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Analyzing the Effect of Surface Coatings on Lithium Cycling Efficiency via Combinatorial Analysis

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There is a continual push to improve the energy density of lithium-ion batteries, but this is becoming increasingly difficult as it is believed that many of the best electrode materials have been found and optimized. In order to achieve higher energy densities to meet future storage demands it may be necessary to move "beyond lithium-ion".
Recent research efforts have focused on reviving the lithium metal negative electrode as a potential path to higher energy density [1]. With its high theoretical capacity and lowest reduction potential among metals, using lithium as a negative electrode can certainly increase the energy density of a cell. However, lithium metal anodes often demonstrate dendrite formation during electrodeposition instead of plating as a smooth film. Since conventional organic electrolytes are thermodynamically unstable to reduction by lithium, dendrite growth leads to continual loss of active lithium, resulting in poor cycling efficiencies (< 90%) and short cell lifetime [2]. These problems are exaggerated as the thickness of the plated lithium increases, making cells with industrially relevant material loadings a significant challenge.
Recent studies have shown that the morphology and plating efficiency of lithium can be greatly improved with nanostructured surface coatings [3,4]. Herein we report on the use of combinatorial materials analysis to investigate the effect of different nanostructured surface coatings on the electrochemical deposition of lithium metal. High throughput sputtering was used to make libraries of thin films with different composition, structure, and thickness. These sputtered libraries were deposited directly on 64-channel electrochemical cell plates and used to analyze the morphology and plating efficiency of lithium as a function of the 64 individual surface coatings. The influence of different electrolyte compositions with these surface coatings was also investigated. These results provide perspective regarding the value of thin film anode surface coatings as part of a broad strategy for achieving high (>98 %) lithium cycling efficiencies.

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