Beyond Li-ion: High Energy Metal-based Batteries

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Advances in the basic science and engineering principles of electrochemical energy storage is imperative for significant progress in electronic devices. Metal based batteries comprising of a metal (like Li, Na, Al, Zn) as the anode have attracted remarkable attention due to their promise of improving the anode-specific capacity by as much as 10-fold, compared to the current state-of-art Li-ion battery that uses a graphitic anode. The metal anodes also enable the utilization of energetic simple molecules (like sulfur, oxygen, carbon dioxide) as the cathode, which could further increase the cell level energy density. However, a persistent challenge with batteries based on the metallic anode, concerns their propensity to fail due to short-circuits produced by dendrite growth during battery recharge, as well as by runaway of the cell resistance due to internal side reactions with the liquid electrolyte. In this talk, I will discuss our research that utilizes ion transport modeling and contemporary experimental efforts to fundamentally understand and to thereby develop rational designs for electrode-electrolyte interphases that overcome these challenges for metal-based batteries. Particularly, on the anode side, we demonstrated that porous zinc electrodes reduce dendrite formation by lowering the diffusion-limited current density. To pair a metal anode with a small molecule (CO_2) gas cathode, we also demonstrated cathode and electrolyte design that enable a rechargeable Al-CO_2 battery.