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TEXAS A&M UNIVERSITY
Research Experience for Teachers

THIN FILM EPITAXY

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Abstract

Traditional Li ion battery electrodes are made using a printing process similar to that used by the newspaper industry, except the "ink" is battery material. Whereas printed electrodes are about as thick as the average paper (100-200 µm), thin film cathodes are usually under 1 µm. Thin film based batteries are made using the same techniques used to make computer and phone processors. The advantage of this approach is the ability to manipulate the structure down to atomic level, i.e. we can make layers just a few 100 atoms thick. Once basic research and design is complete using thin film techniques, these can be applied to commercial batteries using the above printing process. We anticipate these new batteries to keep laptops running twice as long and enable electric cars to go over 300 miles on a single charge. In the future we also hope that such batteries can be directly built in your phone's circuit board with no need for a separate battery. So an IPhone will be just 2 mm thick! Finally, while achieving these goals we are also trying to use environmentally friendly materials that are far less toxic than existing Li ion battery materials.

Research Objectives

Since the first release of smart phones engineers have worked to improve the battery life and charge cycles of these devices. In this activity you will apply the Chemistry and Physics concepts you have learned in building a battery. Using common household items, you will effectively combine electrodes and electrolytes to create and test your very own working battery.

Methodology

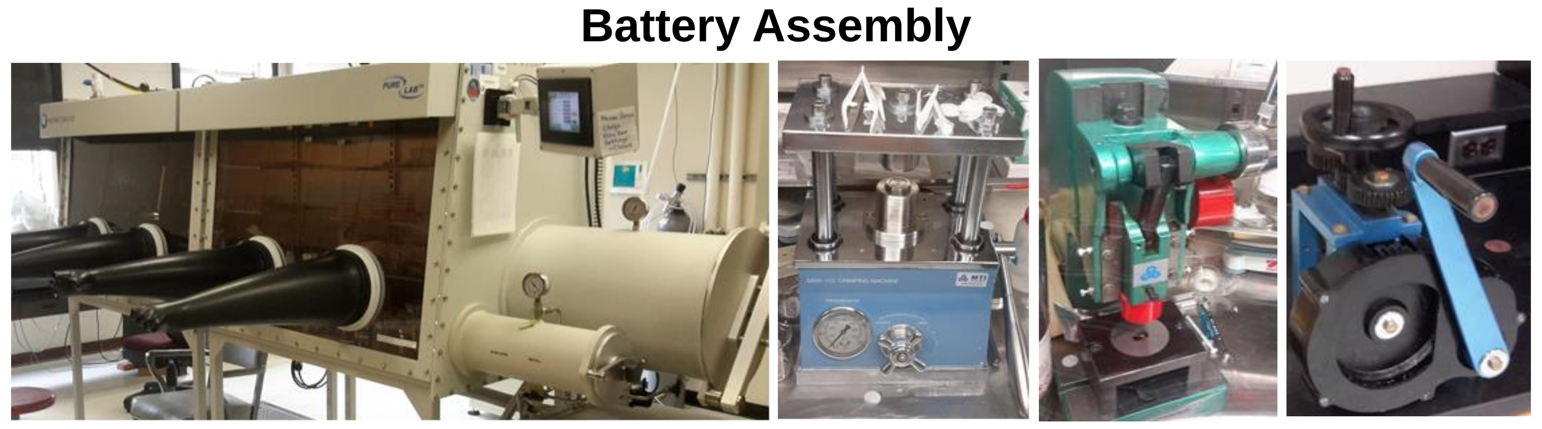
Material Development → Battery Assembly → Battery Pack Design and Assembly

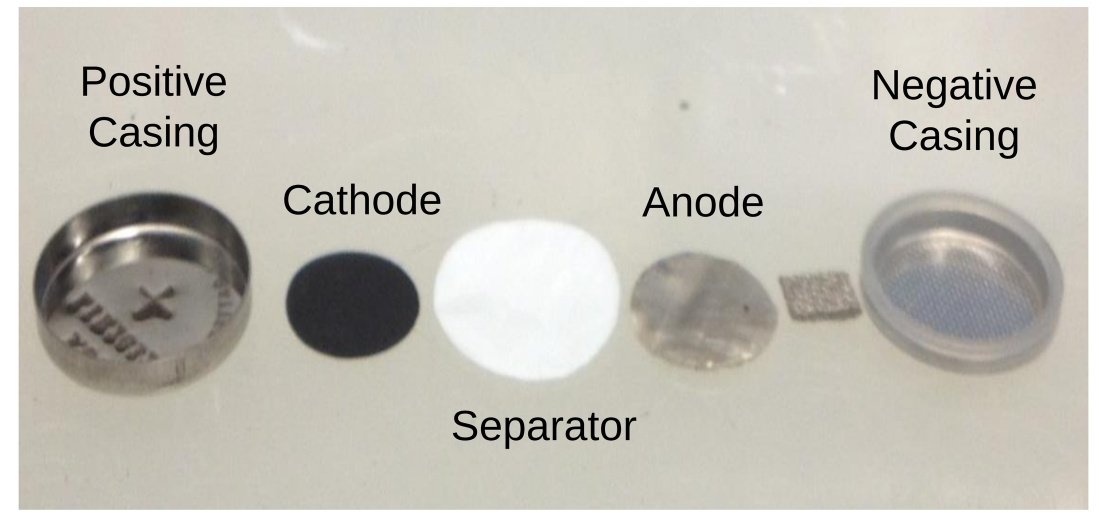
Material Development
- Electrode & Electrolyte Synthesis.
- Scaling Synthesis Techniques.
- Material Characterization.
- Electrochemical Evaluation.

Battery Assembly
- Cell Geometry.
- Sealing.

Battery Pack Design and Assembly
- Electrical Arrangement.
- Packaging and Sensors.
- Battery Management System (BMS).
- Testing.

Battery Assembly





1. Begin by identifying your electrodes. Using the Table of Standard Electrode Potentials, find the value of your cathode and anode and calculate your theoretical potential difference. Be sure to put your answer in proper engineering notation and use the correct units.

   Cathode: ____________________ Standard Potential E° = _____V

   Anode:______________________ Standard Potential E° = _____V

   Potential Difference = _____V

2. Assemble the parts of your battery. Remember there are 4 components.
   Electrolyte Set-up
   How much salt did you use for your electrolyte solution? ___________g
   How much water did you use for your electrolyte solution? ___________ml
   What is the concentration of your electrolyte solution? ___________g/ml

   Battery Set-up
   How much voltage did your battery hold? ___________V
   How much current did your battery generate? ___________A

3. Set up batteries in series.
   Electrolyte Set-up
   How much salt did you use for your electrolyte solution? ___________g
   How much water did you use for your electrolyte solution? ___________ml
   What is the concentration of your electrolyte solution? ___________g/ml

   Battery Set-up
   How many separators did you use? ___________
   How many cathodes did you use? ___________
   How many anodes did you use? ___________
   How much voltage did your battery hold? ___________V
   How much current did your battery generate? ___________A

1. Set up batteries in parallel.
   Electrolyte Set-up
   How much salt did you use for your electrolyte solution? ___________g
   How much water did you use for your electrolyte solution? ___________ml
   What is the concentration of your electrolyte solution? ___________g/ml

   Battery Set-up
   How many separators did you use? ___________
   How many cathodes did you use? ___________
   How many anodes did you use? ___________
   How much voltage did your battery hold? ___________V
   How much current did your battery generate? ___________A

Results and Conclusions

Using standardized electrodes (1cm x 1cm)—cathode: Ni (~-0.23 E°), anode: Al (~-1.66 E°) and a standardized cardboard separator (1cm x 1 cm) saturated with 0.05 g/mL saline, the battery was able to hold a 1.15 V charge. Setting up a series circuit allowed it to generate a 54.0 µA current. The parallel circuit set up generated a higher current of 67.0 µA current.
Because the current is directly affected by the electrolyte concentration, future directions may include determining the most effective electrolyte solution to use in a parallel circuit setup to generate higher currents and hold greater voltage.

References

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