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Microscopic Origins of Physical Property Variations in WTe_2 Thin Films and Flakes

Transition metal dichalcogenides (TMDCs) have received increased attention due to their exotic electronic properties, especially in the few- or mono-layer limit. Fabricating nano-devices based on monolayer TMDCs necessitates that the desired electronic phases are preserved as the layer number decreases. The extremely large non-saturating magnetoresistance of WTe_2 and quantum spin Hall state in the mono-layer limit make WTe_2 an attractive system for both technological applications and fundamental science.

Direct synthesis of WTe_2 thin films is desirable for potential electronic and thermal property-related applications, because it can be more easily scaled up to incorporate in wafer-scale production. We demonstrate a large-area, facile synthesis of WTe_2 thin films by reacting sputtered metal films with H_2Te, an intermediate vapor phase formed from Te vapor and H_2 carrier gas. We also report on the layer-dependent transport measurements of WTe_2 exfoliated to show that the transport properties of thin flakes are degraded by surface oxidation. We find that a roughly 2nm oxide layer forms at the WTe_2 surface. The amorphous oxide layer degrades the overall mobility due to scattering from the increased disorder that is observed with decreasing flake thickness when fitting the transport behavior to a two-band electrical conduction model. Our observation of the extrinsic effects on the electrical properties of WTe_2 underscores the need to understand and mitigate detrimental surface conditions in order to preserve the interesting electronic phases in the few- and mono-layer limit for TMDCs and other 2D layered materials.