A lattice model framework for the durability analysis of lithium-ion battery electrodes

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ABSTRACT

Durability and performance of lithium-ion batteries (LIBs) are constrained by different degradation mechanisms that take place during charge and discharge cycles. The important volume changes experienced by the electrode particles during both the lithium insertion and extraction promotes the apparition of high mechanical stress resulting in mechanical degradation, cracking, and fracture of these. Therefore, degradation of LIBs is a complex problem involving several physical phenomena (e.g., diffusion, heat transfer, mechanical deformation), which can be analyzed by means of numerical methods. Some examples of coupled models including lithium diffusion, stress evolution, and crack propagation can be found in the literature [1]

In this work, we present a finite element model accounting for the coupled effects between lithium diffusion and mechanical stress. Namely, we follow a lattice model approach [2] to characterize the electrochemomechanical behavior of brittle heterogeneous electrodes when subjected to charge/discharge cycles. This coupled problem is solved iteratively at specific states of charge, obtaining the crack patterns associated to specific charge and discharge strategies.

The presented model is able to correctly reproduce trends in the mechanical stress and the evolution of damage at different states of charge. Finally, this framework can be used to gain insight into the microstructural evolution, morphological changes, and mechanical degradation in electrodes.

REFERENCES

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