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(Invited) All-Solid-State Batteries Using $\text{Li}_7\text{La}_3\text{Zr}_2\text{O}_{12}$ Garnet Electrolyte Framework

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All-Solid-State Batteries Using $\text{Li}_7\text{La}_3\text{Zr}_2\text{O}_{12}$ Garnet Electrolyte Framework

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Abstract Text:

All-solid-state batteries (ASSB) using LLZO (variants of $\text{Li}_7\text{La}_3\text{Zr}_2\text{O}_{12}$) garnet solid electrolyte with lithium metal anode potentially offer higher energy density and improved safety. Rational design of cell architecture as well as manufacturing scalability are key aspects to consider as the technology readiness level advances. A thick composite cathode layer attached to a thin solid electrolyte layer is desirable to obtain superior energy densities. Furthermore, the architecture within the composite cathode may be engineered to contain directional conduction paths of lithium ions or electrons for enhanced rate capabilities.

Here, we demonstrate a functioning bulk-type LLZO based all-solid-state battery with a practical form factor incorporating the above described design concepts. Freeze-tape-casting (FTC), a scalable and environmentally friendly ceramic processing method, is used to construct 3D porous LLZO scaffolds composed of vertical arrays of LLZO walls. The thin solid-electrolyte layer is fabricated by tape-casting (TC). By sintering the stacks of FTC and TC green tapes, porous/dense bilayers and porous/dense/porous trilayers of LLZO frameworks are obtained. An ASSB was constructed using a porous/dense bilayer by infiltrating $\text{LiNi}_{0.6}\text{Mn}_{0.2}\text{Co}_{0.2}\text{O}_2$ cathode powder and carbon black into the porous layer and adhering lithium metal foil to the dense side. We find it crucial to introduce a plastic crystal based soft solid electrolyte to the porous layer to electrochemically connect all cathode components, obviating the need for co-sintering to establish contact. The soft nature of the plastic crystal based solid-electrolyte may be able to accommodate the volume change of the cathode material as it cycles. In this device, which contained no liquid component, the initial discharge capacities were similar to those observed in a lithium ion battery configuration using the same cathode powder at C/10 rates.

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Second Presenting

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