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Phase-engineered programmable MoS_2/WSe_2 p-n diode *via* lithium-ion intercalation

Semiconductor p-n junctions are the basic building blocks for solar cells, rectifiers, light-emitting diodes, photodetectors, and tunnel diodes. Tremendous efforts have been dedicated to the development of thin p-n diodes using the atomically thin nature of two-dimensional (2D) materials for electronic and optoelectronic applications in the post-silicon era. To date, several strategies have been developed for the preparation of 2D p-n junctions, including multiple split local gate, doping, and laser irradiation. Recent studies suggest that high-quality p-n junction can be achieved by stacking 2D materials with dissimilar charge carrier types because the surface of 2D materials is naturally passivated without any dangling bonds, enables the formation of atomically sharp interface without strain. In addition, the availability of versatile platforms of semiconducting transition metal dichalcogenides (TMDCs) with different bandgaps and workfunctions allows the modulation of junction barrier at the heterointerface, facilitating various electronic band alignment for diverse applications. However, for the realization of higher-level devices, such as neuromorphic computing and pattern recognition, higher degree of freedom of circuit elements is required.

In this study, we demonstrated programmable MoS_2/WSe_2 p-n diode in which the junction barrier at the heterointerface can be modulated through phase engineering of 2D TMDCs. Mechanically exfoliated MoS_2 flakes were transferred onto a SiO_2/p^{++}-Si substrate, followed by defining of Ti/Au electrodes by using electron-beam (e-beam) lithography. The sample was then immersed in 1.6 M n-butyl lithium solution to lithiate the MoS_2 layer. Afterward, WSe_2 flake was stacked on the lithiated MoS_2 layer using PDMS-assisted direct transfer technique, followed by defining of Pt/Au electrodes to complete the fabrication of a tunable p-n diode. The reversible modulation of semiconducting (2H)-semimetallic (1T') phase transition was achieved in MoS_2 by intercalated Li^+ ions within the layers. The rectifying behavior of p-n diode can be effectively tuned by redistributing Li^+ ion at the junction area through the magnitude and polarity of the applied electric field to the MoS_2 layer. Moreover, we observed tunable photovoltaic response across the p-n interface. The details of the experimental results will be presented.

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Figures

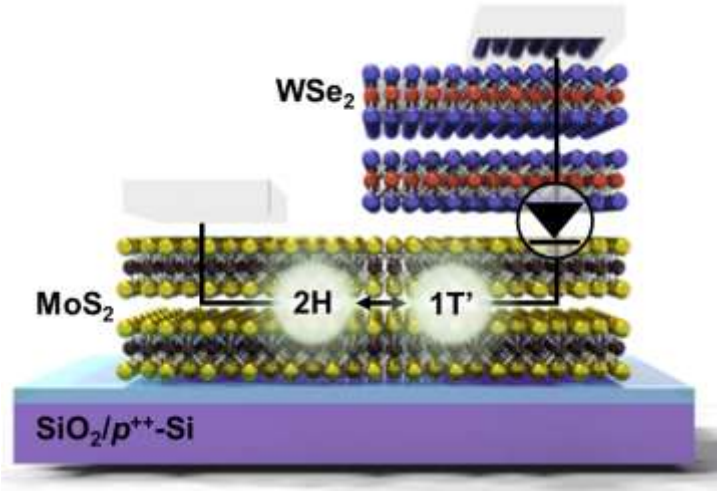

Figure 1: Schematic of MoS_2/WSe_2 programmable p-n diode.