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Session I
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Electrode Specific Degradation Tailored by the Directionality of Thermal Gradients in Li-ion Batteries

Herein we demonstrate that intentionally applied interelectrode thermal gradients accelerate capacity loss in warm (35 °C) cells, and further the directionality of the thermal gradient dictates the degradation mode responsible.[1] By simulating cell self-heating at various ambient temperatures and C-rates, we identify 35 °C and C/5 as a condition that does not typically exhibit Li plating under isothermal conditions, but is sensitive to thermal gradients. When subjected to an interelectrode thermal gradient, we observe a 77% capacity fade over 20 cycles when the negative electrode (NE) is warmer than the positive electrode (PE) (ΔTint=+2 °C), and a 100% capacity fade when the PE is warmer than the NE (ΔTint=-2 °C). Incremental capacity (IC) analysis diagnoses PE degradation for the ΔTint=+2 °C case and NE degradation for the ΔTint=-2 °C case. Electrochemical impedance spectroscopy and post mortem optical investigation corroborate these findings. Our findings identify interelectrode thermal gradients as a means to achieve accelerated aging of Li-ion cells with the capability to dictate a limiting electrode and/or decouple the degradation of each electrode.

1. Carter, R.; Kingston, T. A.; Atkinson, R. W.; Parmananda, M.; Dubarry, M.; Fear, C.; Mukherjee, P. P.; Love, C. T. (2021). Directionality of thermal gradients in lithium-ion batteries dictates diverging degradation modes. Cell Reports Physical Science 2, 100351.

About the speaker

Dr. Rachel Carter is Research Mechanical Engineer at the US Naval Research Laboratory (NRL). Prior to this role she has held the positions of Karles Distinguished Scholar Fellow and National Research Council postdoctoral fellow at NRL. In fall of 2019 she was awarded the MRS Postdoctoral Award. Rachel received her Ph.D. in mechanical engineering from Vanderbilt University in 2017. Her dissertation research focused on material and processing challenges for alkali-sulfur batteries, which boast 6X the energy of Li-ion with lower cost and more environmentally friendly materials.

At NRL, Rachel continues to work on sulfur chemistries, while also focusing on safer and more effective uses of conventional Li-ion batteries. In her 8 years as an energy storage researcher, she has published 53 peer-reviewed articles (h-index 26, i10-intex 42) and obtained 3 patents. In 2019, Rachel was recognized by Nature as a top 5 emerging material scientists. In efforts to support women in STEM, Rachel was a co-founder of the Partnership of Women across the Naval Research Enterprise and has had the opportunity to mentor many young female researchers from the high school to graduate level.