Asymmetric Schottky Contacts in Bilayer MoS$_2$ Field Effect Transistors

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The high-bias electrical characteristics of back-gated field-effect transistors with chemical vapor deposition synthesized bilayer MoS$_2$ channel and Ti Schottky contacts are discussed. It is found that oxidized Ti contacts on MoS$_2$ form rectifying junctions with $\approx 0.3$ to $0.5$ eV Schottky barrier height. To explain the rectifying output characteristics of the transistors, a model is proposed based on two slightly asymmetric back-to-back Schottky barriers, where the highest current arises from image force barrier lowering at the electrically forced junction, while the reverse current is due to Schottky barrier-limited injection at the grounded junction. The device achieves a photoresponsivity greater than 2.5 A W$^{-1}$ under 5 mW cm$^{-2}$ white-LED light. By comparing two- and four-probe measurements, it is demonstrated that the hysteresis and persistent photoconductivity exhibited by the transistor are peculiarities of the MoS$_2$ channel rather than effects of the Ti/MoS$_2$ interface.

Fig. 1: a) SEM top view of a CVD-synthesized bilayer MoS$_2$ with Ti/Au contacts. b) Schematic of the back-gate transistors. c) Raman spectrum of the bilayer MoS$_2$. d) Map of the difference between A$_{1g}$ and E$_{2g}$ peaks of micro-Raman spectra.

Fig. 2: Band diagram based on two back-to-back Schottky barriers. The forward current for negative $V_{ds}$ is due to the image force barrier lowering at the forced junction, while the lower (reverse) current at $V_{ds} > 0$ V is limited by the low electric field at the grounded junction.