Influence of temperature treatment and grain boundary modification of Li-argyrodite Li_6PS_5Cl

Ruth Giesecke [a,b], Mara Göttlinger[b,c], Murat Yavuz [a], Sylvio Indris[a], Thomas Hupfer[b], Lars Epple[b], Helmut Ehrenberg[a]

[a] *Institute for Applied Materials (IAM), Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany.*

b Robert Bosch GmbH, CR Renningen, Robert-Bosch-Campus 1, D-71212 Renningen, Germany

c Department of Electrochemistry and Electroplating, Ilmenau University of Technology, Gustav-Kirchhoff-Str. 6, 98693 Ilmenau, Germany

E-mail: *ruth.giesecke@de.bosch.com*

Over the last couple of years, all-solid-state batteries have attracted much attention. In comparison to liquid-based batteries, they are expected to be safer and to have better thermal stability, higher conductivity over broader temperature range and longer cycle life. Many solid-state electrolytes have now reached the conductivity of liquid electrolytes and some even outperform them. The Li+ conductor Li6PS5Cl with argyrodite-type structure is one example for such a solid-state electrolyte as it provides exceptionally high Li-ion conductivity in the range of 10^{-2} to 10^{-3} S cm^{-1} at RT [1]. This property makes it important for high-energy-density batteries with the usage of lithium-metal anode. One major issue for the usage of lithium anode is the lithium-dendrite growth during cycling, which can cause a short circuit.

In this work we present a study of heat treatment of Li_6PS_5Cl electrolyte and its influence on lithium-dendrite growth. The electrolyte is pressed into a pellet and sintered at different temperatures for different periods in order to modify grain boundaries. XRD measurements were used to obtain more information on the structural change of the material during heat treatment. In addition, the correlation between sintering conditions and relative density is studied as density can have an impact on ionic conductivity. SEM analysis of the pellet surface gives an insight of the grain boundary modification. Cycling experiments are carried out on a Li | Li_6PS_5Cl | Li set up to monitor changes of the critical current density with sintering conditions, which detect any short circuits due to lithium-dendrite formation.

References:

[1] H.-J. Deiseroth, S.-T. Kong, H. Eckert, J. Vannahme, C. Reiner, T. Zaiß, M. Schlosser, Li6PS5Cl: A class of crystalline Li-rich solids with an unusually high Li+ mobility, Angew. Chem. Int. Ed., 2008, pp.755-758.