MATHSYS PROJECT

TITLE: Mathematical models for long-term prediction of lithium-ion batteries

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The strong uptake of lithium-ion batteries for energy storage is creating new fundamental challenges for the state-of-the-art (SOA) battery models. These are typically defined by system identification techniques and fail to capture the intrinsic functional dependence of the parameters on the material attributes and to predict irreversible and complex non-linear phenomena such as fast (dis)charge and degradation. In this project we propose new mathematical techniques to develop simple and efficient reduced order models to enable the fast, yet accurate, simulation of short and long-term behaviour of lithium-ion cells. Starting from the well-know porous electrode theory and Newman's PDE model, we derive and solve simple differential equations that can retain the interesting features of the full model (e.g., solid diffusion, non-linearities). This model can easily be implemented in online battery management systems and can be coupled with advanced data-assimilation techniques. We also propose a new integrated framework to incorporate both micro- and system scale experimental data into our model. PDEs defined in the complex micro-structure of the electrodes can be analysed by means of homogenisation and solved numerically to complement experimental data with physically and mathematically rigorous upscaling and parameter identification.

The project requires an interest in PDEs and applications and ability to work in an interdisciplinary environment.