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A more focused, coordinated effort is needed to accelerate US manufacturing towards extreme mass customization. Mass customization enables the ability to quickly tailor a manufactured product based on real-time consumer or customer input without sacrificing approaches and processing required for cost-effective mass production. Currently, mass customization for manufacturing generally involves the flexibility to alter a fixed set of parameters within a finite set of possible solutions.

Taking mass customization to the extreme would involve expanding beyond "auxiliary feature" customization within a finite set of predetermined "customized" solutions to property-based customization where an infinite number of solutions are possible within a predefined property space. As a simple example, rather than manufacturing shoes in discrete sizes for a given activity, a shoe could be manufacturing with a sole customized not only for the size and shape of an individuals foot, but also customized based on the exact weight of the individual. This would require a rapid manufacturing approach that could individually tune the exact shape and compliance (i.e. mechanical property) of the sole without sacrificing cost-effective mass production capabilities (i.e. minimal or no touch labor).

Recently, a new materials platform has been discovered that could take mass customization to the extreme. This new approach enables fabrication of unique open-cellular materials with micro-scale truss, or lattice features ranging from tens to hundreds of microns. These materials are formed from a three-dimensional, interconnected array of self-propagating photopolymer waveguides, as shown in Figure 1. Intrinsic to the process is the ability to control the *material micro-architecture*, which ultimately affects the bulk material properties. Unlike stereolithography, this new fabrication technique is rapid (~ minutes to form an entire part) and relies on a single two-dimensional exposure surface to form three-dimensional structures (thickness > 25 mm possible). This combination of speed and planar scalability opens the possibility to establish a new US manufacturing effort that is anticipated to seed new product innovations and market demand for high performance, customized engineered materials. The utility of these new materials range from lightweight energy absorbing structures to thermal management materials to bio-scaffolds.

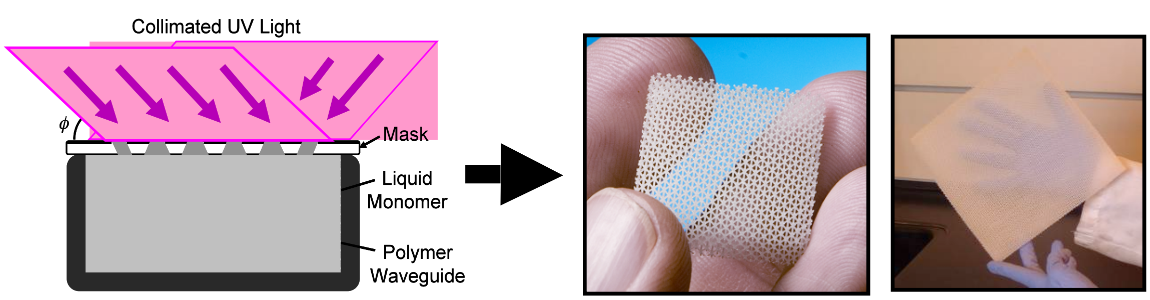

Figure 1. Schematic representation of a new manufacturing process that enables the rapid formation of micro-lattice structures from a self-propagating polymer waveguides.

More generally, to take mass customization to the extreme and provide the US with a manufacturing competitive advantage, five areas of innovation are required:

(1) New manufacturing approaches must be developed that enable real-time, tunable properties for a manufactured material/product without adding additional touch labor. As an example, the manufacturing method described above can tailor the material properties by tailoring material micro-architecture through automated adjustments within the process.

(2) There must be predictive capabilities and reliable manufacturing tools that can link the desired customer requirements to optimized material properties and ultimately to the fabrication process.

(3) For demanding applications where some level of qualification may be required (e.g. aerospace), new technology advances are necessary that efficiently and cost-effectively qualify each customized solution. I anticipate this point will be a major topic of discussion throughout the workshop, as it will likely relate to many new manufacturing technologies.

(4) To further capitalize on new, flexible manufacturing approaches, the manufacturing innovation must be accessible to product designers and engineers to enable design innovation. We are proposing a module-type manufacturing system, but this would require defined and accepted industry standards and processes.

(5) Lastly, for a new manufacturing platform to be harnessed to its full potential, basic research in academia would be instrumental to develop a comprehensive systemic understanding of new material properties and material interactions (e.g. bio-scaffolds) that could eventually provide incentive and direction for further manufacturing development.

In order for the US to have a sustained leadership position, we need a focused, coordinated effort whereby NIST can fund the development of advanced manufacturing tools that can help take mass customization to the extreme. In addition, NIST can help establish the interoperability standards and measurements needed so that new innovations, manufacturing scaling for new products, and rapid market adoption can occur. NSF funding for the next generation of scientific breakthroughs and basic material science research can also be harnessed for newly developed materials platforms. Industry consortia similar to the HRL model can provide some of the research and development, application engineering, and scaling required; however, because these will be high risk, high impact efforts, federal and state participation can play an instrumental role to help reduce the risk and accelerate the next generation US manufacturing base.

Short Bio

Alan J. Jacobsen is a Senior Scientist in the Bio- and Nanomaterials Department at HRL Laboratories, LLC. He received his B.S. in Mechanical Engineering from New Mexico State University, M.S. in Mechanical Engineering from Northwestern University, and Ph.D. in Mechanical Engineering from University of Southern California. He has pioneered the new process to rapidly fabricate micro-scale truss structures from self-propagating photopolymer waveguides. He holds 4 patents on the topic, has numerous patents pending, and has authored / co-authored 9 related publications.