UV Curing in a 3-Dimensional World

by Beth Rundlett, Ph.D.

It seems everywhere you look lately, you can find articles about 3-dimensional (3-D) printing, also often called additive manufacturing. 3-D printing is being used in the creation of new machines, clothing, medical devices and even toys such as personal action figures. What you may not have read is that one distinct and unique subset of additive manufacturing—stereolithography—utilizes UV-curing technology.

Stereolithography is a process that replicates or creates any computer-designed article into a solid 3-D object using the same UV-curing technology upon which RadTech was founded. The rapid-prototyping capability combined with precise dimensional accuracy enabled by using UV curing in the stereolithography process offers many advantages for a wide variety of applications. Practically any 3-D shape can be created, and often various iterations of the same piece can be formed on one platform. Potential objects include complicated parts with internal cavities, hinges or interconnecting sections (Figure 1). The stereolithography process and equipment can be easily scaled to fit the size of parts needed, and machines exist that are specifically built for the manufacture of even very large parts. These machines are used to make large objects, including automobile parts, life-size skeleton replicas or even furniture. Alternatively, there are stereolithography machines that can build parts as small as 40µm!

The stereolithography process first requires a 3-D computer image (typically a CAD file) which is then converted into a "sliced up" version with very thin layers. Inside the stereolithography machine, a solid-state 355 nm laser will draw the layers of the file onto a platform, which is suspended within a vat of UV-curable resin. Anywhere the UV laser beam irradiates, photons activate the photoinitiators and immediately cure the UV resin into a solid polymer state. The platform on which the polymer layer cures then lowers slightly and the UV-curable resin flows onto the top of the solid polymer layer. The laser then repeats the drawing process, building the object layer-by-layer until the final part is complete.

The physical properties of the resulting parts (large or small) depend greatly on the UV-curable

FIGURE 1

Examples of stereolithography parts

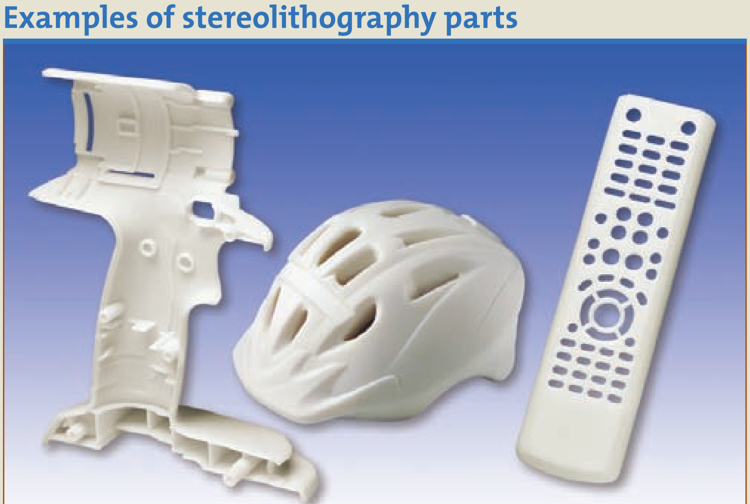
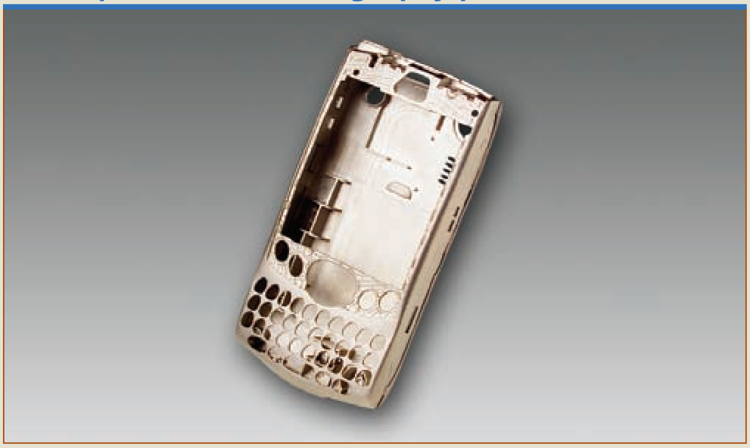


FIGURE 2

Metal-plated stereolithography part



resin that is used in the machine. At stereolithography's inception, parts were very brittle and demonstrated limited accuracy, mostly due to shrinkage in the 100% acrylate systems that were used. This limited the process to primarily creating prototypes. Since then, stereolithography has greatly evolved and parts are now being used in prototyping, functional testing or finished goods. A key advancement in stereolithography resins available today is that they can utilize a combination of two UV-curable chemistries—free-radical and cationic. The combination of these chemistries allows the resin to be fast-curing while yielding extremely dimensionally accurate parts that can exhibit a wide variety of properties.

Not all materials are alike and stereolithography resins must be selected depending on the end-application goal. A wide variety of specialized stereolithography resins are available, each with their own unique properties. For example, stereolithography materials can be designed to mimic ceramics, glass or thermoplastics and can, in some cases, be metalized for specific applications (see Figure 2). Metal plating is where a stereolithography-cured part is coated with a thin layer of metal to mimic the look and feel of metal, but without the weight. Metal plating the stereolithography part enhances many physical properties and creates a conductive part. This process is often used for prototyping metal parts for small-scale testing.

For other applications, stereolithography resins are available that have the optical clarity of glass or acrylic polymers. These resin types are used in applications ranging from car head lamps to fish bowls (Figure 3) and even microfluidic devices in which channels of any shape or size can be created for fluid to pass through, with essentially no change in dimensional stability, enabling easy visualization studies and analysis.

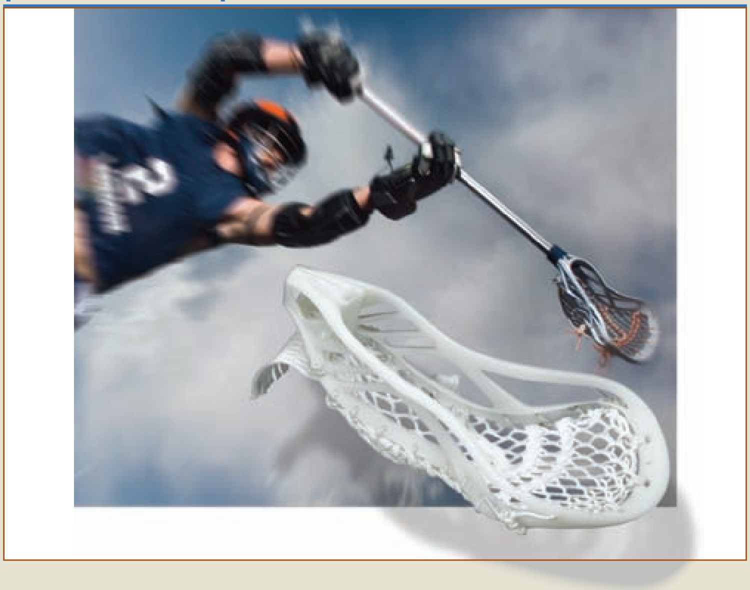
Stereolithography resins can demonstrate a wide range of plastic properties and have made great strides in mimicking thermoplastics. Specially designed tough resins are especially ideal for creating functional end-use performance prototypes, including snap-fit designs, impellers, duct work, connectors and electronic covers, automotive housings and dashboard assemblies, packaging and sporting goods. For example, when Warrior Sports (a leading American sports equipment supplier specializing in ice hockey and lacrosse merchandise) needed to find a smarter way to prototype a new lacrosse stick head, they turned to stereolithography.

FIGURE 3

Stereolithography fish bowl demonstrating high-resin clarity and water resistance

FIGURE 4

Lacrosse stick head functional prototype enabling rapid realistic performance testing to reduce product development time



During testing, a lacrosse stick head prototype (Figure 4) was truly put through its paces, from wind tunnel testing to live-action performance trials with lacrosse players shooting balls at speeds of up to 90 mph at the prototype part

"This is unlike anything we've seen before from stereolithography—a resin that truly looks, feels and performs like a thermoplastic. We were amazed," said Tom Burns, product manager at Warrior Sports. "We were able to simulate in-game scenarios of repetitive throwing and catching at high speeds where the prototype performed almost like a production head."

Whatever needs to be created, stereolithography can produce. All thanks to the UV-curable technology upon which it was founded.

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