Free-Form Design of Autonomous Microenvironments

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The increasing interest in free-form fabrication and three dimensional (3D) printing promises to broadly redefine technology and manufacturing in the coming years. Though various 3D printing strategies exist competitively, at the pinnacle of feature resolution stands two-photon or multiphoton lithography (MPL) developed over the past 15 years. A particular challenge facing the further progress of this technique is narrow range of materials that are currently compatible with MPL.

Here, I will describe our efforts in the development of MPL techniques using (dynamic) mask-directed approaches and our results aimed at expanding the library of MPL-compatible materials. As a guide for this work, our interests are toward developing 'functional' materials with inspiration drawn from biological systems where the basic operational 3D unit (the cell) mirrors the scale accessible for MPL materials (Figure 1).

For example, I will discuss studies aimed at directing cellular behaviors using biocompatible chemistries and biological materials[1]. Structures built from biological building blocks such as proteins can be tuned to respond mechanically to environmental cues [2] and direct biomimetic mineralization[3]. Integration of responsive and catalytic materials into prescribed microenvironments can produce 'life-like' behaviors, operating autonomously as actuators and pumps[4]. Further, I will present our recent attempts to expand MPL materials into transition metals and metal oxides, and the opportunities for the development of complex compartmentalized reactors built from tightly organized traditional and biological catalysts.

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[3] C. Y. Khripin, D. Pristinski, D. R. Dunphy, C. J. Brinker, and B. Kaehr, ACS nano **5** (2), 1401 (2011).

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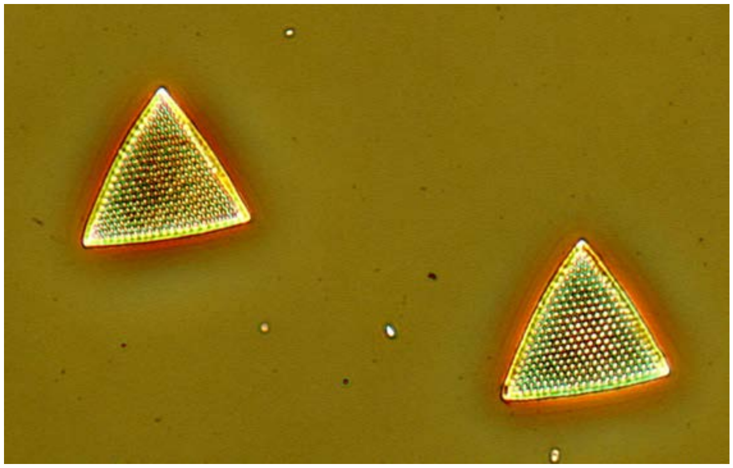

Figure 1: Synthetic Diatoms: Optical image of MPL-derived microscale biological templates following their catalytic transformation into inorganic glass.