High Resolution Projection Microstereolithography for 3-D Fabrication

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There is a growing need to develop fabrication and manufacturing technologies which can rapidly generate 3-D components at the meso-scale with micro- and nano-scale features as well as graded density structures with multiple material constituents. Applications of interest for LLNL include laser fusion targets for the Nation Ignition Campaign (NIC) and Laser Inertial Confinement Fusion-Fission Energy (LIFE), high energy density physics targets, and complex micro and nanostructures for national security such as sensing technologies.

Projection Microstereolithography (PμSL) is a potentially low cost, high throughput, micro-scale, stereolithography technique which uses a spatial light modulator (Liquid Crystal on Silicon - LCoS) chip as a dynamically reconfigurable digital photomask. PμSL is capable of fabricating complex 3-D microstructures in a bottom-up, layer-by-layer fashion. A 3-D model is first sliced into a series of closely spaced horizontal planes. These 2-D images are transmitted to the LCoS and illuminated with an ultra-violet source. The LCoS acts as a dynamically reconfigurable photomask and transmits the image through a reduction lens into a bath of photosensitive resin. The resin that is exposed to the UV light is cured and anchored to a substrate and z-axis motion stage. The stage is lowered a small increment and the next two-dimensional slice is projected into the resin and cured on top of the previously exposed structure.

We are currently working on refining this capability in order to produce nano-scale features and to use multiple materials. This is being accomplished by:

1. Incorporation of a far-field superlens (FSL) to enhance resolution to the tens of nanometer-scale (well below the diffraction limit of UV light).
2. Use of laminar flow microfluidic systems to more optimally deliver and distribute photosensitive resins enabling fabrication with multiple materials.
3. A coupled optical-chemical-fluidic model to elucidate the governing physics.

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