Strain engineering of Schottky barriers in single and few-layer MoS_2 vertical devices

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Abstract – Two-dimensional transition metal dichalcogenides have demonstrated a huge potential for the development of novel electronic and devices. Among them, atomically thin MoS_2 raises special interest due to its relatively high carrier mobility and intrinsic 1.8 eV bandgap [1, 2]. Further, it has been recently demonstrated that the band structure of atomically thin MoS_2 crystals can be modified applying uniaxial or biaxial strain [3], enhancing even more their technological possibilities.

In this work we study experimentally the electron transport through vertical metal-atomically thin MoS_2-metal junctions, using a conductive AFM tip to contact single and few-layer MoS_2 crystals deposited onto a metallic substrate. Remarkably, even when the MoS_2 crystal is just one layer thick, two metal-semiconductor barriers are formed at the tip-MoS_2 and MoS_2-substrate interfaces. As a consequence, the structure shows a strong rectifying I-V characteristic. Furthermore, the rectification ratio of the I-V characteristic can be modified by applying mechanical pressure to the MoS_2 crystal with the AFM tip.

To further demonstrate the studied devices, we use them to rectify a periodic voltage, controlling the rectification ratio through the mechanical pressure applied with the AFM tip.

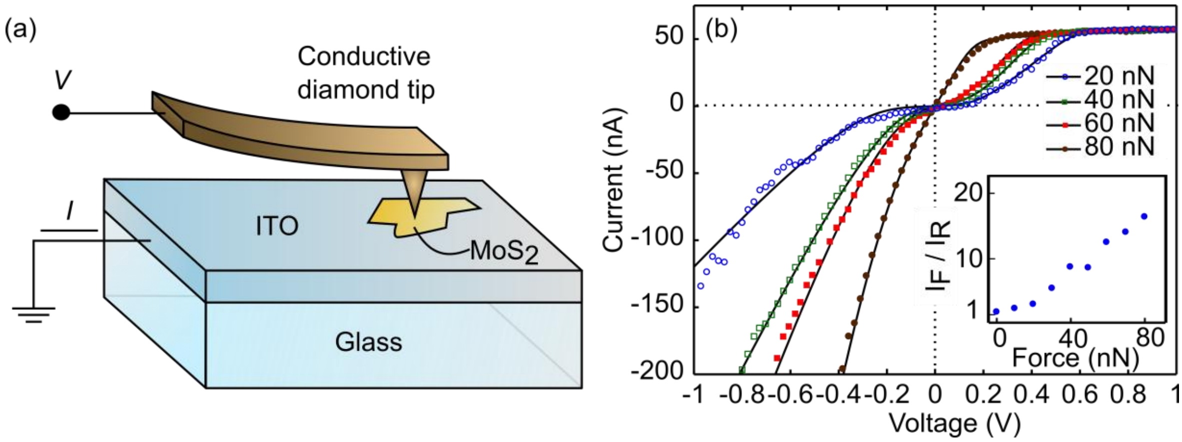

Figure 1. (a) Schematic of the experimental setup: The semiconducting MoS_2 flake is sandwiched between the conductive ITO substrate and the AFM tip. Two metal-semiconductor junctions in series are thus obtained: one at the interface between the conductive tip and the MoS_2 flake and other at the interface between the MoS_2 flake and the ITO substrate. A Schottky barrier is formed at each of these interfaces. The I-V characteristic of the structure is obtained by applying a voltage bias (V) between the conductive tip and the ITO substrate. (b) Measured I-V characteristics of an atomically thin MoS_2 flake under four different tip-flake contact forces: 20, 40, 60 and 80 nN. Black lines are least square fittings to a double-barrier model. Inset: Force-dependent rectification ratio measured at ± 1V.

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3. Castellanos-Gomez, A., et al., *Local strain engineering in atomically thin MoS2.* Nano letters, 2013. **13**(11): p. 5361-5366.