Three-dimensional Model Based Numerical Investigation on the Distributed Characteristics of Lithium-ion Batteries

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Large-format plastic lithium ion batteries are under intense development for application as energy storage systems in the electric vehicles (EV) and hybrid electrical vehicles (HEV) [1]. The enlarged battery has high energy and can improve the energy density of system, but some behaviors such as potential, electrochemical reaction rate, current density, state of charge and electrolyte concentration, etc. are more non-uniform. The situation becomes more serious when the battery working at very harsh electrical and thermal conditions [2]. The non-uniform distribution of these behaviors lead to the stress and temperature concentration causing the fracture and exfoliation of active materials during long time cycles [3, 4]. However, due to the sealed package feature, these behaviors of battery during cycling are difficult to measure by experiments.

In this study, a three dimensional numerical model based on porous electrode theory for lithium ion battery is developed. Using this model, the interior non-uniform behaviors on the across section of the cell can be obtained. We can simulate how these behaviors change with various design and control parameters including both macroscopic and small scale factors, such as cell layer thicknesses, current collector tab placement, overall cell dimensions, particle size and porosity, and various physical property parameters of each cell layer.

Example Results

The graph below shows a local current density distribution across the 3D negative electrode during constant galvanostatic discharging. In this example, the current distribution at the cross section of negative electrode is changing over time and the maximum current density locates at the position near tabs.

![Figure 1. Local current density distribution at cross-section of negative electrode (A m⁻²).](image)

References