Project Title: Morphogenic Manufacturing

Advisors: Evan Lloyd (PhD Candidate, Chemical and Biomolecular Engineering), Prof. Nancy Sottos (Material Science and Engineering Engineering)

Project Description: Biological systems display an astonishing level of complexity despite developing from an initial state of symmetry. The multiplex structures, intricate patterns, and advanced functionalities emerge through a process known as morphogenesis. Central to morphogenesis is the coupled reaction and diffusion of activator and inhibitor morphogens. While reaction-diffusion (RD) networks are ubiquitous in biological systems, a synthetic manufacturing mimic has yet to be realized in engineering materials. In this project, we seek to develop a synthetic mimic to biological morphogenesis by employing frontal ring-opening metathesis polymerization (FROMP) as the RD network. Through precise control of reaction and thermal diffusion rates, spatially patterned thermal profiles emerge from an initial state of symmetry (Figure 1a). Undulations in temperature give rise to patterned optical (Figure 1b) and mechanical properties.

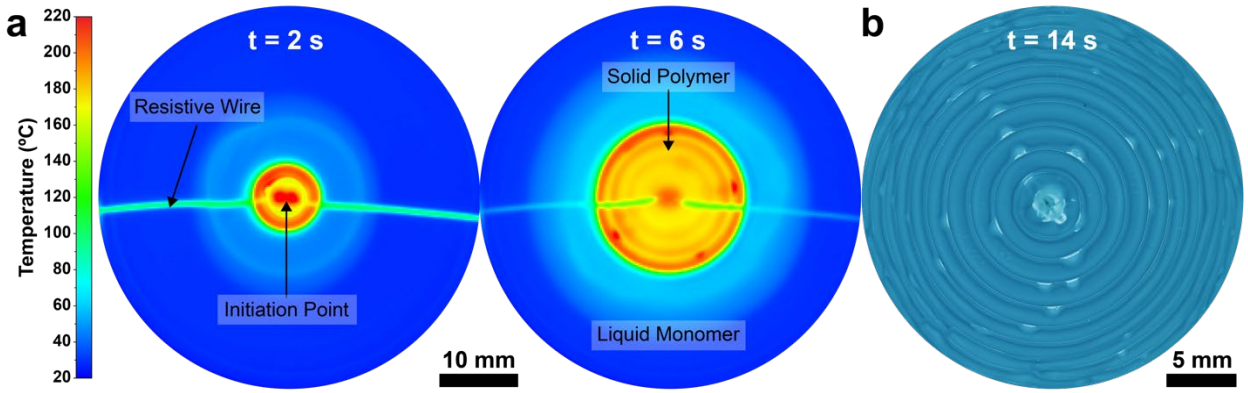

Figure 1 | Emergence of thermal gradients and patterns during morphogenic manufacturing. a) Thermal profiles at t = 2 and 6 s after point initiation with a resistive wire in the center of the specimen. **b)** Optical image of the surface pattern in the resultant material generated by the thermal gradients shown in a.

As an undergraduate research assistant, your duties will include the fabrication of samples which display the desired morphogenic patterning. Fabrication will involve blending of FROMP resins with varied reaction kinetics and preparation of mold materials with varied thermal conductivities. Patterns will be evaluated with optical microscopy, surface profilometry, and nanoindentation. The final goal will be investigation of pattern dependence on reaction kinetics and thermal diffusion rates.

Student Background and Expected Research Activities:
We are seeking a highly motivated, enthusiastic student with interests in *polymer synthesis, material fabrication, and/or polymer characterization*. Laboratory experience in a research setting is desired, but not mandatory, as the student will be thoroughly trained in every aspect of the experiments in question. The student should be comfortable handling chemicals and operating testing equipment, be able to precisely follow safety and experimental protocols with great attention to detail, and exhibit strong communication skills.

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