Ceramic Derived All-solid-state sodium Ion Battery Prepared by Laser Processing

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In oxide-based all-solid-state batteries, grain boundaries limit ion conduction, making it essential to develop strategies for creating well-bonded interfaces. One promising approach is to employ glass-ceramic materials that undergo softening and flow at elevated temperatures, enabling close contact with solid electrolytes before crystallization. Additionally, laser irradiation offers a powerful technique for localized heating of oxide glasses, inducing melting and micro-crystalline structures through highly localized thermal fields. In this study, tin–iron–sodium–silicate (yFe-SNS) glasses with compositions $55SnO–15Na_2O–yFe_2O_3–(30–y)SiO_2$ (y = 0–9 mol%) were synthesized by melt-quenching and subsequent mechanochemical processing. These glasses were investigated as anode materials in combination with a NASICON-type solid electrolyte, $Na_3Zr_2Si_2PO_{12}$ (NZSP). For electrode fabrication, 6.75Fe-SNS powders were mixed with a polyimide binder (85:15 wt.%) and N-methyl-2-pyrrolidone to form an ink, which was then applied to NZSP substrates via screen printing.

The coated solid electrolytes were subjected to laser irradiation using a pulsed Yb doped fiber laser (λ = 1064 nm, P = 3 W) with a 60 μm spot diameter. Laser scanning speeds varied from 100 mm/s upward, and processing was carried out over areas of 20 × 20 mm² with a hatch spacing of 40 μm. Depending on laser energy input, the anode material formed either droplet-like structures or well-wetted, dense interfaces with the NZSP surface. a favorable hetero-interface was achieved between the Fe-SNS glass-derived anode and the NZSP electrolyte by laser irradiation. This enabled the construction of an all-solid-state sodium-ion battery, which successfully demonstrated operation under these processing conditions. The results confirm that laser-assisted interface engineering is an effective means to realize dense bonding and enhance electrochemical performance in oxide-based all-solid-state sodium-ion batteries.