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Fermi Level Pinning-Free 1D Electrical Contact at a Metal-2D MoS_2 Junction

Currently 2D crystals are being studied intensively for use in future nano-electronics, as conventional semiconductor devices face challenges in high power consumption and short channel effects when scaled to the quantum limit. Toward this end, achieving barrier-free contact to 2D semiconductors has emerged as a major roadblock. In conventional contacts to bulk metals, the 2D semiconductor Fermi levels becomes pinned inside the bandgap, deviating from the ideal Schottky-Mott rule and resulting in significant suppression of carrier transport in the device. Here we achieve near-ideal alignment of the Fermi level with a pinning factor of 0.98, by employing a 1D edge contact scheme. Use of high work function palladium (Pd, 5.6 eV) achieved ambipolar contact to MoS_2, which typically shows unipolar n-type characteristics. Field-effect transistors (FET) with Pd edge contacts show high performance with hole mobility reaching 330 $cm^2V^{-1}s^{-1}$ at 300 K with on/off ratios of 10^8. The ideal Fermi level alignment allows creation of p- and n-type FETs on the same MoS_2 flake using Pd and molybdenum (Mo, work function 4.5 eV) contacts, respectively. This device acts as an efficient inverter – a basic building block for future 2D semiconductor integrated circuits -- with gain reaching 15 at V_D=5 V.

Figures

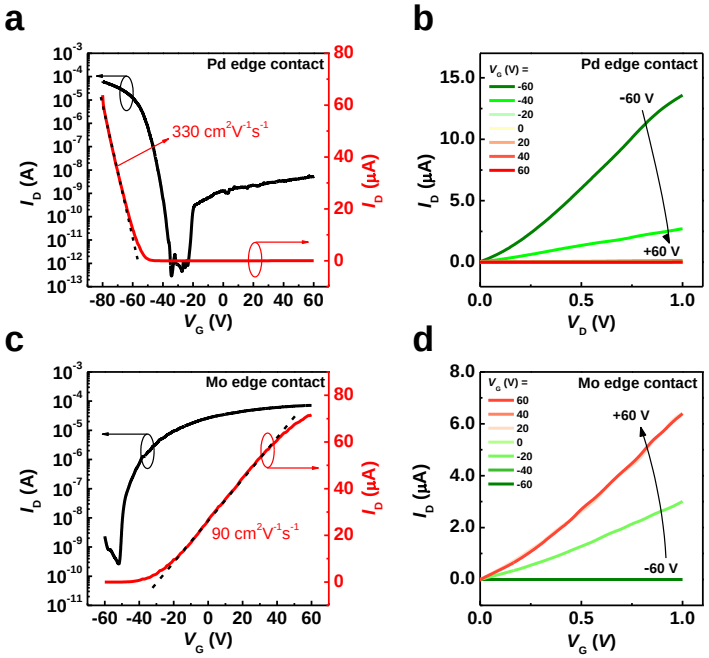

Figure 1: Electrical performance of Mo/ MoS_2 and Pd/ MoS_2 edge contact FETs. Transfer curves on the log (black) and linear (red) scales, for Pd (**a**) and Mo (**c**) at V_D = 1 V (Pd) and 2 V (Mo). Output curves with different gate voltages of Mo (**b**) and Pd (**d**). Mo edge contact FET (L= 6 μm, W=2 μm). Pd edge contact FET (L= 10 μm, W=16 μm).