Symposium: Excellence in Graduate Student Research

Title: Additive manufacturing of functional materials via photopolymer complex synthesis

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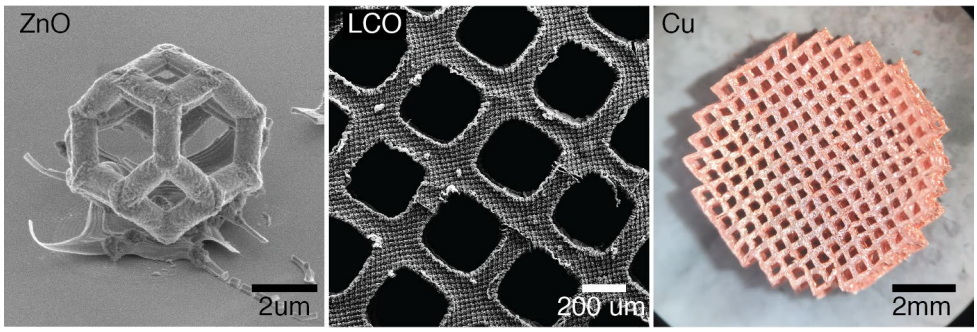
Additive manufacturing is one of the most powerful manufacturing tools available today, due to its potential in fabricating a wide variety of materials at resolutions ranging from nanometers to meters. In particular, significant advances have been made in polymeric 3D printing, with recent work showing the fabrication of polymers with unique properties, such as self-healing, stimuli-responsive behaviors, and etc. However, there is still a dearth of techniques for the printing of multifunctional metal oxides and metals. Conventional methods involve: a) the patterning of slurries containing a metal oxide/metal powder, with a subsequent debinding and sintering step, b) printing with inorganic-organic polymers, followed by a similar thermal treatment, or c) the use of a high-powered laser to fuse metal oxide/metal powder together. However, these techniques have difficulties with issues ranging from inhomogeneous dispersion of particles in slurries, challenging synthesis of inorganic-organic resists, to cost of equipment respectively.

In this presentation, a new technique, called “Photopolymer Complex Synthesis,” that addresses some of the challenges above, is demonstrated. Aqueous metal-ion containing photoresins are prepared and used with photolithography, in conjunction with post-processing techniques to fabricate architected metal oxide or metal structures. These photopolymer systems are facile to prepare and can be modified to fabricate various multifunctional complex metal oxides or alloys. As examples of this technique, we fabricate and characterized zinc oxide (ZnO)[1] and lithium cobalt oxide (LCO)[2] architected structures with sub-micron and sub-millimetre features respectively. Compression of the ZnO structures resulted in an electromechanical response, and electrochemical cycling of the LCO structures showed efficient performance as a lithium ion battery cathode. We also demonstrate the fabrication and characterization of metal structures made from copper and cupronickel alloys[3]. Our work highlights the use of polymer chemistry and materials science in expanding the range of materials that can be made via additive manufacturing.



Caption: Examples of materials made using PCS. Left: Zinc oxide, Middle: Lithium Cobalt Oxide, Right: Copper. Note the scales at which these materials can be fabricated.

[1] Yee, Daryl W., et al. "Additive Manufacturing of 3D-Architected Multifunctional Metal Oxides." *Advanced Materials* 31.33 (2019): 1901345.
[2-3] Yee, Daryl W., et al. In preparation. (2020)