Investigating the novel CrSCl material system: A 2D van der Waals ferromagnetic semiconductor

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Emergent material systems such as the layered 2D van der Waals ferromagnetic semiconductors (FMS) offer the possibility of the precise control and manipulation of both carrier charge and spin - the prerequisites for both quantum materials [1] and spintronic devices [2]. However to date, the realization of technologically viable FMS material systems has remained elusive. The holy grail of FMS research continues to be the pursuit of semiconducting behavior coupled with low coercivity, room temperature ferromagnetism. Recent efforts to explore, and subsequently engineer, the nature of the exchange interaction to enhance magnetic coupling have been directed towards the CrXY (X is a chalcogenide and Y is a halide) class of material systems [3]. Through the tuning of the *p-d* hybridization of the Cr-X bonds, the CrXY material systems have been predicted to possess elevated Curie temperatures together with semiconducting optoelectronic properties [3].

In this work, we report the synthesis and the characterization of the geometric, electronic and magnetic structure of chromium sulfide chloride. Employing chemical vapor transport in a dual-zone tube furnace, single crystals of CrSCl have been synthesized. Following mechanical exfoliation high structural integrity is evidenced by x-ray diffraction, second harmonic generation, and scanning transmission electron microscopy, demonstrating that CrSCl forms a stable bulk layered material exhibiting long-rage order in the *ab*-plane. An optical band gap of 2.66 eV is confirmed by photoluminescence measurements and magnetic and structural characteristics are evidenced through photoemission spectroscopy and magnetometry. Temperature dependent magnetization curves indicate a low coercivity and in-plane easy axis, but with a finite interplanar exchange coupling in this bulk layered 2D material system. Preliminary exploration of the nature of the exchange interaction and the model for magnetic ordering will be presented together with comparison with ab initio calculated predicted behavior.

References

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