and Gd 4f core-level photoelectron spectra measured with SPEM. (left) For MoS_2 on GFNO film annealed at various temperatures; (right) Pulse voltage applied after annealing for MoS_2/ GFNO heterostructure.