All-Solid-State Battery using NCM-622 and a Lithium Metal Anode

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Increasing energy density of energy storage devices is a major incentive for the development of all-solid-state batteries (SSBs). Present-day lithium-ion batteries (LIBs) reach energy density and specific energy up to 770 $Wh \cdot l^{-1}$ and 260 $Wh \cdot kg^{-1}$, respectively.[1] Due to intensive research efforts over the past decades, the energy density of conventional LIBs is close to its predicted limits.[2] To overcome these limits, new battery types need to be explored. One of these is the all-solid-state battery using a lithium metal anode. This also promises to avoid well-publicized safety issues of LIBs, improve quick charge capability, and increase the temperature window of operation. With a lithium metal anode the attainable energy density of the battery may be increased by up to 70 %.[1] The successful integration of a lithium metal anode is necessary to maximize energy density.

In this work, we present a SSB containing a lithium metal anode, NCM-622 cathode active material and β-Li_3PS_4 (LPS) solid electrolyte. We investigate its cycling performance and use symmetrical Li/LPS/Li cells as models to analyze the Li-LPS-interface and lithium dendritic growth. We applied different pressures on the components during preparation to determine a critical pressure for lithium dendrite formation and for increasing the performance of a SSB. Additionally, we investigated the long-term stability of the used battery components by electrochemical impedance measurements and X-ray photoelectron spectroscopy studies. The SSBs showed stable cycling performance beyond 150 cycles at 0.1 C with an average Coulombic efficiency of 99.55 %. The initial discharge capacity showed 130 $mAh \cdot g^{-1}$ for the active material. These results demonstrate the applicability of lithium metal, but also reveal two challenges that still need to be overcome: restricting electrochemical reduction of the solid electrolyte by the lithium metal anode[3] and preventing lithium dendritic growth.

References:

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