World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:17, No:03, 2023

Atomic Layer Deposition of Metal Oxides on Si/C Materials for the Improved Cycling Stability of High-Capacity Lithium-Ion Batteries

Authors : Philipp Stehle, Dragoljub Vrankovic, Montaha Anjass

Abstract : Due to its high availability and extremely high specific capacity, silicon (Si) is the most promising anode material for next generation lithium-ion batteries (LIBs). However, Si anodes are suffering from high volume changes during cycling causing unstable solid-electrolyte interface (SEI). One approach for mitigation of these effects is to embed Si particles into a carbon matrix to create silicon/carbon composites (Si/C). These typically show more stable electrochemical performance than bare silicon materials. Nevertheless, the same failure mechanisms mentioned earlier appear in a less pronounced form. In this work, we further improved the cycling performance of two commercially available Si/C materials by coating thin metal oxide films of different thicknesses on the powders via Atomic Layer Deposition (ALD). The coated powders were analyzed via ICP-OES and AFM measurements. Si/C-graphite anodes with automotive-relevant loadings (~3.5 mAh/cm2) were processed out of the materials and tested in half coin cells (HCCs) and full pouch cells (FPCs). During long-term cycling in FPCs, a significant improvement was observed for some of the ALD-coated materials. After 500 cycles, the capacity retention was already up to 10% higher compared to the pristine materials. Cycling of the FPCs continued until they reached a state of health (SOH) of 80%. By this point, up to the triple number of cycles were achieved by ALD-coated compared to pristine anodes. Post-mortem analysis via various methods was carried out to evaluate the differences in SEI formation and thicknesses.

Keywords : silicon anodes, li-ion batteries, atomic layer deposition, silicon-carbon composites, surface coatings
Conference Title : ICLB 2023 : International Conference on Lithium Batteries
Conference Location : Miami, United States
Conference Dates : March 16-17, 2023