Exploration of New 2D Materials and Their New Properties

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Identification of two-dimensional (2D) materials in the monolayer limit has led to discoveries of new phenomena and unusual properties. In this lecture, I'll first report the growth of large-area high-quality 2D ultrathin Mo_2C crystals by CVD [1], which show 2D characteristics of superconducting transitions that are consistent with Berezinskii–Kosterlitz–Thouless behaviour and show strong dependence of the superconductivity on the crystal thickness. Furthermore, when we introduce elemental silicon during CVD growth of nonlayered molybdenum nitride, we have grown centimeter-scale monolayer films of $MoSi_2N_4$ which does not exist in nature and exhibits semiconducting behavior, high strength, and excellent ambient stability [2]. On the other hand, we have found some interesting properties from well-known 2D materials such as h-BN. For example, a class of membranes assembled with 2D transition-metal phosphorus trichalcogenide nanosheets give exceptionally high ion conductivity and superhigh lithium ion conductivity [3]. We even demonstrate an anomalously large magneto-birefringence effect in transparent suspension of magnetic 2D crystals [4], with orders of magnitude larger than that in previously known transparent materials. Moreover, based on this phenomenon, we develop a stable and birefringence-tunable deep-ultraviolet modulator from 2D hexagonal boron nitride which gives rise to a ultra-high specific magneto-optical Cotton–Mouton coefficient, about five orders of magnitude higher than other potential deep-ultraviolet-transparent media [5]. Very recently, we have found that strong bulk van der Waals materials can be densified from their nanosheets at near room temperatures with mediation of water [6]. These findings indicate a great promise of 2D materials.

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