IEC seminar by Koffi Yao

Quantifying lithium concentration gradients in the graphite electrode of Li-ion cells using operando energy dispersive X-ray diffraction

Safe and energy efficient fast charging of lithium ion batteries is desired in many practical applications such as portable electronics and electrified transportation. However, diffusive transport modeling predicts steep intercalant gradients in the electrodes during high-current cycling. The heterogeneities in the electrodes created by these gradients negatively impacts battery lifetimes as mechano-chemical stresses develop in the structure of the cell’s electrodes. Direct experimental measurement of these gradients is lacking to steer pragmatic optimization of Li-Ion electrodes for gradient-free fast utilization. In this talk, we will discuss the novel use of spatially resolved energy dispersive X-ray diffraction to obtain a direct spatiotemporal "movie" of insertion and de-insertion in different sections of the cell and quantify gradients in lithium distribution that develop in a typical graphite electrode during one-hour full charges and discharges. We discovered, even at this moderate charge/discharge rate, that unexpectedly large spatial inhomogeneities in the ordered Li₅C₆ phases and thereby in Li-content are prevalent causing mechano-chemical stresses in the cell. In the specific case of the typical graphite with reversible potential perilously close to that of metallic lithium, these steep gradients polarize the battery cell on charge and lithium plating conditions can be met near the electrode surface resulting in the potential for dendrite-induced short circuits and compromised fire safety.

Bio:
Dr. Koffi P. Yao is currently an assistant professor in the department of Mechanical Engineering at the University of Delaware. Prior to joining the faculty, Dr. Yao graduated with a Ph.D from the Massachusetts Institute of Technology in 2016 and completed two years as a postdoctoral researcher at the Argonne National Laboratory. Dr. Yao is also an Alumni of the University of Delaware Department of Mechanical Engineering where he received his Bachelor’s (Summa Cum Laude). During his Ph.D, Dr. Yao received five years of research funding from Toyota Motor Europe R&D Advanced Technologies.