Large-Scale Production of Single Crystal 2D Materials

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Abstract:

Two-dimensional materials (2DMs) have been intensively studied for almost two-decade since the isolation of graphene from bulk graphite into devices in 2004. Over the past few years, the utilization of 2DMs in various areas of industry has strongly intensified. However, even though considerable efforts have been spent on the development of various methods of the production of 2DMs, the efficient production of 2DMs of a guaranteed quality over a large scale remains a challenge. In this seminar, I am going to introduce our strategies to produce 2DMs via top-down and bottom-up approaches. At first, I will present a scalable growth of single-crystal graphene (SCG) on through "transplanting" uniaxially aligned graphene "seedlings" on the larger-area catalytic growth substrate [1]. By inducing homo-epitaxial growth of graphene from the edges of the seed arrays without additional nucleation, we achieved the SCG with an area four times larger than the mother graphene seed substrate. And then, I will introduce atomic spalling of the van der Waals crystals that achieve large area 2DMs (graphene, MoS_2, $MoSe_2$, and WSe_2) with a controlled number of layers [2]. We found that being a layered crystal with a weak interlayer vdW force enables to control of the crack propagation depth at the scale corresponding to the single atomic thickness by adjusting interfacial toughness and the internal stress of the stressor film. The presented results show huge potential for the manufacture of layer-resolved high-quality vdW materials, which can be developed into practical functional electronic and photonic devices.

References

[1] *Science* **344**, 286 (2014); *Adv. Mater.* **31**, 1803469 (2019); *ACS Nano* **14**, 3141 (2020)

[2] *Sci. Adv.* **6**, eabc6601 (2020); *Matter* **5**, 3935-3946 (2022).