Dr. Sang-Don Han has over ten years of experience in electrochemistry and electrochemical energy storage as a PhD student at North Carolina State University, a post-doctoral researcher at Argon National Laboratory, and a staff scientist at National Renewable Energy Laboratory. He is generally interested in cell aging behaviors and failure mechanisms, electrode-electrolyte interphase stabilization, and electrolyte solution structure and properties to develop advanced (beyond) Li-ion batteries with high energy density, better safety and long lifetime. Highlights of Dr. Han's work include (1) introducing novel in-situ multi-modal characterization techniques and utilizing electrochemical analysis and diagnostic for studying cell aging and failure mechanisms, and publishing a unique characterization tool for understanding the link between electrolyte solution structure and properties, (2) publications of 1 book chapter, 3 patents, and 55 peer-reviewed journals and reviewer of journals and Department of Energy proposals, and (3) recipient of NREL President's Award and committee and/or session chair in Beyond Lithium-Ion Symposium and Electrochemical Society Meeting. Dr. Han is the principle investigator of two Department of Energy programs focused on electrode-electrolyte interphase characterization and multi-modal approach for a holistic understanding of the electrode and electrolyte aging behaviors and battery failure mechanisms, and the participant of biocrude derived carbon anode material development project.

Investigating Electrode-Electrolyte Interfacial Chemistry and Electrode and Electrolyte Aging Behaviors Using In-situ Multi-modal Characterization Techniques

The improvements in electrochemical energy storage with next-generation materials are currently offset by their rapid degradation due to the unstable electrode-electrolyte interphases (EEIs) and the undesirable (electro)chemical reactions at electrode surface.[1,2] Understanding the formation and evolution of the EEIs, as well as the complex reactions taking place in each phase is essential to the development of mitigation strategies enabling longer battery life with better safety. In this presentation, I will discuss our recently developed in-situ multi-modal characterization techniques for a better understanding of the critical mechanisms occurring near the electrode surfaces by monitoring the EEIs "in real-time" during cell cycling.[3,4] For example, with in-situ ATR-FTIR and in-situ gas chromatography with flame ionization detection, we have investigated the voltage dependent electrolyte solution structure changes and gas evolution at the interface, electrode changes correlated to transition metal redox chemistry, and the interfacial layer formation and evolution for higher Ni-content cathodes. In-situ Raman was also utilized to study spatial and time-resolved aging behaviors of silicon-based electrodes. Those newly developed techniques are applicable to other battery systems and the EEI contained within.

1. S.-D. Han, *et al.*, "Intrinsic Properties of Individual Inorganic Silicon−Electrolyte Interphase Constituents," *ACS Appl. Mater. Interfaces* **2019**, *11*, 46993−47002.
2. S.-D. Han, *et al.*, "Effect of Water Concentration in $LiPF_6$-Based Electrolytes on the Formation, Evolution, and Properties of the Solid Electrolyte Interphase on Si Anodes," *ACS Appl. Mater. Interfaces* **2020**, *12*, 49563−49573.
3. S.-D. Han, *et al.*, "Probing the Evolution of Surface Chemistry at the Silicon-Electrolyte Interphase via *In-situ* Surface-Enhanced Raman Spectroscopy," *J. Phys. Chem. Lett.* **2020**, *11*, 286-291.
4. S.-D. Han, *et al.*, "*In Situ* ATR-FTIR Study of Cathode-Electrolyte Interphase: Electrolyte Solution Structure, Transition Metal Redox, and Surface Layer Evolution," *Batter. Supercaps* **2021**, *4*, 778-784.