Transition Metal Dichalcogenides Fabrication and Self-assembly

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Abstract

Transition metal dichalcogenides like molybdenum disulphide have attracted great interest as two-dimensional materials beyond graphene due to their unique electronic and optical properties. The scalable fabrication of atomically thin transition metal dichalcogenides is vital for industrial applications. We demonstrated a high-yield exfoliation process using lithium, potassium and sodium naphthalenide where an intermediate ternary Li_xMX_n crystalline phase (X=selenium, sulphur, and so on) is produced. Using a two-step expansion and intercalation method, we produce high-quality single-layer molybdenum disulphide sheets with unprecedentedly large flake size, that is up to 400 mm_2. Single-layer dichalcogenide inks prepared by this method may be directly inkjet-printed on a wide range of substrates.

The self-assembly of transition metal dichalcogenides flakes, as an emerging area, is largely unexplored. High-quality nanoscrolls rolled up from chemical vapour deposition-grown transition metal dichalcogenides flakes were demonstrated. Based on the internal open topology, nanoscrolls hybridized with a variety of functional materials have been fabricated, which is expected to confer transition metal dichalcogenides nanoscrolls with additional properties and functions attractive for potential application.

References

[1] Jian Zheng, Han Zhang, Shaohua Dong, Yanpeng Liu, Chang Tai Nai, Hyeon Suk Shin, Hu Young Jeong, Bo Liu & Kian Ping Loh, Nat.Commun., 5 (2014) 2995.

Figures

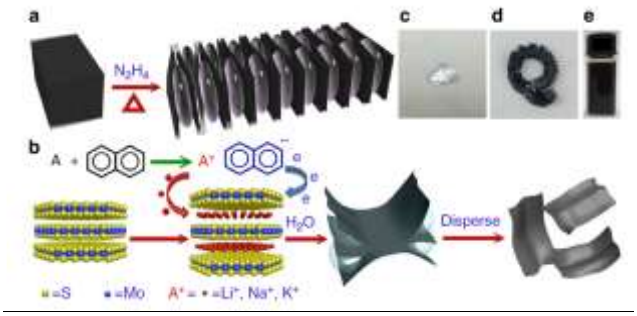

Figure 1: Schematic of fabrication processes. (a) Bulk MoS_2 is pre-exfoliated by the decomposition products of N_2H_4. (b) Pre-exfoliated MoS_2 reacts with $A^+C_{10}H_8^-$ to form an intercalation sample, and then exfoliates to single-layer sheets in water. (c) Photograph of bulk single-crystal MoS_2.(d) photograph of pre-exfoliated MoS_2.(e) photograph of Na-exfoliated single-layer MoS_2 dispersion in water.

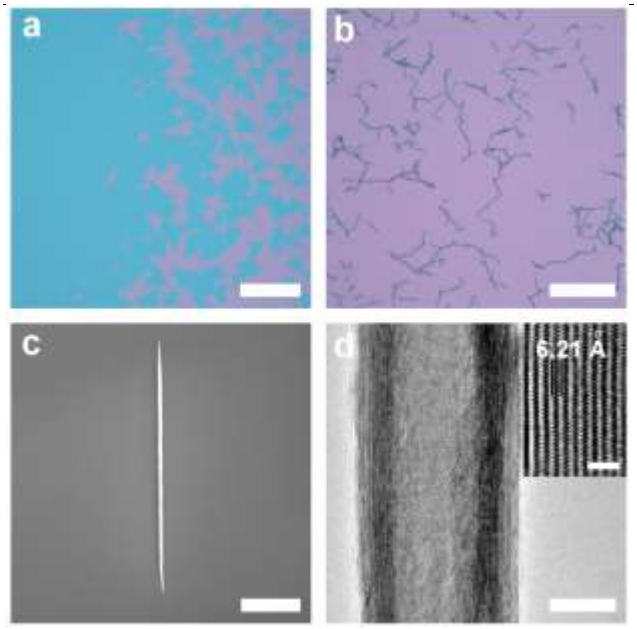

Figure 2: a, Optical image of CVD-grown MoS_2 monolayer flakes on a SiO_2/Si substrate. b, Optical image of MoS_2 nanoscrolls on a SiO_2/Si substrate. c, SEM images of MoS_2 nanoscrolls. d, TEM images of MoS_2 nanoscrolls. Inset: High-magnification images of sidewalls of MoS_2 nanoscrolls. (Scale bars, 500 μm in a, 100 μm in b, 5 μm in f and 2 nm for the inset).