$LiNoO_3$ as a protective layer on $LiCoO_2$ for solid state batteries

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Batteries

Current Lithium ion batteries have three major parts

- **Anode**: usually lithium intercalated into graphite.
- **Liquid electrolyte**: an organic solvent with a lithium salt dissolved in.
- **Cathode**: mixture of carbon, binder and active material.

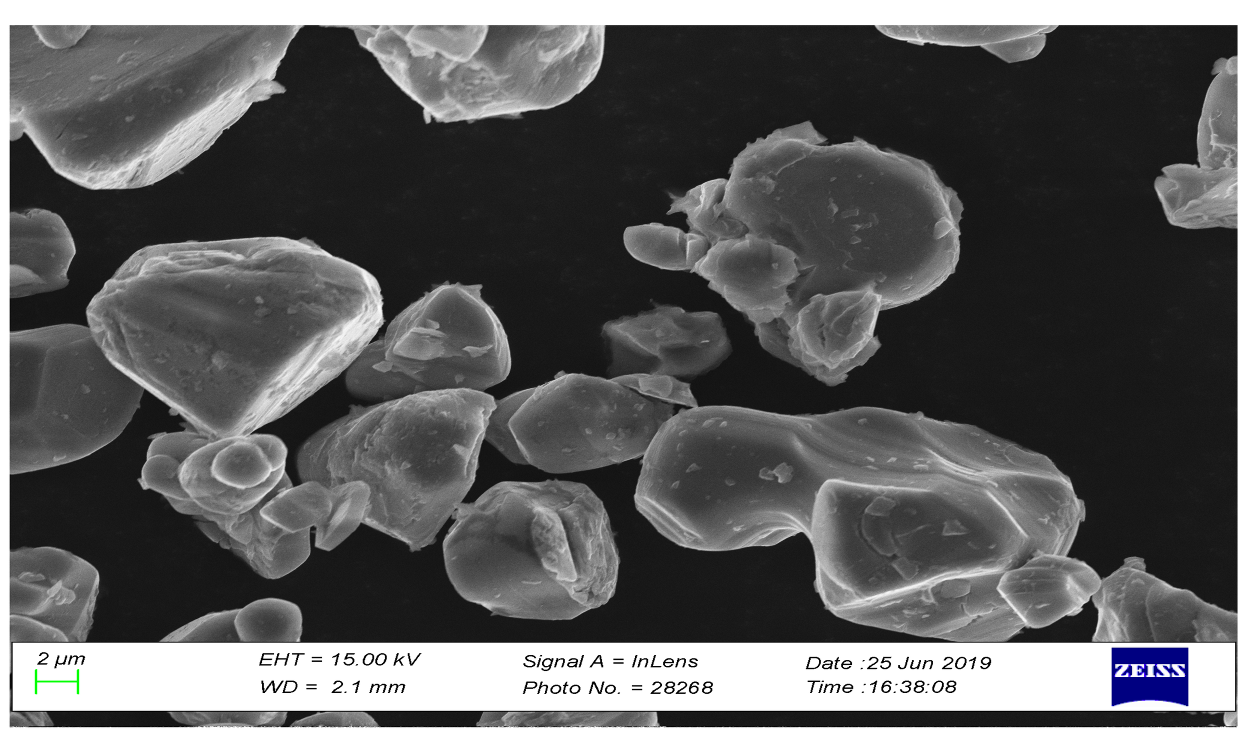
These batteries are easily set off and prone to either exploding or catching fire.

solid-state lithium batteries offer

- Added capacity from metallic lithium anode.
- Improved safety from its solid electrolyte consisting of sulfur compounds like Li3PS4, thus eliminating flammability hazards.

Coating Lithium Cobalt Oxide

Lithium Cobalt Oxide, the active cathode material will naturally react when in contact with Li3PS4. This reduces capacity of the battery and heightens its internal resistance. Therefore a coating material for the active cathode material is needed. Below is a close-up picture of coated Lithium Cobalt Oxide.



Lithium Cobalt Oxide can either be coated with Al2O3 or with Lithium Niobium Oxide but the later is the better choice.

- Better conductivity since Al2O3 has no lithium in its structure.
- Lithium Niobium Oxide is stable throughout 2-4 volts which is the standard operating voltages.

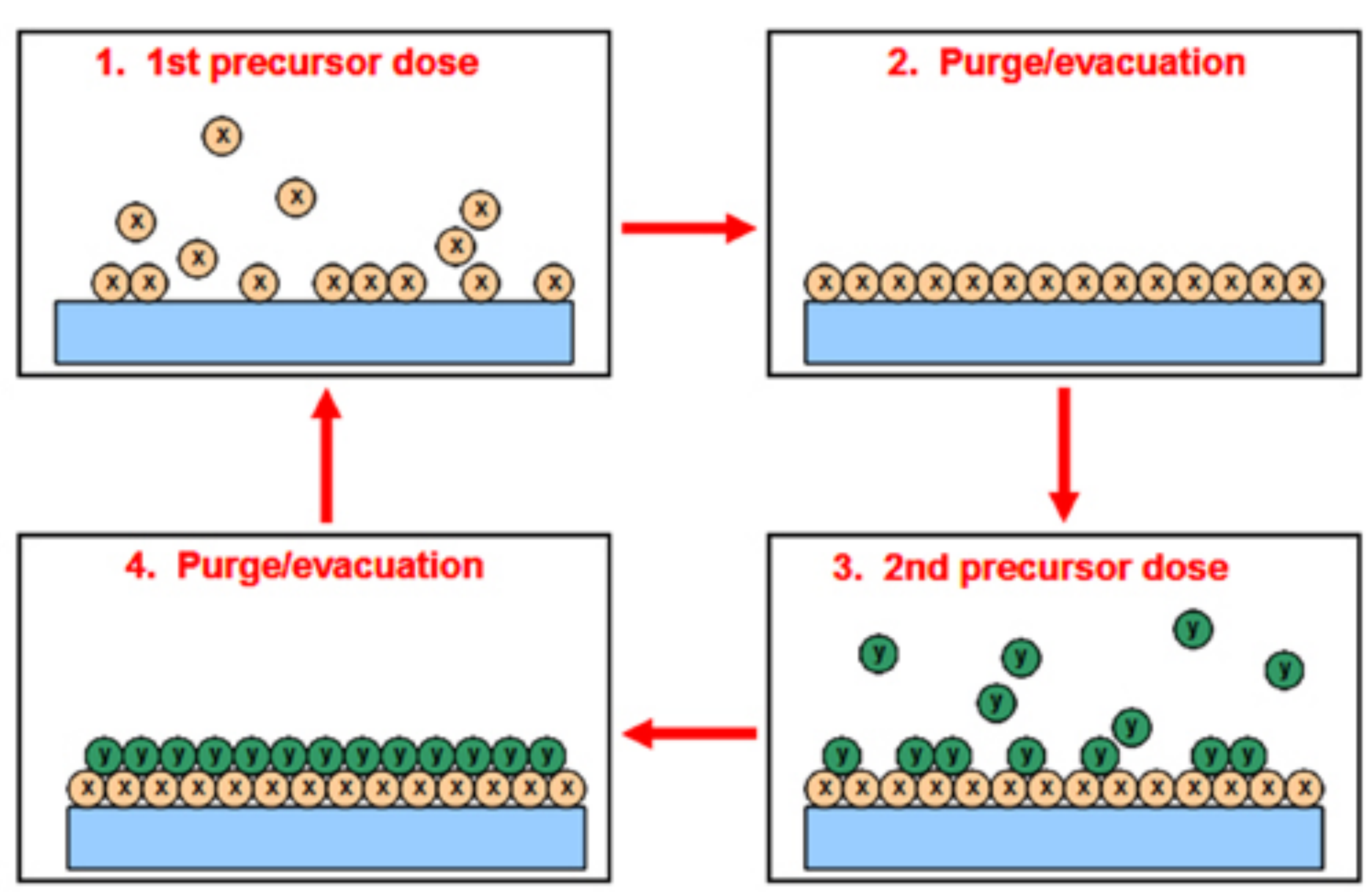
Coating methods

Wet Chemical Process:

- 1 to 1 molar ratio of lithium ethoxide and Niobium ethoxide dissolved in anhydrous ethanol.
- LCO dropped in solution with different weight percentages to get different coating thicknesses.
- Solvent evaporated and then super heated in oxygen atmosphere to 400 degrees Celsius in order to produce LiNbO3.
- Each coating can come out different even if all procedures are done the same.

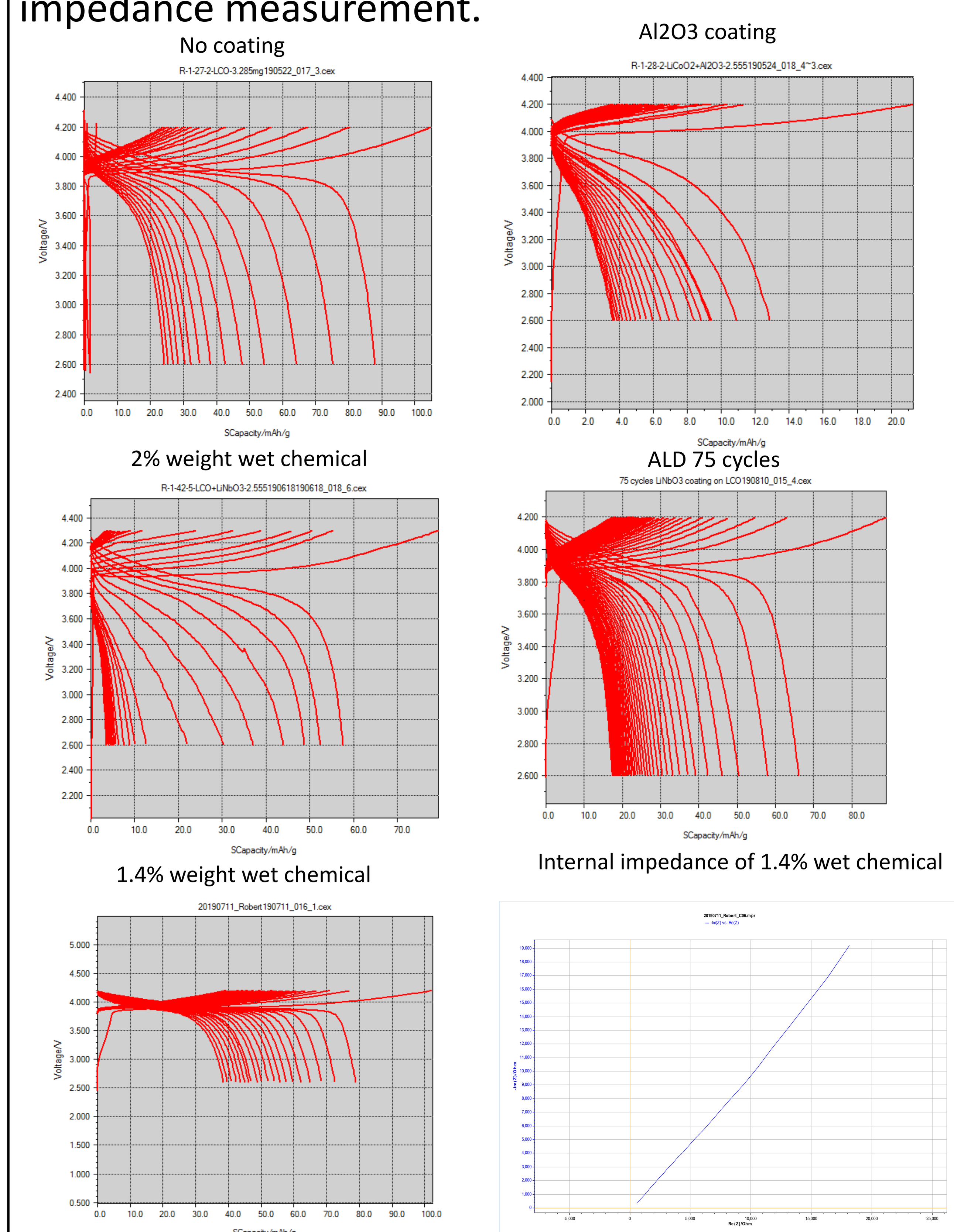
Rotational evaporation machine

- **Atomic Layer Deposition:**
- A layer of lithium is deposited.
- Then a layer of Niobium is deposited, exact ratio may change on the specified sub cycles.
- Layers are heated to extremely high temperature to form LINbO3.
- Depending on how many layers , that determines the thickness of the coating.
- Each coating is very reproducible, meaning results can be very consistent.



Results

Below are the discharge, charge curves of different cathode coatings turned into batteries and an internal impedance measurement.



Conclusion

- A LiNbO3 coated battery did show better capacity retention than one without coating.
- Further work can be done on Atomic Layer Deposition since it is exactly the same each time unlike the wet chemical process where differences can occur with the same starting procedures.
- Further improvement can be done on the thickness and how well coated each particle is.

Acknowledgements

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