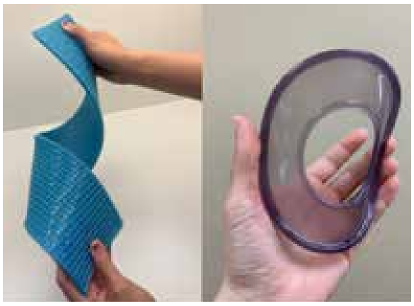
Industrial 3D Printing Surges Forward with High-Performance Elastomers

At a market size of $12 billion, additive manufacturing holds tremendous promise for industrial applications. On-demand production saves both time and money and can be more efficient than some traditional forms of manufacturing. Currently, however, 3D printing comprises less than 0.1% of all manufacturing, due in part to the finite number of printable materials that are viable for industrial use.

With funding from the National Science Foundation, Minnesota-based Chromatic 3D Materials is commercializing a deposition printing technology for high-performance thermoset elastomers, which traditionally are available only through slow, costly molding. Chromatic's novel reactive liquid mixing process, Reactive Liquid Additive Manufacturing (RLAM), yields more durable flexible components than existing 3D-printing technologies. RLAM also enables complete customization, including multi-material designs, large formats, and complex shapes.

Typical 3D printing creates a layered buildout of volume that is heterogeneous in structure and properties. To print a part using RLAM, two liquids are pumped through a mixing tip, where they react. The resulting gel seals gaps within itself and, as it continues to react with the surrounding material, forms chemical bonds throughout the entire printed structure. The resulting smooth, nonporous elastomers are ready for use within a day, with no need for post-processing.



▲ Chromatic can produce parts with lengths up to 1 m. The flexible part on the left is used for sealing a pipe. The printed air seal on the right can hold up to 4 bar of air pressure without leaking or tearing.

The liquid feed components can be altered easily to change elastomer properties including toughness, flexibility, elasticity, and color — all without negatively affecting the printing process. Furthermore, Chromatic can print directly onto existing substrates, such as metal, plastic, electronics, and textiles, reducing the need for assembly. These superglue-like elastomers can even be used as adhesives that are as strong as the materials themselves, a property that is highly desirable in the automotive industry.

Notoriously, thermoplastic properties tend to degrade during physical blending processes. In Chromatic's method, the reaction components are blended prior to polymerization, ensuring durability — a key issue for existing 3D-printed parts, whose materials have so far been limited to meltable thermoplastics, photo-cured thermosets, and fusible powders. Furthermore, by placing the gel upon the printing substrate prior to the completion of the reaction, the part is free from the seams, voids, and fusing lines that lead to weakness and failure in comparable components produced via filament-, powder-, or droplet-fusing processes. Chromatic's flexible, crosslinked elastomer materials can withstand repeated stress as well as corrosive chemicals, high pressures, and high temperatures.

Shore hardness, using either the Shore A or Shore D scale, is the preferred method for rating rubbers and thermoplastic elastomers. Shore A 40 (*e.g.,* a pencil eraser) to 90 (*e.g.,* a shoe heel) is a particular hardness range in which 3D-printed elastomers have struggled to meet the demands of industrial applications. For example, fused-filament fabrication materials currently on the market are limited to Shore A 70 and above. Acrylate-rubber photopolymers that are available on the softer end of the Shore A hardness scale are not durable. Conversely, Chromatic's FlexTune materials, which range from Shore A 40 to 90, make it possible to print with the same reliable materials that have been used for decades in applications such as hydraulic-seal gaskets.

In testing for an air-brake membrane, Deutsche Bahn (DB) — the largest rail service provider in Europe — selected Chromatic alone as a satisfactory supplier for this safety-critical part. "Amongst the competitors, Chromatic 3D Materials' technology showed the largest improvement per cycle and holds the largest improvement potential," says Stefanie Brickwede, head of additive manufacturing at DB Vehicle Maintenance. "Chromatic 3D Materials will be an important supplier of 3D-printed elastomeric spare parts in the years to come."

Such adaptable materials are also well suited to the diverse demands of the product-development market, from incorporating environmentally friendly materials to designing groundbreaking medical devices. In combination with such thermoset chemistries, 3D-printing technology could spur new product designs never before possible. CEP

This technology was funded through the NSF Small Business Innovation Research (SBIR) Program.

This article was prepared by the National Science Foundation in partnership with *CEP*.