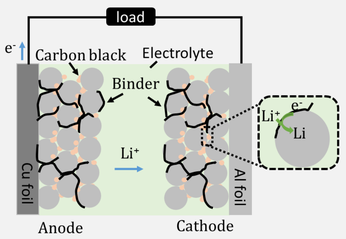
Surface Engineering of $LiMn_2O_4$ Electrode using Nanoscale Polymer Thin Film via Chemical Vapor Deposition Polymerization

Laisuo Su[1], Phil Smith[1], Priyanka Anand[2], B. Reeja Jayan[1]*,
[1]Department of Mechanical Engineering, Carnegie Mellon University, [2]Department of Material Science & Engineering, Carnegie Mellon University

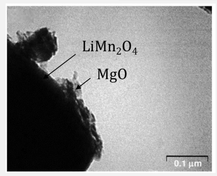
Motivation



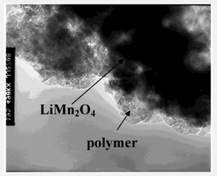
Cathode limits overall battery performance due to its low specific capacity and bad cycling performance

Existing Surface Engineering Techniques

Solution processing



Gnanaraj, J.S., et al. Electrochemistry Communications, 2003. 5(11): p. 940-945.



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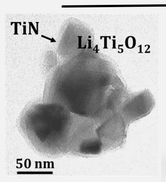
Vapor-based techniques



Snyder, M.Q., et al.,. Journal of Power Sources, 2007. 165(1): p. 379-385.

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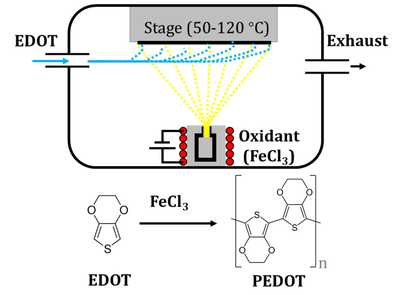
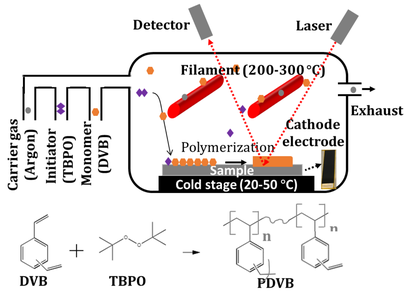
Lack of research to engineer uniform organic coatings on cathodes and study their effects.

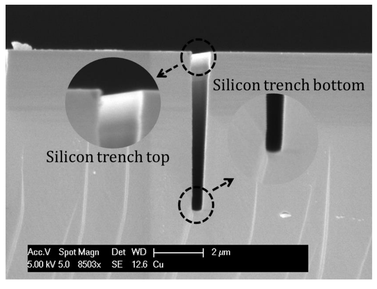
Chemical Vapor Deposition Polymerization

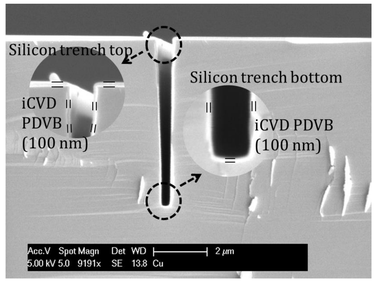
Oxidative chemical vapor deposition (oCVD)

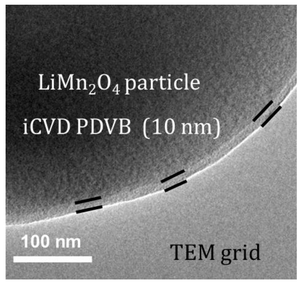


Initiated chemical vapor deposition (iCVD)

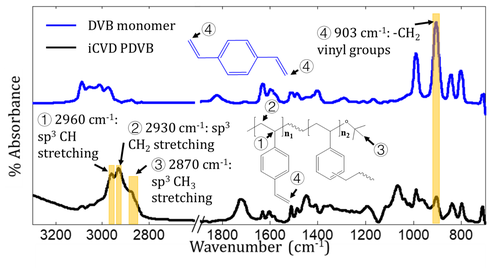


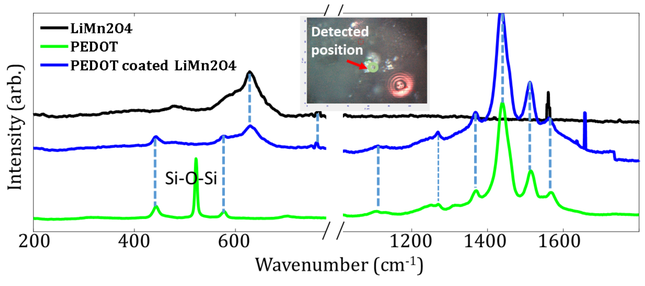






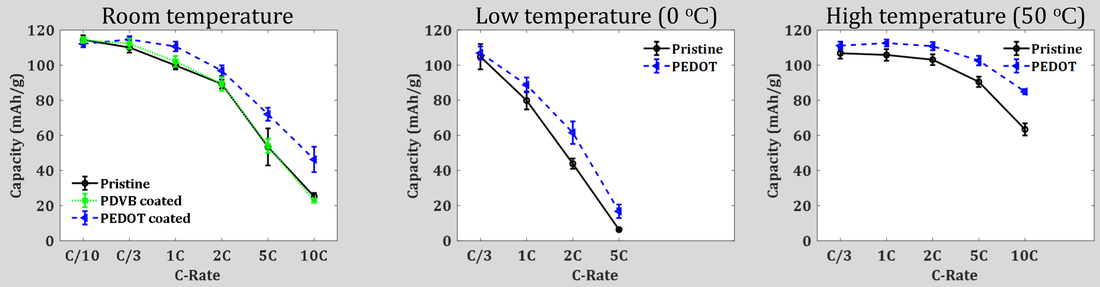
CVD technique can uniformly coat polymer thin film on complex structures, like silicon trenches and $LiMn_2O_4$ particles.



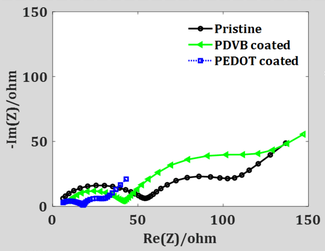


Successful polymerizations of PDVB & PEDOT were proven by FTIR and Raman spectroscopy.

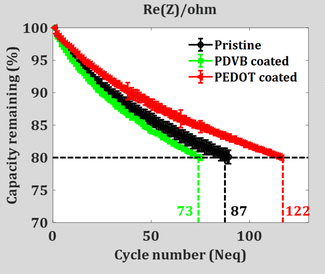
Coin Cell Test Results



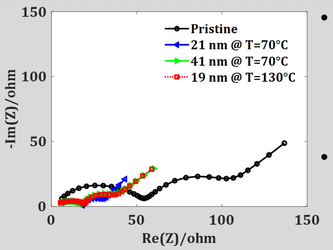
- The conductive PEDOT coating improves the rate capability of the $LiMn_2O_4$ electrode in a wide temperature range, the 10C capacity increases by 83% at 25 °C (from 23 to 42 mAh/g) and by 30% at 50 °C (from 64 to 83 mAh/g).
- In contrast, the insulating PDVB polymer does not improve the rate capability of the LiMn2O4 electrode.

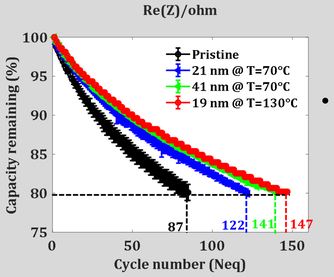


- PEDOT coating largely reduces the overall impedance of cells, while the PDVB has little effect.



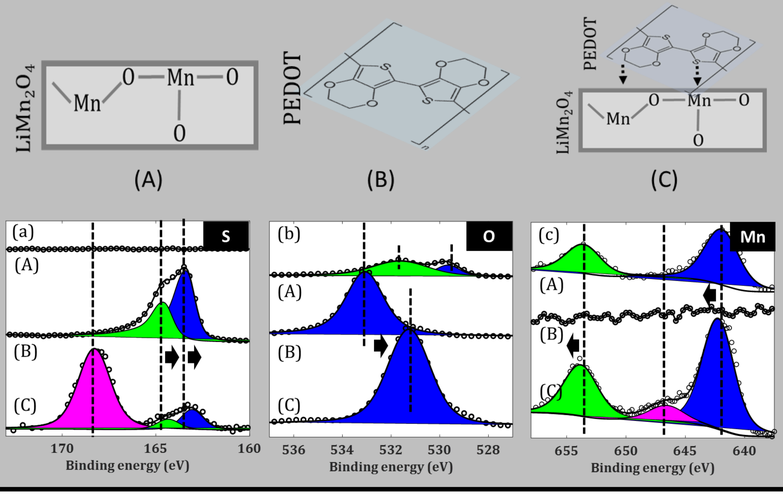
- The PEDOT coating extends cell cycling life (at 50 °C) by over 40%, while PDVB reduces it cycling life.





- The effect of coating thickness and stage temperature are considered.
- The electrochemical impedance of the $LiMn_2O_4$ electrode is largely reduced by PEDOT coatings at all examined conditions.
- The cell lifespan is further extended by tuning the coating thickness and stage temperature during oCVD experiment.

X-ray Photoelectron Spectroscopy



- There are bonds formation between manganese in $LiMn_2O_4$ and oxygen and sulfur in PEDOT at the interface of the coating. These bonds further oxidize manganese on the surface of $LiMn_2O_4$. Therefore, the stability of the $LiMn_2O_4$ is increased since extra energy is needed to destroy the spinel structure.

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