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# Battery energy device development and system integration

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ABSTRACT

Battery technology plays a pivotal role in achieving a decarbonized future by enabling renewable energy integration, ensuring grid stability, and advancing electrified transportation. Despite significant progress, challenges remain in enhancing the energy density, safety, and sustainability of batteries. Due to their high theoretical capacity (10 times that of commercial graphite anodes in Li-ion batteries), lithium (Li) metal anodes represent a promising solution. However, the commercialization of Li-metal batteries is hindered by Li dendrite formation, which degrades performance and poses safety risks. To address this challenge, we developed a series of cost-effective electrolyte additive strategies to prevent dendrite growth while maintaining compatibility with existing production processes. Further, by employing advanced techniques such as synchrotron-based X-ray absorption spectroscopy and microscopy, we demonstrate a novel interface chemistry that enables safer and more efficient lithium batteries. In parallel, we are exploring alternative battery technologies beyond Li, such as zinc (Zn) and aluminum (Al) batteries, which offer improved sustainability and resource efficiency. Several representative works will be presented, addressing critical issues such as battery material design, component development, and cell assembly. We will cover liquid batteries, flow batteries, and all-solid-state batteries. Finally, we highlight key challenges that remain, including safety management, battery recycling, and the broader implications for supporting the energy transition.