Analyzing Thickness Dependent Electronic Properties of MoS_2

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Abstract

Transition metal dichalcogenides (TMDs) with formula MX_2, where M is a group 4-6 transition metal and X is a chalcogen, have captured immense research interest as a unique class of 2D materials with favorable electronic and optical properties[1]. One notable aspect of this material is its tunable properties with thickness as demonstrated by optical techniques[2]. This work analyzes the changes in the electronic structure and properties of MoS_2 with thickness using the analytical scanning transmission electron microscope (STEM). Annular dark field – STEM (ADF-STEM) provided atomic resolution images which, in conjunction with *multislice* simulations, allowed complete verification of layer thickness (Figure 1). Furthermore, electron energy loss spectroscopy (EELS) was used to acquire electronic information from 1 to 3 layer thick MoS_2 (Figure 2). With each additional layer, the spectrum showed changes in the band gap, bulk and surface plasmon excitations, and other low energy transitions indicating a change in the electronic properties with thickness as theoretically predicted[3].

References

1. Wang, Q.H. et al., Nature Nanotechnology, **11**, (2012) 699-712
2. Mak, K.F. et al., Physical Review Letters**, 13**, (2010) 136805
3. Johari, P., Shenoy, V.B., ACS Nano, **7**, (2011) 5903-5908

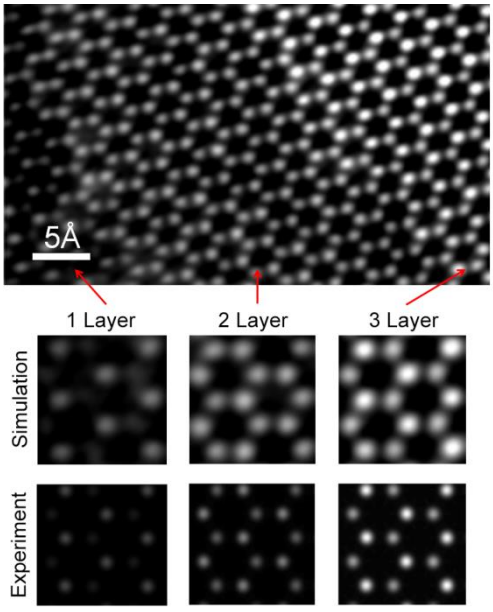

Figure 1: (Top) Filtered STEM image showing step change in thickness from 1-3 layers. (Bottom) Comparison of experimental and simulated ADF-STEM images at each thickness.

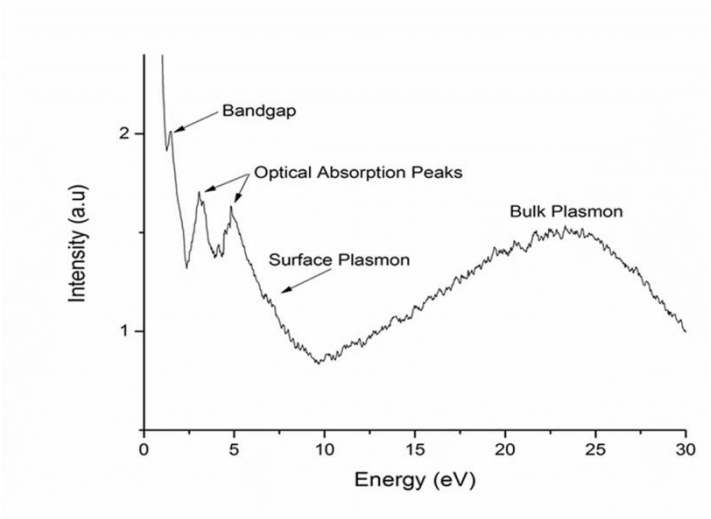

Figure 2: Low-Loss EELS spectrum of a 3 layer MoS_2. Notable peaks are highlighted.