Simulation of Thin Film All-Solid-State Lithium Ion Batteries

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Abstract

There is great interest in developing all-solid-state lithium-ion batteries. They are ideal micro-power sources for many applications in portable electronic devices, electric vehicles and biomedical engineering. The batteries are possessed of high energy and power densities, good capacity retention for thousands of discharge/charge cycles, and an extremely low self-discharge rate. It is known that all-solid-state lithium-ion batteries are often fabricated by thin film methods, with thicknesses in the range of a few micrometers. Since porous electrodes are not used for this kind of batteries, all electrochemical reactions take place on the interface between the electrolyte and solid electrode domains. The conductivity of the solid electrolyte is typically several orders of magnitude lower than that of a traditional liquid electrolyte lithium-ion battery, which is the drawback of the solid electrolyte. All solid state lithium-ion batteries molded into nano/submicron scale thin film on micro-pillar arrays are attractive, because they would allow the improvement of their conductivity dramatically. In order to make further improvement in the technology of thin film solid-state batteries on micro-pillar arrays, an in-depth understanding of the electrochemical processes involved in thin film batteries on micro-pillar arrays is necessary. However, the measurements and an evaluations of these batteries are very difficult due to complicated structure of them. Numerical simulation method is a powerful tool to realize the processes. In this work, the model of thin film all solid-state lithium-ion batteries is developed based on COMSOL Multiphysics@. The tertiary current density in the electrolyte is calculated. The transport of lithium species in the positive electrode is solved in coupling with the calculation of current density. The effects of film thickness of all solid state lithium ion batteries on the properties itself are obtained and analyzed.

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