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Synthesis and Stabilization of Large-Scale Monolayer 1T'-MoTe2

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Out of the different structural phases of molybdenum ditelluride (MoTe2), the distorted octahedral 1T' hosts great interest for fundamental physics and could pave the way to the implementation of novel devices such as topological transistors. Indeed, 1T'-MoTe2 is a semimetal hosting superconductivity, which has been predicted to be a Weyl semimetal and a quantum spin Hall insulator in bulk and monolayer form, respectively. The large instability of monolayer 1T'-MoTe2 in environmental conditions, however, has made its investigation extremely challenging so far. In this work, we demonstrate the homogeneous growth of large single-crystal (up to 500 µm) monolayer 1T'-MoTe2 via chemical vapor deposition (CVD) and its stabilization in air with a scalable encapsulation approach [1]. The encapsulant is obtained by electrochemically delaminating CVD hexagonal boron nitride (hBN) from copper foil and it is applied on the freshly grown 1T'-MoTe2 via a top-down dry lamination step. The structural and electrical properties of encapsulated 1T'-MoTe2 have been monitored over several months to assess the degree of degradation of the material. We find that when encapsulated with hBN, the lifetime of monolayer 1T'-MoTe2 successfully increases from few minutes to several months. Furthermore, the encapsulated monolayer can be subjected to transfer, device processing, and heating and cooling cycles without degradation of its properties. The potential of this scalable heterostack is confirmed by the first observation of signatures of low-temperature phase transition in monolayer 1T'- MoTe2 both by Raman spectroscopy and electrical measurements.

References

[1] S. Pace, L. Martini, D. Convertino, D.-H. Keum, S. Forti, S. Pezzini, F. Fabbri, V. Mišeikis, C. Coletti, ACS nano 15 3 (2021) 4213-4225.

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