LiPON Thin Film Deposition for 3D Lithium Microbatteries

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PREM RESEARCH AND EDUCATION IN MATERIALS PARTNERSHIPS
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Introduction

In recent years there has been the realization that improved battery performance can be achieved by moving from the conventional 2-D batteries (Fig 1) to 3-D architectures (Fig. 2).

Fig. 1

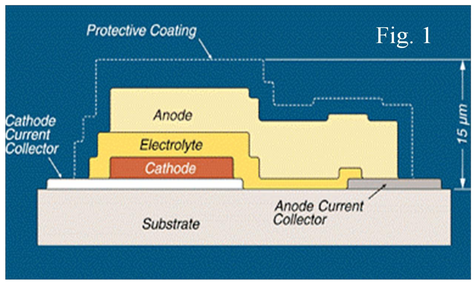

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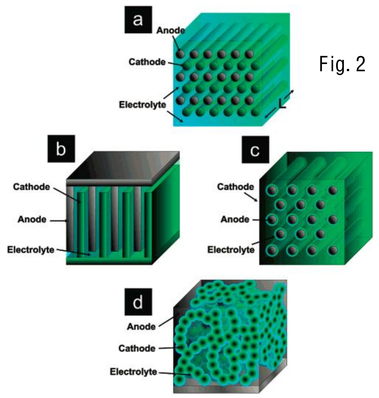
Fig. 2



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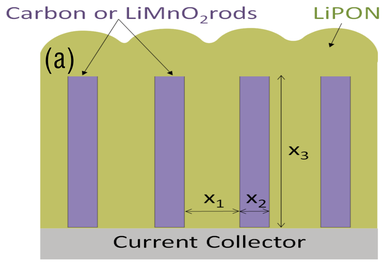
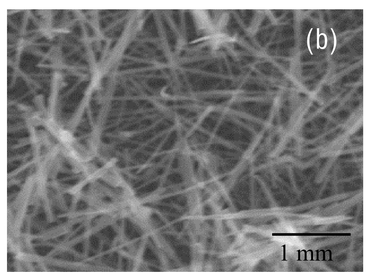
Project Goal: Use RF magnetron sputtering processes to grow LiPON thin films on nanorods or nanowires (see Fig. 3 below).



Schematic of LiPON-coated C anode or Li_xMnO_{2-y} cathode nanorod arrays. *(Meda and Yushin (Unpublished)*

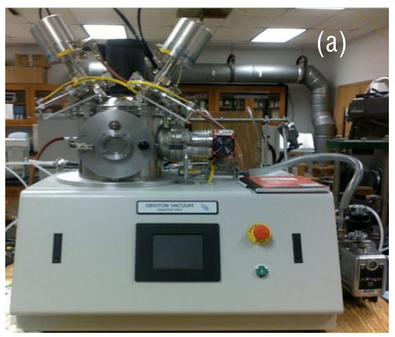


WO_3 deposited by vapor solid (VS) growth method. *L. Meda and C. White (Unpublished)*

Fig. 3: (a) Illustration of cathode and anode materials coated with LiPON and (b) WO_3 nanowires.

Materials and method

Lipon thin films deposited by the RF-magnetron sputtering process (Fig. 4) on 3000 Å of Au current collector.



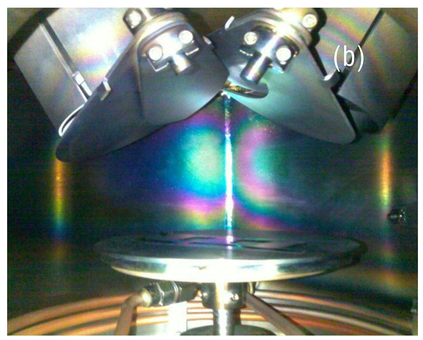


Fig. 4. (a) Dual magnetron sputtering system and (b) Inside the chamber

LiPON Deposition Process

The targets were sputtered in an environment of pure N_2, preset to a flow of 25 sccm. The RF power in the chamber was kept at a constant 100 W while sputtering the targets for 5 hours.

Characterization

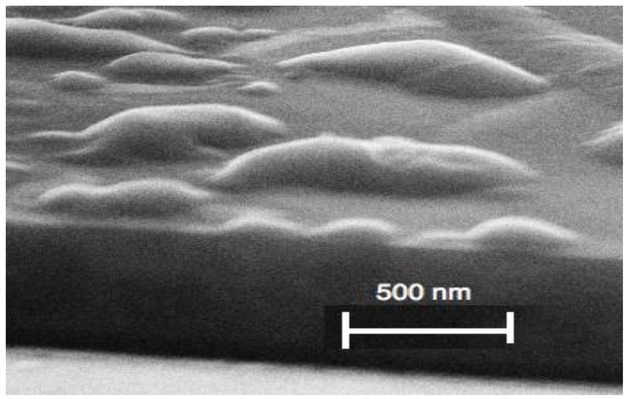


Fig. 5 Cross-section SEM Image of LiPON on Si with a growth rate of ~ 30 Å/min. Some pinhole-defects may be present but will be filled via electro-polymerization.

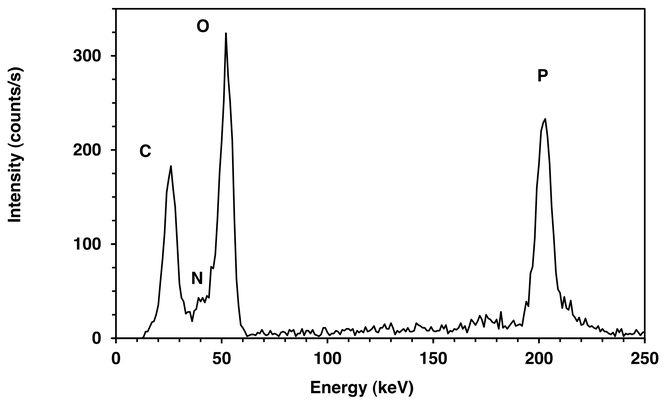
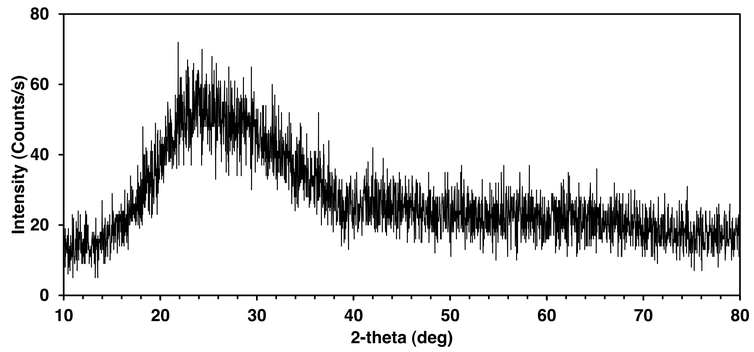


Fig. 6.: Elemental analysis of a LiPON thin film.

XPS analysis of LiPON deposited by sputtering.

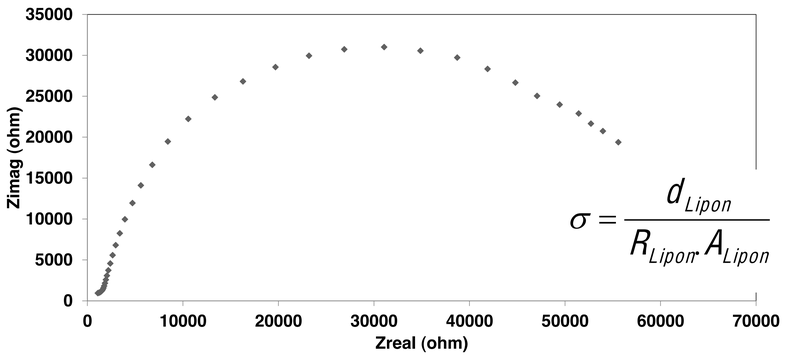
at%	Sputtering in Ar-N_2
Li	25
P	17
O	49
N	4
C	4.8

Fig. 7 shows an XRD graph obtained from a LiPON sample on glass.



X-ray powder diffraction showing the as-deposited film is amorphous.

AC Impedance Fig. 8 shows the complex impedance of Lipon. Lipon was sandwiched between Au current collectors (Au area (*A*) ~ 0.06 cm^2). Lipon thickness (*d*) was ~ 1mm and ionic conductivity was 2.2 x 10^{-88} $ohm^{-1}cm^{-1}$.



Conclusion: Lipon thin films were deposited by magnetron sputtering with ionic conductivity approximately 2.2 x 10^{-8} ohm^{-1} cm^{-1}.

Acknowledgements: This work was supported partially by the PREM Program of the National Science Foundation under Award Number DMR-0934111 and NSF-EPSCoR under award number EPS-1003897.