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CVD-Grown High-Quality Ultrathin Mo_2C Crystals and Their Vertical Heterostructures with Graphene

Transition metal carbides (TMCs) are a large family of materials that combine the properties of ceramics and metals. High-quality 2D TMCs are essential for investigating new physics and properties in 2D limit. However, the commonly used chemical etching method can only produce functionalized 2D TMC nanosheets with abundant defects and functional groups, known as MXenes. Recently, we developed a universal CVD method [1] to fabricate large-area high-quality ultrathin 2D TMC crystals. The obtained α-Mo_2C crystals are a few nanometres thick and over 100 µm in size. They show 2D characteristics of superconducting transitions; moreover, the superconductivity is also strongly dependent on the crystal thickness. Further studies show that 2D α-Mo_2C crystals have unique domain structure with rotational-symmetry and well-defined line-shaped domain boundaries, and the domain boundaries have a significant influence on 2D superconductivity [2]. We also realized the direct growth of high-quality graphene/2D superconducting α-Mo_2C vertical heterostructures with uniformly well-aligned lattice orientation and strong interface coupling by a two-step CVD process [3]. The strong interface coupling leads to a phase diagram of superconducting transition with multiple voltage steps being observed in the transition regime. Furthermore, we demonstrated the realization of highly transparent Josephson junction devices based on these heterostructures.

References

[1] C. Xu, et al., Nature Materials, 11 (2015) 1135-1141
[2] Z. Liu, et al., Nano Letters, 7 (2016) 4243-4250
[3] C. Xu, et al., ACS Nano, 6 (2017) 5906-5914

Figures

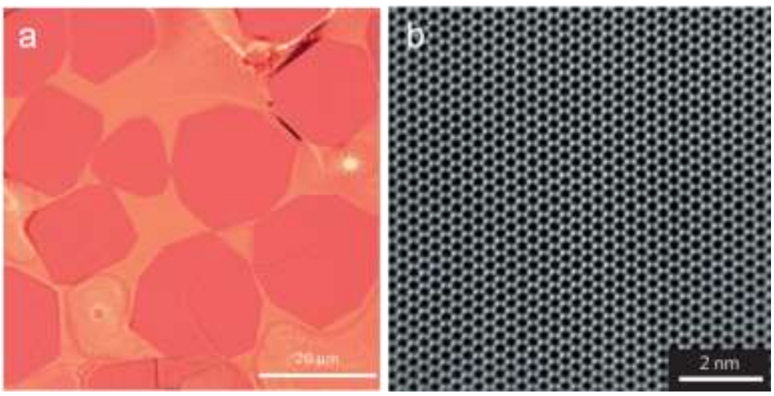

Figure 1: (a) Typical optical image of ultrathin α-Mo_2C crystals on a Cu/Mo substrate, showing different regular shapes. (b) Atomic-level HAADF-STEM image of an α-Mo_2C sheet, showing highly crystalline quality.