DREXEL UNIVERSITY
Materials Science and Engineering
College of Engineering

Department of Materials Science and Engineering,

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Regulating Alkali Metal Nucleation and Growth via Solid Polymer Electrolytes (SPEs) for Solid-State Batteries

William R. Fullerton
Advisor: Dr. Christopher Y. Li

Abstract

Electrochemical cells employing alkali metal anodes have attracted considerable research attention due to their high theoretical energy density. However, chemical and morphological instabilities at the metal anode during cycling promote dendrite formation, reducing cycling reversibility and potentially causing short-circuits. Solid polymer electrolytes (SPEs) present a cost-effective candidate to better regulate these instabilities at the metal anode. Although SPEs have shown considerable promise in regulating alkali metal deposition relative to conventional liquid electrolytes, interfacial instabilities at the metal-SPE interface still remain a significant and poorly understood challenge. Accordingly, elucidating how specific SPE material properties influence electrodeposition is essential for identifying the governing parameters that inform rational design of next-generation SPEs.

In this dissertation, we first explore how crosslinked network architecture influences the physical and electrochemical properties of a series of comb-chain network SPEs, and how these properties correlate to dendrite resistance and overall battery performance in lithium metal batteries (LMBs). We then utilize this comb-chain network synthetic platform to investigate the role of polymer modulus

on the morphology and kinetics of *in situ* formed sodium metal anodes for "anode-free" sodium metal batteries (SMBs). Finally, we utilize this platform to fabricate structurally and chemically patterned SPEs (pSPEs) to spatially control nucleation location and template the growth of sodium metal for "anode-free" SMBs.