Development of silicon polymer electrodes for all-solid-state lithium-ion batteries

Mara Göttlinger[a,*], Christian Piesold[a], Mario Weller[a], Guinevere A. Giffin[a,b]

*mara.goettlinger@isc.fraunhofer.de

[a]*Fraunhofer R&D Center Electromobility, Fraunhofer Institute for Silicate Research ISC, Neunerplatz 2, 97082 Würzburg, Germany*

[b]*Chemical Technology of Materials Synthesis, Faculty of Chemistry and Pharmacy, Julius-Maximilians-University Würzburg, Röntgenring 11, 97070 Würzburg, Germany*

The growing market for battery electric vehicles has resulted in an increasing demand for battery materials that meet the requirements of low cost, high safety, long lifetime and high energy density [1]. Solid-state batteries offer an opportunity for enhancement in several of these areas. For example, the absence of a flammable, toxic and potentially leaking liquid electrolyte clearly enhances battery safety [2]. To achieve a high energy density, the positive and negative electrode materials must have high specific capacities along with a high and low reduction potential, respectively. For the negative electrode, silicon fulfills these criteria with a very high theoretical specific capacity of 3579 mAh g^{-1} [3] and a suitable delithiation potential of approx. 0.4 V vs. Li/Li^+ [3,4]. Also, in contrast to lithium metal electrodes, silicon electrodes are significantly less prone to the dendrite growth that would cause safety issues and limit the cycle life. The main challenges of silicon electrodes in cells with a liquid electrolyte result from the large volume changes of silicon during (de)lithiation. A flexible polymer electrolyte may help to compensate for these volume changes and thereby minimize the related issues like disintegration of the electrodes and irreversible loss of lithium.

In this work, the development of silicon polymer electrodes is presented. The anode contains a hybrid inorganic-organic polymer electrolyte (HPE). HPEs used in this work are a molecular hybrid polymer with polyether organic domains and an inorganic SiO_2 network [5]. The electrochemical performance of the silicon polymer electrodes will be examined in solid-state cells with a lithium counter electrode. The rate capability, capacity retention as well as side reactions in the first cycle are identified as challenges to be addressed in the HPE-based cells. Different approaches like the variation of the conductive salt and the use of additives will be implemented.

References:

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