Low Temperature Deposition of Lithium Cobalt Oxide for Stable Performance as the Cathode of Solid-State Thin Film Batteries

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Abstract

There has been a considerable amount of work on the deposition of lithium cobalt oxide thin films on the metalized silicon substrate using room temperature deposition and post-deposition annealing at 700 ^{o}C. High-temperature annealing leads to tensile stress-induced cracking in the lithium cobalt oxide thin film. After film cracking, a considerable amount of tensile stress gets stored in the cathode material, that leads to further degradation during the charge-discharge process. The other issue with high-temperature annealing is, lithium desorption that leads to the reduction in the lithium content in the cathode materials. To address this issue, we have developed a deposition process at a lower temperature of 500^{o}C. The substrate used in the process was aluminium and the reason for choosing aluminium was its widely used current collector property in lithium-ion battery fabrication process. The deposited films at 500^{o}C showed predominantly (104) orientation, which is a favourable texture for high diffusivity of lithium. SEM micrographs showed columnar growth and different textures for the films which were deposited with different thicknesses. The Raman spectra showed single phase lithium cobalt oxide and high crystalline nature. To avoid temperature induced effects, magnetron efficiency was also monitored during 500^{o}C substrate temperature. The ideal target to substrate distance was optimized as 6 cm and the sputtering magnetron efficiency was unchanged. The electrochemical performance was evaluated using chronopotentiometry technique and the capacity of the deposited lithium cobalt oxide film was 120 µAh/cm^{2}. The performance of the cathode was stable even up to 80 cycles.