Department of Materials Science and Engineering

PhD Thesis Proposal

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COE Hill Conference Room (Lebow 240)
and
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Mechanism and Kinetics of MXene Synthesis

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Abstract

The family of 2D carbides and nitrides called MXenes has grown to encompass numerous structures and compositions. These materials have been explored in a variety of applications such as energy storage, wireless communication, optoelectronics, and medicine because of their high electrical conductivity, redox-active surfaces, plasmonic behavior and other attractive properties. MXenes are typically derived via topochemical etching of atomically thick layers from precursor layered MAX phases using aqueous corrosive etchants. Knowledge of the reaction mechanism and process kinetics are of fundamental importance for synthesis and property control of MXenes. Prediction of the optimal synthesis approaches will facilitate new MXene composition discovery and prediction of optical processing time as a function of various parameters will also facilitate scaling up wet chemical synthesis of MXenes for industrial use. Despite their importance, such studies have been challenging because of the atomic thickness of the A-element layers being etched and the aggressive etchants that hinder in situ studies. In this thesis, I explore various ex-situ techniques to probe the effect of critical etching parameters on the structure, chemistry, and properties of the resulting MXenes; as well as developed various in-situ analytical techniques to quantitatively measure the etching kinetics and microscopic techniques to directly visualize the structural evolution during the etching reaction. Beyond liquid phase etching, I am exploring alternative methods for MXene synthesis through vapor phase etchants that introduce new functional groups and enable rapid and scalable synthesis by eliminating the need for a solvent as in conventional synthesis.