PURDUE UNIVERSITY | Maha Fluid Power Research Center

- WEBINAR SERIES -

November 4th, 2024

Online*

Degradation-Safety Analytics for Li-ion Batteries

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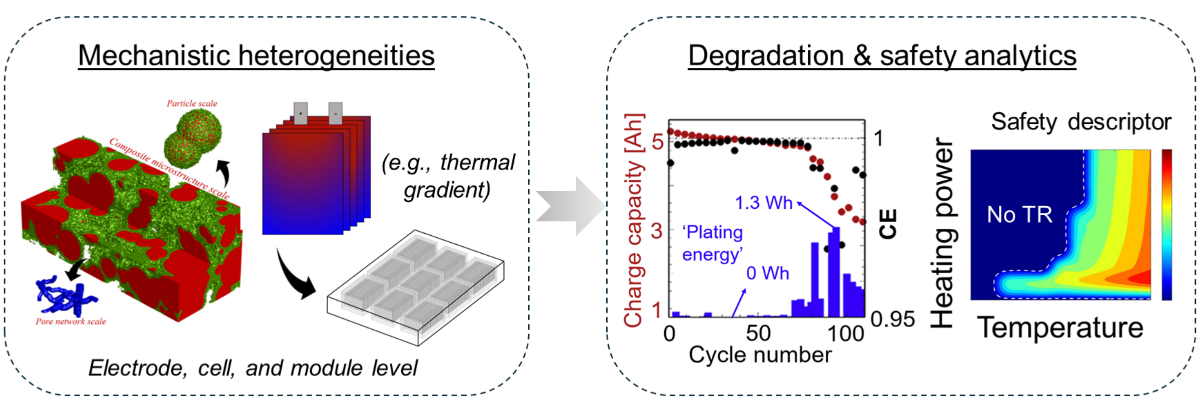
Abstract

While Li-ion batteries have attracted tremendous interest for applications such as electric vehicles and portable electronics, understanding and diagnosing their degradation and safety behavior under different operational extremes continues to remain a key challenge. Future electromobility demands such as extreme fast charging and low temperature operation are confronted with mechanistic thermo-electrochemical limitations and degradation processes including Li plating, solid electrolyte interphase growth, and loss of active material. The onset and severity of such degradation mechanisms under different operating conditions, cell chemistries, and form factors further affects the thermal stability and safety response of Li-ion cells. In addition, emerging technologies such as electric vertical takeoff and landing aircraft involve more stringent power requirements, leading to unique degradation and safety signatures. In this presentation, a mechanistic framework combining physics-based modeling, thermo-electrochemical sensing, and analytics, capable of delineating various degradation mechanisms, failure modes, and safety descriptors will be discussed. The crucial role of physics-informed digital twins in accelerating the development of advanced electrode/cell designs, thermal management approaches, and diagnostic and prognostic tools will be highlighted.



Mechanistic framework combining physics-based modeling, thermo-electrochemical sensing, and analytics for Li-ion batteries