State Estimation of Lithium-Ion Batteries in Aerospace

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ABSTRACT

Lithium-ion batteries are the technology of choice for a broad range of applications due to their performance and long-term stability. The performance and durability of lithium-ion batteries is strongly impacted by various degradation mechanisms. These include the growth of the solid-electrolyte interphase (SEI) and the deposition of metallic lithium on the surface of the negative electrode, referred to as lithium plating. Long-term SEI growth is the greatest contributor to capacity fade in lithium-ion batteries. Lithium plating, which occurs at low temperature or high current charging, can result in capacity fade or even thermal runaway. In our group we develop multiscale models and perform simulations for various types of batteries. In order to describe the internal processes of Li-ion batteries, we derive thermodynamic consistent transport theories [1]. Based on these, our group has developed models for long-term SEI growth [2,3] and for lithium plating in 3D electrode microstructures [4]. Here, we discuss performance and lifetime for the batteries of in-orbit satellite REIMEI [5]. To this end, we developed a model which describes the inner states of the battery over short time scales during single charging and discharging as well as battery degradation over long time scales during continued cycling. We parameterize our model with microstructure data which we extracted from CT images and by comparing the electrochemical simulations to various experimental and in-flight data. Finally, we want to understand the processes taking place in Li-ion batteries and observe them during battery operation. As the inner states cannot be measured directly and the measurements and model parameters are uncertain we make use of state estimation methods like Kalman filters. Hereby we are able to predict the state of charge and the state of health of the satellite's batteries.

References

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