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Modeling Of 3d All-Solid-State Rechargeable Batteries

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Li-ion batteries are a well-established technology, nowadays widely applied in stationary and mobile energy storage systems. However, conventional Li-ion batteries are based on porous electrodes and liquid electrolytes, and are therefore prone to degradation and serious safety issues. In that case the application of 3D all-solid-state batteries (3DASSB) is a good alternative since these battery systems are based on solid electrolytes, which often combine a better thermal and electrochemical stability and avoids hazardous electrolyte leakage in comparison to their liquid elecrtolytes [1,2]. This makes 3DASSB safety devices for implementation in, for example, wireless sensor applications and medical implants. Moreover, the absence of a liquid electrolyte and hence the lack of need for a liquid container and separator implies a larger freedom of design as well as certain advantages in terms of safety. The conductivity of 3DASSB is typically several orders of magnitude lower than that of a traditional liquid electrolyte lithium-ion battery. To mitigate this drawback, in this work, a two-dimensional model of 3DASSB, fabricated by a stepwise electrodeposition of Ni/NiO-based anode, coating of conformal and pinhole-free solid polymer electrolyte (SPE), and consequent insertion of cathode/polymer composite, into 3D current-collector substrates, is developed based on COMSOL Multiphysics. In this model all electrochemical reactions instead take place on the interface between the electrolyte and solid electrode domains. The solid electrolyte differs from a binary concentrated liquid electrolyte, and hence this model does not use the Lithium-Ion Battery interface. Instead, the Tertiary Current Distribution interface was used to model the electrolyte transport and the electrochemical reactions, solving for the electrolyte potential, (SI unit: V), the electrolyte concentration of Li ions, cLi+ (SI unit: mol/m3), and the positive electrode concentration of Li ions, cLi+ (SI unit: mol/m3) at different time and C-rates. In addition, the model the Transport of Diluted Species interface was used to model the transport of lithium in the positive electrode, solving for the concentration of solid lithium, cLi.

The concentrations of lithium ions in the electrolyte at discharge and charge for various C-rates are shown in figure 1.

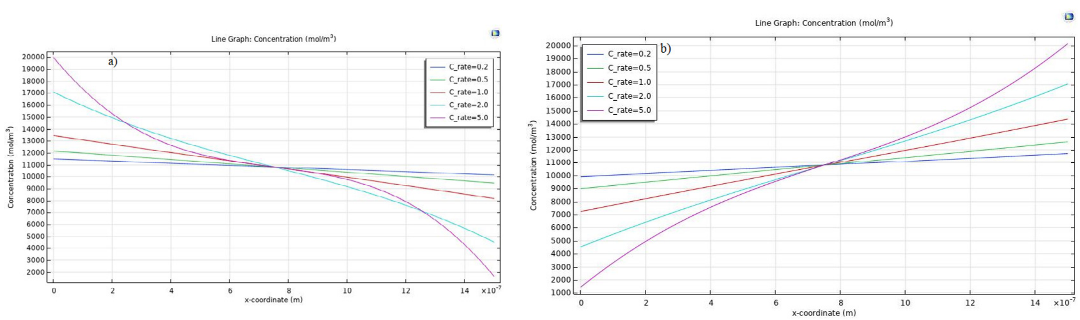

Figure 1. The concentrations of lithium ions in the electrolyte at (a) discharge and (b) charge for various C-rates

Key words: Lithium-ion batteries, All-solid-state, Charge/discharge, electrolyte concentration.

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Biography

Yer-Targyn Tleukenov has completed his PhD at the age of 27 years from Al-Farabi Kazakh National University (Kazakhstan). He is a senior resercher at National Laboratory Astana, Nazarbayev University. He has more than 10 publications.