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Deterministic three-dimensional composite structures for energy storage

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DETERMINISTIC THREE DIMENSIONAL COMPOSITE STRUCTURES FOR ENERGY STORAGE

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Through mesoscale design of a 3D current collector, high power density and high energy density primary and secondary (rechargeable) large format and microbatteries (Figure 1) were fabricated. At the most fundamental level, mesostructuring enables optimization of the trade-off between energy and power density in energy storage systems due to unavoidable ohmic and other losses that occur during charge or discharge. Of course, it is at fast charge and discharge, where these effects are most important. By efficient design of the ion and electron transport pathways, we and others have shown it is possible to significantly improve the power-energy relationship. We have found a particularly effective way to provide these pathways is to use holographic and colloidal-based templates to form a mesostructured 3D current collector. The electrochemically active material is then deposited on this current collector. Using this approach, Li-ion batteries which could be discharged at up to 300C with 75% capacity retention were formed. The combination of a high surface area and short solid-state diffusion lengths offers a number of unique opportunities for both high energy and high power chemistries. As examples, we have formed conventional form-factor and microbattery high power cells based on lithiated manganese oxide and other oxide-based cathodes, and carbon, NiSn, iron oxide, and silicon-based anodes.

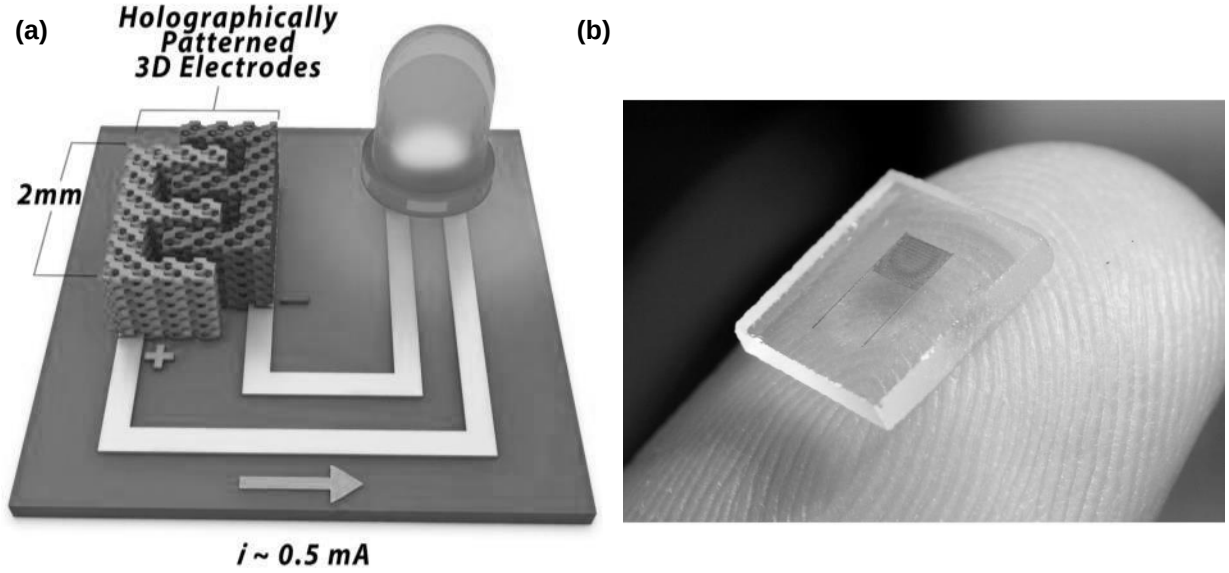

Figure 1 – (a) Schematic of a holographically defined lithium-ion microbattery, illustrating it lighting an LED with a 0.5 mA current which corresponds to a 600 C (~10 second) discharge. (b) Optical image of the holographically patterned microbattery on a glass substrate.