DREXEL UNIVERSITY
Materials Science and Engineering
College of Engineering

Department of Materials Science and Engineering,

PhD Proposal Exam

January 26th, 2023, 10am
Hill Conference Room, Lebow 240

Strategies for Integrating and Transforming MXene to Alter the Properties of Layered Transition Metal Oxides in Electrochemical Systems

Timofey Averianov
Advisor: Ekaterina Pomerantseva

Cathode materials, typically layered oxides, continue to be a major bottleneck in the performance of rechargeable batteries, marred by their low electronic conductivities and mechanical stability. As a result, we would like to understand how these layered materials can be modified to improve their performance in battery cycling. In this work, we propose the use of layered transition metal carbides, also known as MXenes, as a platform for developing new cathode materials through two distinct methods. The first method is the integration of MXene with existing layered oxides in order to produce heterostructured materials. Using bilayered vanadium oxide as our model oxide material, we explore the exfoliation of this layered oxide into few-layer particles, followed by the assembly of suspended bilayered vanadium oxide and delaminated MXene into heterostructure materials. This assembly will be controlled by a cation-driven assembly process that introduces electrochemical active or inactive ionic species that can alter the behavior of the heterostructure during Li-ion cycling. By examining differences in transport behavior and electrochemical cycling, we can make conclusions on the best practices for developing heterostructure materials using cation-driven assembly. The second method is the transformation of MXene into layered oxides. By leveraging their chemical properties, we can oxidize MXene through a combination of dissolution and recrystallization processes to form layered oxides with unique morphologies and structures. Our first step is to understand cycling behavior of these derived oxides in potassium-ion battery systems, to gauge whether the improvements to performance in Li-ion systems of MXene-derived oxides can be transferred to other systems. Next, solid-solution MXene will be introduced in order to understand how multiple transition metals affect the transformation process. We explore the properties of solid-solution derived oxides by varying the composition of MXene used in the transformation. We then explore the preintercalation of alkali ions during the transformation of solid-solution MXene to establish if similar improvements to stability and capacity in bilayered vanadium oxide can be applied to solid-solution derived oxides.