Plenary speaker: Hayden Taylor Department of Mechanical Engineering, University of California, Berkeley- ***Volumetric additive manufacturing via tomographic reconstruction: process capabilities and scaling principles***

Hayden Taylor is an Associate Professor in the Department of Mechanical Engineering at the University of California, Berkeley. His research seeks to invent, model, and simulate a new generation of manufacturing processes to make more efficient use of materials and energy and enable industrial decarbonization. The themes of his research are: (A) multiscale additive manufacturing, (B) contact mechanics in semiconductor manufacturing, and (C) materials and processes for sustainable construction. Hayden received a Ph.D. in EECS from MIT in 2009, and the B.A. and M.Eng. from Cambridge.

Abstract: Industrially established additive manufacturing processes build 3D geometries by repeating lower-dimensional unit processes such as extrusion, localized powder fusion or layer-wise photo-polymerization. The fabrication speed, surface quality and mechanical properties of components produced with these methods are strongly constrained by the thermal, hydrodynamic and optomechanical characteristics of the processes.

The emerging class of volumetric additive manufacturing processes seeks to overcome these limitations by transforming material at all points in a desired component simultaneously. Until recently, however, no practicable technique existed for creating arbitrary 3D geometries volumetrically. Computed Axial Lithography1 (CAL) offers a way to address this need. CAL is inspired by the principles of computed tomography — widely used in imaging, but not previously in fabrication — and synthesizes a three-dimensionally controlled illumination dose within a volume of photocurable resin precursor. The photosensitive volume rotates steadily while synchronized patterns of light are projected through it. In this way, the cumulative light dose in the material is controlled in 3D, and where the dose exceeds a threshold, the resin solidifies and the part is formed.

The CAL printing technique has several advantages. Because the component being printed does not move relative to the precursor material during printing, the processing speed is not limited by hydrodynamic stresses, as it can be in layer-by-layer photo-polymerization. The absence of relative motion also allows highly viscous solutions or even solid gels to be used as the starting material, so that a wider range of mechanical properties can be achieved in printed components. Crucially, CAL is inherently more energy-efficient than layer-wise digital light manufacturing because precursor materials for CAL are free of the passive light absorbers that are needed when localizing light to microscopic layers of material.

In this talk I will describe some important considerations for computing optimal light patterns for projection in CAL2. I will also review the material-dependent, optical, and mechanical factors governing the position- and orientation-dependent spatial resolution of CAL, as well as its fabrication speed and potential for scaling. I will describe the application of CAL to producing silica glass components via sintering of a printed nanocomposite resin3. This ‘micro-CAL’ process has defined lattices, microfluidic channels, and lenslet arrays with features as small as 50 µm in silica and 20 µm in polymeric material. Finally, I will describe some other envisaged applications of CAL, including the ‘over-printing’ of structures around pre-existing solid objects.

References:

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