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# Surface characterization of coated cathodes with lithium phosphorous oxynitride thin film for all-solid-state Li-S batteries

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Increasing use of systems based on renewable energy sources has made the battery research an important area. Li-ion batteries are commonly used in electronics devices but require many improvements to obtain longer life-time and higher energy densities. Various alternatives to current state-of-art lithium-ion batteries exist. Among them are lithium-sulfur solid-state batteries; solid electrolytes have higher stability when compared to liquid electrolytes, with no risks of vaporization and leakage while sulfur cathodes have high theoretical energy density. $LiBH_4$ is a promising material for solid-state batteries as it is lightweight and stable electrochemically at least up to 6 V. We have successfully built and cycled solid-state lithium-sulphur batteries based on nanoconfined $LiBH_4$. To protect the cathode from forming an interface with the solid electrolyte we have deposited a thin film of lithium phosphorous oxynitride (LiPON) by magnetron sputtering (see figure 1 and 2).

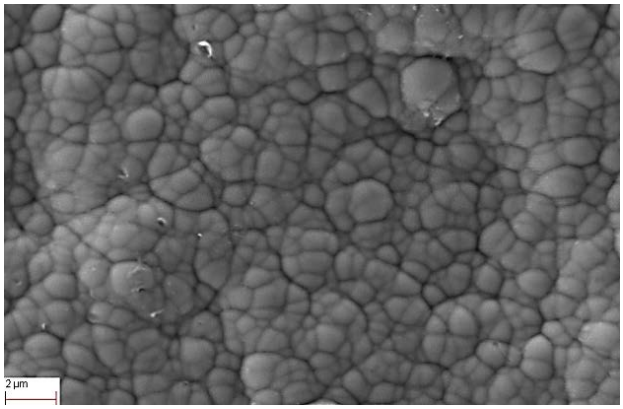


**Figure 1.** SEM image of the surface of cathodes covered with LiPON thin films (1µm)

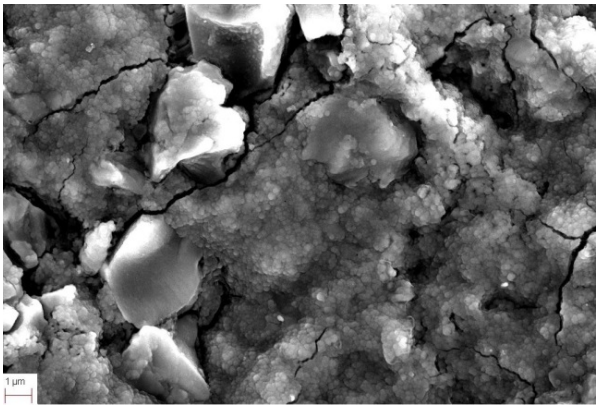


**Figure 2.** SEM image of the surface of cathodes covered with LiPON thin films (100 nm)

LiPON has high electrochemical stability window (0 - 5.5V) vs Li and is stable against Li metal. It is an acceptable Li-ion conductor (~$2 \cdot 10^{-6}$ mS $cm^{-1}$) and has low electron conductivity (~$8 \cdot 10^{-14}$ S $cm^{-1}$) at 25˚C, furthermore the films are flexible and do not crack, even during the swelling of the cathode [2]. We have deposited LiPON films of 1 µm and 100 nm for protection of cathodes and 1 µm films show uniform surfaces while 100 nm films show rough surface with distinct sulphur particles. We have built and cycled solid-state lithium-sulphur batteries using 1µm LiPON protected cathodes. The batteries show no electrochemical parasitic reactions, otherwise present and giving capacity two times larger than higher than the theoretical ones during the first discharge. Furthermore, the batteries exhibit better capacity retention during charge-discharge cycling compared to batteries with non-coated cathodes.

References

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