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PVD LITHIUM BATTERY ENCAPSULATION

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Abstract

In this work, a multilayer physical vapour deposition (PVD) thin-film encapsulation was developed for lithium microbatteries, see Figure 1. Lithium microbatteries with a lithium cobalt oxide ($LiCoO_2$) cathode, a lithium phosphorous oxynitride (LiPON) electrolyte and a metallic lithium anode are under development by our group. Metallic lithium film is still the most common anode on this type of batteries, however presents a huge challenge in terms of encapsulation (almost instantaneously oxidation in contact with atmosphere). Despite the oxidation, lithium is also a material that reacts very easily with other materials, so lithium phosphorous oxide (LiPO) was the first material to deposit on top of lithium. To prove concept and perform all the experiments, lithium films were deposited on top of a glass substrate, with previously patterned titanium contacts. After deposition of lithium, the multilayer of thin-films were deposited without open the vacuum chamber. The multilayer is composed of LiPO, LiPON and silicon nitride (Si_3N_4), each film 20 nm of thickness. Si_3N_4 is a common material used in microelectronics to encapsulate devices and allows mechanical and dielectric protection to the battery. Si_3N_4 cannot be deposited directly on top of LiPO films because reactions occurred. Because of this reaction, LiPON was used to interface between LiPO and Si_3N_4 films with success. After breaking the vacuum, epoxy was applied on top of the Si_3N_4 thin-film. Metallic lithium was deposited by thermal evaporation and the three thin-films of multilayer deposited by RF sputtering. This PVD multilayer exonerates the use of chemical vapour deposition (CVD) and glove-Box chambers, reducing significantly the fabrication cost. To evaluate oxidation state of lithium films, the lithium resistance was measured in a four probes setup, to avoid wires/contact resistances and resistivity calculated, considering physical dimensions. In the graph of Figure 2, is visible that the theoretical lithium resistivity of 0.1 Ω.µm was maintained more than 5 hours. This work allows that all the battery, including encapsulation to be fabricated only recurring to PVD techniques and without any glove box.

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Figures

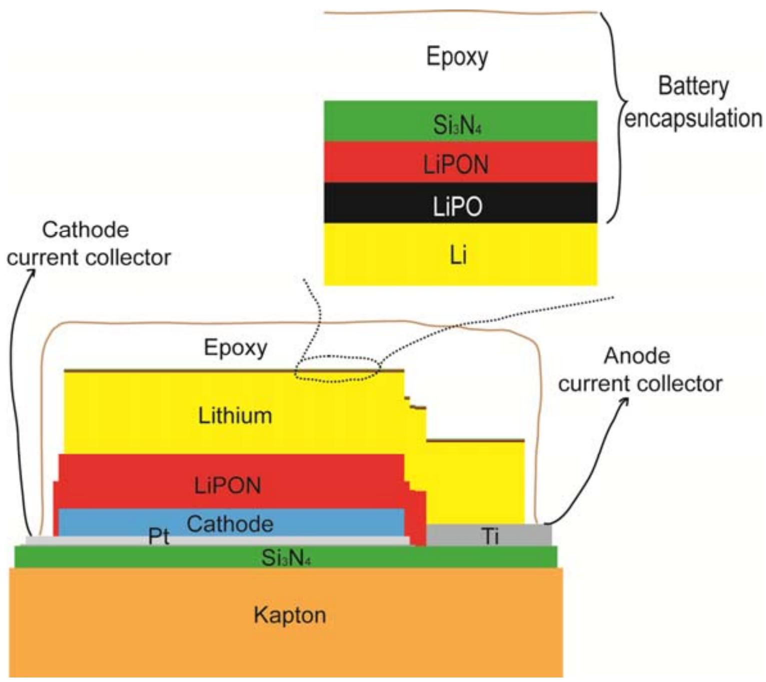

Figure 1: Battery art design (not on scale for better visualization). Zoom on battery encapsulation with materials indication.

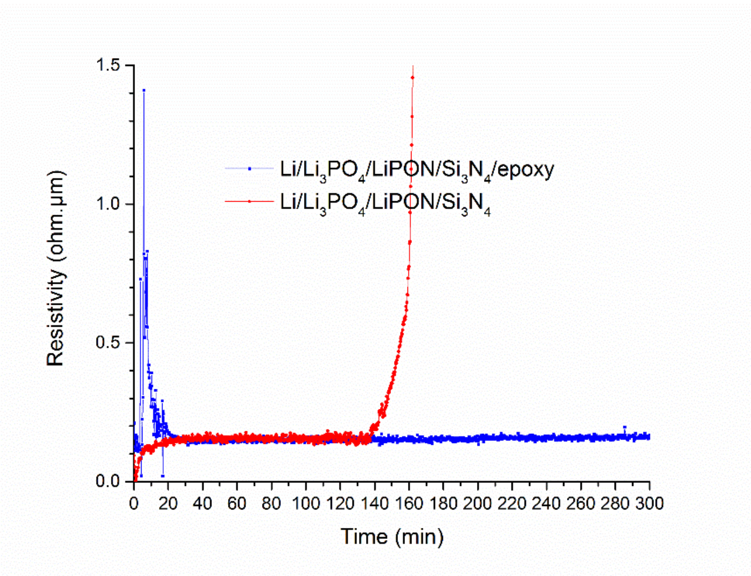

Figure 2: Lithium resistivity with and without epoxy.