Atomic Layer Etching of the Quantum Spin Hall Insulator WTe_2 Towards the Study of Topological Josephson Junction Devices

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The 2-dimensional (2D), van der Waals materials have a variety of unique optical and electronic properties that have been exploited to create novel Field-Effect Transistors (FETs) and photodetectors. Weak interlayer interactions allow these materials to be isolated in the few- and monolayer limit, a state in which their properties differ significantly from the bulk. We report on an Atomic Layer Etching[1] (ALE) method for WTe_2, a 2D material that undergoes a structural phase transition in the monolayer limit and becomes a Quantum Spin Hall Insulator[2] (QSHI). Given the extreme air sensitivity of this material and its propensity to exfoliate into small monolayers (< 5um), the optimization of an ALE method is critical for creating devices which exploit QSHI physics. Of particular interest are Josephson Junctions[3], in which a monolayer of WTe_2 is sandwiched between s-wave superconductors. This realizes a proposed geometry for studying Majorana bound states, having applications in fault-tolerant quantum computing. We report on the applicability of our ALE method for etching large, bulk flakes into the few-layer limit as well as for making thin constrictions, which is critical for designing a Josephson Junction device.

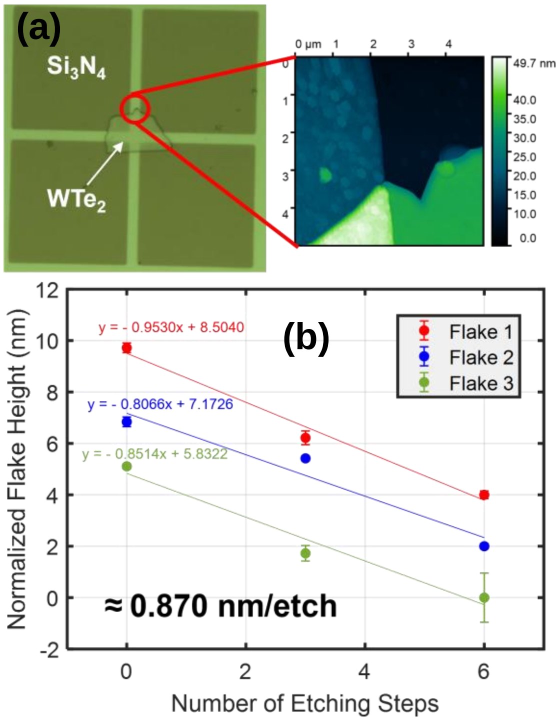

Figure 1: (a) Optical image of a bulk WTe_2 flake with AFM scan of an etched area. (b) Etch rate testing on three bulk flakes.

[1] Li et al., ACS Nano, 10, 6836-6842 (2016)
[2] Wu et al., Science, 359, 76-79 (2018)
[3] Randle et al., Adv. Mater., 35, 2301683 (2023)