Thin Film Epitaxy

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Background: 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.

Methods: The Li-Ion Batteries project has three phases: Material Development; Battery Assembly; and Battery Pack Design and Assembly. Material development includes: Electrode and Electrolyte Synthesis; Scaling Synthesis Techniques; Material Characterization; and Electrochemical Evaluation. Battery assembly involves Cell Geometry and Sealing. The final stage of battery pack design and assembly includes: Electrical Arrangement; Packing and Sensors; Battery Management System (BMS); and Testing. My research will be focused on a rudimentary version of battery assembly.

Results: 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.

Conclusion: 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.