Local Conduction in Transition Metal Dichalcogenides: The Role of Stacking Faults, Defects and Alloying

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Abstract: Understanding the electronic contact between transition metal dichalcogenides (TMD) and metal electrodes is vital for the realization of future TMD-based electronic devices. TMD materials have the drawback of a high density of defects and impurities. We have investigated, with high-spatial-resolution conductive atomic force microscopy [1], the effect of these defects on the local conduction of the TMD material [2]. We find that subsurface metal-like defects drastically decrease the metal/TMD Schottky barrier height as compared to that in the pristine regions, see Fig.1. The magnitude of the decrease depends on the contact metal and the TMD composition. The decrease of the Schottky barrier height is attributed to strong Fermi level pinning. In addition, we found that stacking faults, step edges and chemical heterogeneities form distinct two-dimensional (2D) and one-dimensional (1D) conduction paths on the TMD surface. In the case of TMD alloys, their conductivity has a strong localized nature, which exactly depends on the underlying chemical composition. Segregation to different phases during the growth process leads to large lateral variations of their conductivity, see Fig.2. These sites provide non-uniform conduction paths and could play a prominent role as the TMD-based devices decrease in size.

References

[1] Sotthewes, K., Bampoulis, P., Zandvliet, H. J., Lohse, D., & Poelsema, B. ACS Nano, 11 (2017), 12723-12731.

[2] Bampoulis, P., Van Bremen, R., Yao, Q., Poelsema, B., Zandvliet, H. J., & Sotthewes, K. ACS Appl. Mater. Interfaces, 9(22), (2017), 19278-19286.

Figures

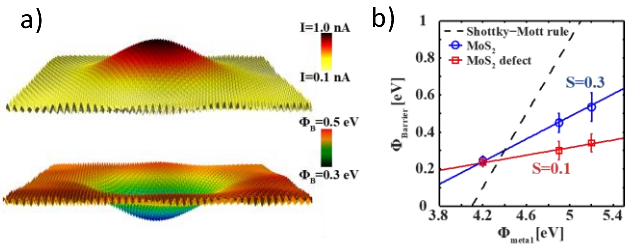

Figure 1: a) Top: Current map on a metal-like defect on MoS2. Bottom: Schottky Barrier Height (SBH) map at the same location. The defect reduces the SBH with the metal AFM tip at this particular location. b) SBH as a function of the tip's work function on the pristine MoS2 surface (blue) and the defect sites (red). The defect sites have a much stronger Fermi level pinning (S=0.1) compared to the pristine regions (S=0.3).

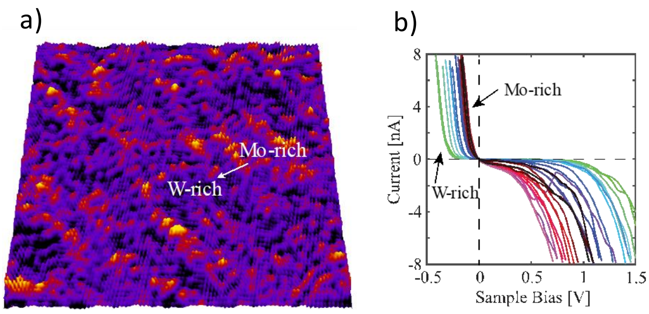

Figure 2: a) Current map of the MoWSe2 alloy surface. Large current variations are observed across the surface. This is apparent also from the recorded I(V) curves of panel (b), where large variations are observed.