Defect mediated properties of 2-D Transition Metal Dichalcogenides studied by ncAFM and STM

Alexander Weber-Bargioni
Barja, Wickenburg Liu, Grushin, Flicker, Pulkin, Zhang, Ryu, Ugeda, Hussain, Shen, Mo, Wong, Salmeron, Wang, Crommie, Yazyev, Ogletree, Schwartzberg, Neaton,
Lawrence Berkeley National Laboratory, one cyclotron road, Berkeley, Ca, USA
awb@lbl.gov

We show how individual atomic defects and linear mirror twin boundaries in 2-D $MoSe_2$, alter the electronic structure leading along mirror twin boundaries to charge density waves and solitons.

2-D $MoSe_2$ is a quantum confined transition metal dichalcogenide (TMD) with fascinating optical and electronic properties due to the confinement in z. Defects in these materials have the potential induce functionality well beyond traditional defect engineering. Using Scanning Tunnelling Microscopy and non contact atomic force microscopy we set out to visualize and correlate in 2-D $MoSe_2$ the morphology and electronic properties of defects with atomic resolution. We show how individual Se vacancies form atomically confined Type 1 hetero junctions – possibly responsible for single photon emission (Fig 1). Another prominent defect are mirror twin boundaries, one-atom wide 1-D defects, forming truly 1-D metal channels embedded in the surrounding semiconductor. At low temperatures a band gap opens at the Fermi level in these metallic states, leading to the formation of isolated 1-D charge density waves (Fig 2).

References

[1] S. Barja, A.Weber-Bargioni, et al., Nature Physics, 12 (2016) 751

Figures

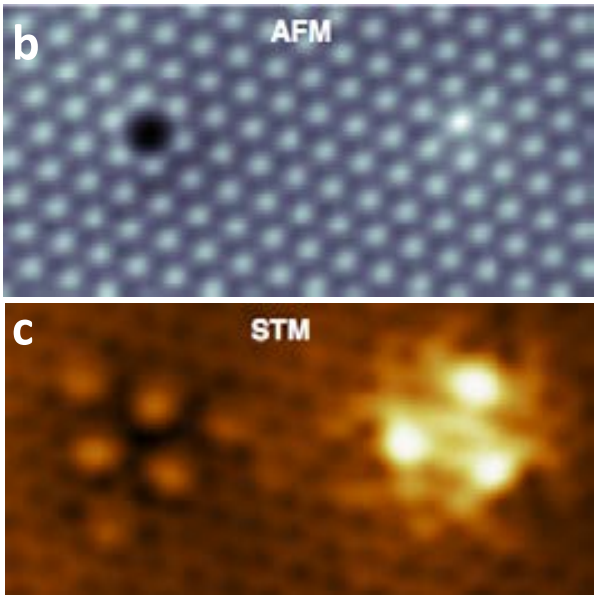

Figure 1: top and bottom Se vacancy in 2-D MoSe2 captured via nc-AFM and STM

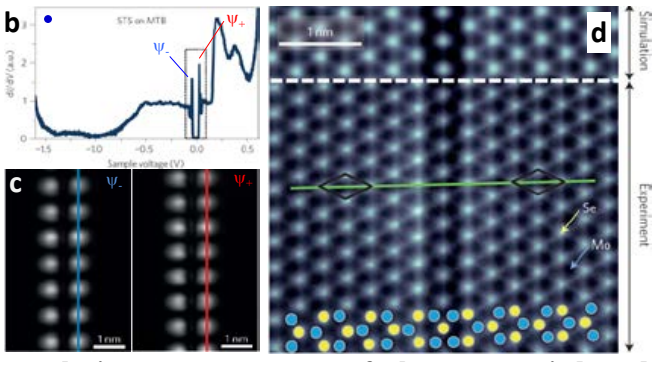

Figure 2: Metallic Mirror Twin Boundaries in 2-D MoSe2 exhibit a small band gap with two sharp edge states. These edge states form a commensurate Charge Density waves with three times the lattice constant.