DREXEL UNIVERSITY
Materials Science and Engineering
College of Engineering

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PhD Defense

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Synthesis of Two-Dimensional Transition Metal Nitrides

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Abstract:

The family of two-dimensional (2D) materials – solids with high aspect ratios and thicknesses consisting of a few atomic layers – has grown far beyond graphene. 2D transition metal carbides, nitrides and carbonitrides, known as MXenes, are one of the latest additions to this family. This rapidly growing class of 2D materials finds applications in fields ranging from energy storage to electromagnetic interference shielding and transparent conductive coatings. However, while over twenty carbide MXenes have been synthesized, very few transition metal nitrides (TMNs), and no nitride MXenes, had previously been reported. Two-dimensional TMNs, including nitride MXenes, have several potential advantages over their carbide analogs. They theoretically have higher values of electrical conductivity than carbide MXenes, which has implications on outperforming carbides in electrochemical and other applications. Compared to carbides, they are superior candidates for promising plasmonic devices and spintronic devices that incorporate magnetic 2D materials.

Although there are theoretically as many nitride MXenes as carbide MXenes predicted, synthesizing nitride MXenes and 2D TMNs in general faces several challenges. Synthesis methods that have produced over two dozen 2D metal carbides (MXenes) have failed to yield 2D TMNs. The major focus of this dissertation is investigating routes of synthesizing 2D TMNs including, but not limited to, selective etching of layered bulk metal nitride precursors. Three promising routes of synthesis are explored, and their electronic and magnetic properties are also characterized. Discovering how to synthesize 2D TMNs will remove the barrier between merely studying their theoretically predicted properties and finally applying these outstanding properties in devices for energy storage, spintronics and beyond.