The rapid growth of portable electronics, electric vehicles, and renewable energy storage has really ramped up the demand for lithium-ion batteries (LIBs) that boast higher energy densities, longer lifespans, and better safety features. A key player in this equation is the anode, which significantly influences the overall performance and stability of LIBs. While traditional graphite anodes have been commercially successful, they are approaching their theoretical capacity limit of 372 mAh/g and are struggling with issues like lithium plating during fast charging.

This proposal zeroes in on the exploration and development of cutting-edge anode materials, such as silicon-based composites, lithium-metal anodes, and transition metal oxides, all of which promise much higher theoretical capacities. However, challenges like volumetric expansion, poor cycle stability, and interfacial degradation still pose significant hurdles. Our research is geared towards creating innovative anode structures with tailored morphologies, surface coatings, and hybrid composites to boost mechanical integrity, conductivity, and the stability of the solid-electrolyte interphase (SEI). We'll use systematic material characterization alongside electrochemical testing to delve into degradation mechanisms and steer material optimization.

The successful outcomes of this project will shed light on how to design next-generation anodes that can greatly enhance the energy density and lifespan of lithium-ion batteries, meeting the increasing demand for more efficient and durable energy storage solutions.