

LLNL ACHIEVES BREAKTHROUGH IN 3D PRINTING OF GLASS

Additive manufacturing, more commonly known as 3D printing, is transforming the way parts and products are being made, and with new material breakthroughs being announced on a regular basis, it seems the sky's the limit for how far the technology can permeate throughout industry.

Recently, scientists at Lawrence Livermore National Lab successfully 3D printed transparent glass, a development they say could lead to changes in the design and structure of lasers and other devices that incorporate high-quality optics.

LLNL researchers, along with scientists from the University of Minnesota and Oklahoma State University, reported the creation of the transparent glass components in the May edition of *Advanced Materials*. In the paper, they detail a new 3D printing technique that enables the printing of glass structures and gradients previously impossible through conventional manufacturing processes.

"The Lab is always looking for different ways to create new materials for optical applications," said LLNL chemical engineer Rebecca Dylla-Spears, who heads the project. "We're not going to replace the optical materials made through traditional means, but we're trying to impart new functionality using additive manufacturing. This is the first step to being able to print compositionally graded glass optics."

Although other institutions have shown 3D printing of glass is possible, LLNL's method uses a custom "slurry" of silica particles that can be printed at room temperature, instead of extruding molten glass or using lasers to melt and fuse glass powders, which can lead to porous structures unsuitable for optical applications. The printed product comes out opaque, but after drying and heat treatment, it becomes transparent. Finally, the processed parts are given an optical quality polish.

"For printing high-quality optics, you shouldn't be able to see any pores and lines, they have to be transparent," said LLNL materials engineer Du Nguyen, who went through numerous mixtures of materials before finding the right combination. "Once we got a general formulation to work, we were able to tweak it so the material could merge during the printing process. Most other groups that have printed glass melt the glass first and cool it down later, which has the potential for residual stress and cracking. Because we print at room temperature, that's less of an issue."

Researchers said the new method could allow scientists to print glass that incorporates different refractive indices in a single flat optic, meaning printed components would be easier and cheaper to finish.

"Polishing complex or aspheric lenses is pretty labor-intensive and requires a lot of skill, but polishing a flat surface is much easier," Nguyen said. "By controlling the refractive index in the printed parts, you alter the bending of light, which enables a lens that could be polished flat."

Rather than replace traditional optics, researchers said they want to explore new applications that don't currently exist on the market today. Designing for novel optical components instead of using off-the-shelf optics could potentially reduce the size, weight or cost of optics systems.

While the research could potentially expand the design space for optical engineers, it may also have applications outside of optics, including microfluidic devices. Glass is a prized material for microfluidics due to its optical transparency, chemical resistance, mechanical properties, and ability to tailor its surface chemistry and functionality, however, glass is difficult to machine and etch to make complex microfluidic device geometries.

Now that they've proven printing transparent glass is possible, researchers are turning their attention to making higher-quality optics, which will require even more understanding and control over the process.

