ALD Al2O3 artificial SEI for improved stability of porous silicon anodes

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Silicon (Si), as one of the most promising anode materials, has attracted significant interest for next-generation lithium-ion batteries (LIBs), owing to its extremely high theoretical capacity [1]. However, its practical application is hindered by severe volume expansion/contraction and unstable interfacial reactions during cycling. In this work, we focus on interfacial stabilization of mesoporous Si, in which the pore structure accommodates volume expansion through an artificial solid electrolyte interphase (SEI) formed via atomic layer deposition (ALD). Porous silicon powders were prepared by electrochemical etching of Si<100> wafers, followed by peeling, milling, and sieving to 10-25 µm. The powder surfaces were then modified by ALD to form conformal ultrathin Al2O3 coatings as artificial SEI layers, with varying numbers of ALD cycles (TMA+water regime) to tune the coating thickness. X-ray photoelectron spectroscopy confirmed the formation of Al2O3 on the surface of powders, evidenced by the characteristic Al-O signal in the O 1s spectrum. Electrochemical results show that ALD-coated samples exhibit improved initial columbic efficiency (ICE) compared to the uncoated sample, while rate performance shows a non-monotonic dependence on coating thickness. Notably, the sample with 5 ALD cycles (~0.5 nm thickness) delivers the best balance between higher ICE and improved capacity retention. Further work will focus on elucidating the underlying stabilization mechanisms.

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