Controlled growth of atomically thin Chromium disulphide-based 2D TMD

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Two-dimensional (2D) Cr-based layered and non-layered materials such as Cr_2S_3, CrSe, and CrI_3 have attracted considerable attention due to their potential application in spintronics, sensing, field-effect devices and data storage.[1] Despite few experimental studies, theoretical studies reported that 2D-TMD chromium dichalcogenide (CrS_2) materials show unique properties, such as valley polarization, and phase dependent intrinsic magnetic properties. By contrast, the study on 2D non-van der Waals magnetic materials is relatively rare, largely restricted by the challenge of ultrathin materials fabrication due to extremely high melting temperature (>1900^{0}C) of chromium precursors. Furthermore, most of the available 2D-TMD magnetic semiconductors (non-layered) were mainly reported by the mechanical exfoliation route, with poor thickness and domain size control, which inevitably restricted the fundamental property explorations and development of practical applications. We have successfully synthesized 2D layered CrS_2 crystals down to the monolayer thickness (1ML) via the chemical vapor deposition (CVD) method (see Figure 1). We have controlled the domain and crystal size and investigated the optical and electronic properties.[2] The material was characterized by Raman spectroscopy, photoluminescence (PL), Uv-Vis, SEM, and AFM. It should be noted that the monolayer 2H-CrS_2 is a direct bandgap semiconductor with a gap of ~0.95 eV predicted, while the 1T/1T'-CrS_2 are metallic and semi-metallic with ~10 meV bandgap, respectively.[3] In addition, 2H-CrS_2 exhibits nonmagnetic semiconducting properties, while for ferromagnetic spin configuration, the 1T/1T' CrS_2 show magnetic characteristics with 0.531μB and 2.206 μB magnetic moment per Cr atom, respectively.[3] Therefore, the study of layered CrS_2 would stimulate further exploration of 2D layered magnetic materials with astonishing properties and open-up a whole new avenue for the urgent need for developing multifunctional 2D materials for nanoelectronics, valleytronics, and spintronics applications.

References

[1] F Cui et al., Adv. Mater. 32 (2020), 1905896

[2] M R Habib, S Wang, W Wang, H Xiao, S M Obaidulla et al., Nanoscale, 11 (2019), 20123

[3] C Wang et al., Phys. Rev. B 2018, 97, 245409

Figures

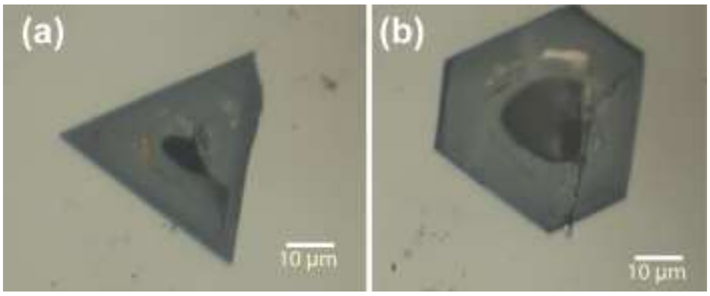

Figure 1: (a) and (b), optical microscopy images typical triangle and hexagonal shaped CrS_2 layered crystal.