Void evolution in the lithium anode of a solid state battery

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Abstract

The growth and collapse of voids within the Li anode of a solid state battery has direct relevance to two commonly observed failure modes: dendrite/filament formation within the ceramic electrolyte and a large increase in Li flux resistance at the Li/electrolyte interface. Thus, there is a need to explore experimentally the collapse of voids within the Li anode of a solid state battery due to the application of a pressure and a superimposed electrical current that drives a Li flux from the Li anode into the underlying ceramic electrolyte. Circular cylindrical specimens of Li were sandwiched between a top layer of copper sheet and a bottom layer of LLZO ceramic. Additionally, a circular cylindrical void was generated within the Li layer but adjacent to the LLZO interface; this was achieved by withdrawing a niobium wire of diameter 0.2 mm from the Li during its manufacture. The collapse of this void was tracked visually under a prescribed pressure on the faces of the sandwich specimen. The sensitivity of void collapse to applied pressure was determined by varying the radius to height of the Li pancake-layer and by varying the applied load. The evolution of specimen height with time is consistent with power law creep of the Li, and the rate of closure of the voids also supports the mechanism of power law creep. An additional set of experiments was performed whereby the Li was forced to migrate into the LLZO substrate by the imposition of a constant electrical current. It was found that the void shrinks at a rate consistent with rigid body motion of the Li layer into the LLZO, with negligible flux focussing in the vicinity of the void. The study has direct relevance to the effect of a stack pressure upon void evolution in a solid state Li battery.

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