2D Quantum Heterostructures via Microfluidic Exfoliation

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Abstract:

The development of scalable and controllable exfoliation techniques is essential for accessing 2D quantum materials with tailored properties. In this work, we present a microfluidic electrochemical exfoliation method tailored for the efficient production of 2D nanosheets from layered quantum materials. The system integrates a custom-designed microfluidic device with an applied voltage and formic acid electrolyte, chosen for its high conductivity and favorable gas evolution behavior on platinum electrodes. Exfoliation occurs continuously along the microchannel, ensuring uniform ion transport and controlled delamination. We systematically explored the effects of applied voltage, electrolyte concentration, and exfoliation time, and observed that moderate voltages provided the best balance between flake thickness, size, and stability. The exfoliated nanosheets were characterized by SEM, TEM, PXRD and FT-IR, confirming the formation of few-layer structures with high crystallinity. This microfluidic approach enables scalable, tunable exfoliation and offers a promising route for assembling clean 2D heterostructures suitable for electronic and topological device applications.

References

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[2] M. Lê Anh, P. Potapov, A. Lubk, T. Doert, M. Ruck, npj 2D Mater. Appl. 2021, 5, 22.

Figures

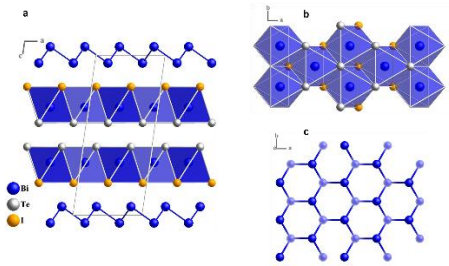

Figure 1. Crystal structure of Bi_2TeI; a Projection along the b-axis. b Top view on a [Bi_2] layer and c a [TeBiI] layer.

Figure 2. Microfluidic device for exfoliation.