Electrochemical Li-Ion Battery Modelisation for Electric Vehicles

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Abstract

The future development of electric vehicles is now strictly linked with their batteries. In parallel of the actual research focused on the development of new materials and increase their performances in terms of energy, power, cost, durability and weight, it is necessary to develop modeling tools. The simulations are helpful for improving the knowledge of both physical and chemical phenomena, optimize the battery design according with the user requirements, and reduce the test/validation phase. In this framework, this articles, contributes to the development on an electrochemical based model for Li-ion batteries [1], using the powerful COMSOL Multiphysics® software, allowing to use custom equation systems. The partial differential equations are resolved coupling a 1D geometry, describing the cell cross section, with a 2D geometry describing the active material particles using the "coefficient form PDE"[2].

This work revisits one of the most used porous electrodes based model to describe the behavior of lithium-ion batteries. Firstly, all the physical quantities are set in a dimensionless form, as commonly used in fluid mechanics: the parameters that act in the same or the opposite ways are regrouped and the total number of simulation parameter is thus reduced. Then the numerical explorations with the limit conditions, allow to understand the effect of each dimensionless parameter, in the overall equation system. The Figure 1 shows the effect of the solid phase diffusion over the practical retained capacity for a galvanostatic discharge, while in Figure 2 shows the voltage drop and relaxation for pulses. The simulations are finally compared with half-cell obtained from commercial 18650 Lithium ion cells for EV. The mid-term perspectives includes the simulation of ageing and temperature [3].

Reference

[1] M. Doyle, et. al., Modeling of Galvanostatic Charge and Discharge of the Lithium/Polymer/Insertion Cell, J. Electrochem. Soc. 140 (1993) 1526.

[2] COMSOL Tutorials, App. ID 14133, App. ID 14527, App. ID 686, App. ID 12667.

[3] M. Tang, et. al., Electrochemical Characterization of SEI-Type Passivating Films Using Redox Shuttles, J. Electrochem. Soc. 156 (2009) A390.

Figures used in the abstract

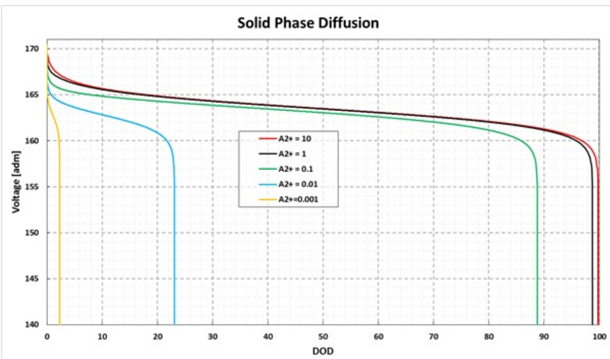

Figure 1: Retained capacity for galvanostatic discharge with reference to solid diffusion parameters

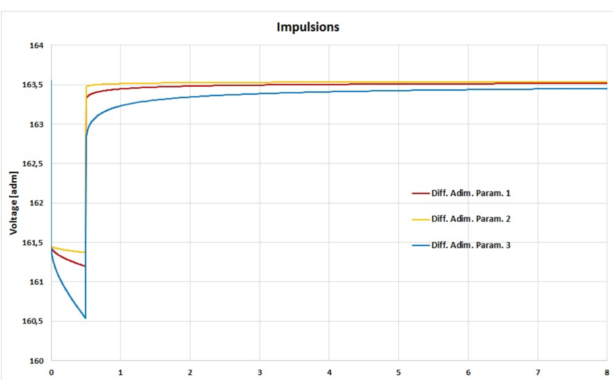

Figure 2: Pulses for different values of solid phase diffusion parameter

Figure 3

Figure 4