Near-room-temperature Fabrication of Bulk van der Waals Materials by Water-mediated Densification of Their Nanosheets

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Abstract

The conventional fabrication of bulk van der Waals (vdW) materials requires a temperature above 1000 °C to sinter from their particulates. Here, we report the near-room-temperature densification (e.g. ~45 °C for 10 minutes) of two-dimensional (2D) nanosheets (hexagonal boron nitride, graphene, MXene and transition metal dichalcogenides) to form strong bulk materials with a porosity of <0.1%, that are mechanically stronger than the conventionally-made ones. The mechanistic study shows that water-mediated activation of the vdW interactions accounts for the strong and dense bulk materials. Initially, water adsorbed on the 2D nanosheets lubricates and promotes their alignment, subsequently, water extrusion from the formed nanosheet capillaries at 45 °C, densifies the aligned nanosheets into strong bulk materials. The water extrusion also generates stresses which increase with molding temperature, and too high a temperature causes intersheet misalignment, thus a near-room-temperature molding process is favored. This technique provides an energy-efficient alternative to design a wide range of dense bulk vdW materials with tailored compositions and properties.

References

[1] Jiuyi Zhu, et al, Nature Materials, Accepted, [2024]

Figures

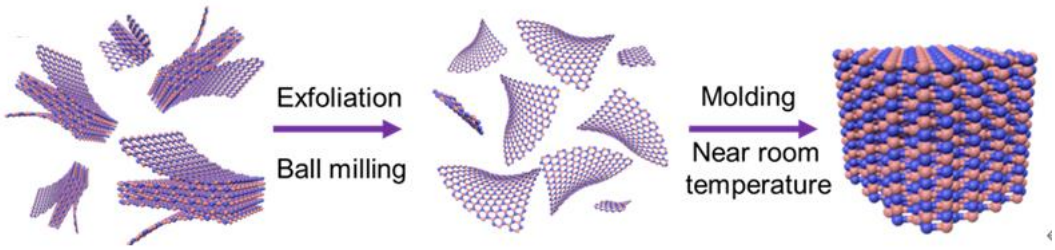

Figure 1: Molding of nanosheets to prepare strong, densified bulk vdW materials.