Project report to Kuwait-MIT Center for Natural Resources and the Environment

A novel design for lithium-ion nano-battery

Project Outcomes Report

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The major outcomes of this project include the miniaturized thin film battery architecture that can be fully fabricated under ambient condition. The lithium-ion nano-battery architecture has the thickness of 200nm and various dimensions from 400x400nm^2 to 1.5x1.5cm^2. The fabrication process includes PVD, PECVD, direct write optical lithography, e-beam lithography, and mask aligner. The tested battery was 20x20 µm^2 using $LiCoO_2$ as the cathode, LiPON (lithium phosphorus oxynitride) as the electrolyte, and silicon as the anode. The battery showed good cyclability; we barely observed capacity retention until 100 cycles at 30C charge/discharge rate.

Moreover, this nano-battery successfully showed high discharge rate up to 120C with almost no capacity retention during 10 cycles since the battery was very thin and used solid electrolyte instead of the liquid electrolyte. Especially, this work reports the use of silicon thin films as the anode material. By showing that silicon thin films may cycle without capacity retention in our battery setup, we provide a potential thin film battery architecture which can be fabricated completely in air, without the conventional use of glove-box or dry-room.

Silicon anodes and other active materials in this battery will be observed by *in situ* Transmission Electron Microscopy to observe the microstructural evolution during cycling and to identify the possible reason for long cycle life. We expect to utilize the MEMS technique and expertise developed during 1st year of this project for fabricating liquid cell using $LiFePO_4$ nanowires with liquid electrolyte. This battery system can be applicable for micro and nano sized electronics require high power and long cyclability.

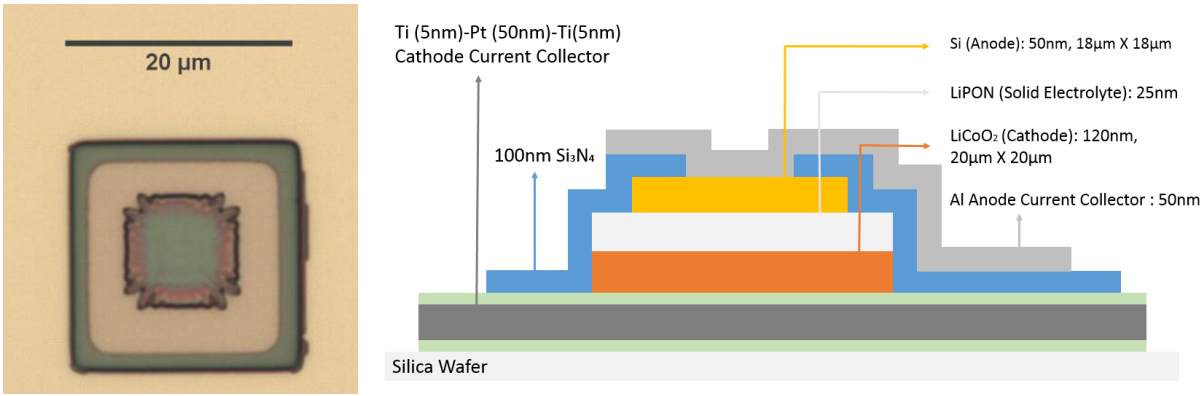

Figure: (left) Top-down view of the assembled nano-battery before silicon nitride encapsulation observed by an optical microscope. (right) Cross sectional view of nano-battery assembly.