Standard hard tooling as prototyping is the best method to produce a part to be micromolded to spec. However, it's not really a rapid process when compared to the other options and it can be more costly.

Rapid prototyping for **micromolded** parts

Comparing test results shows the best RP methods for small parts.

Which rapid-prototyping technique works best for micromolded components? To find out, we developed a test part to send to several RP service bureaus. We designed the part to include many of the dimensions and features that medical, optic, and microelectronics industries require. Thus, the part's overall dimensions were 0.200 × 0.200 × 0.125 in. Features included 0.010 and 0.020-in.-diameter through holes; 0.015 × 0.006 in. and 0.005 × 0.0025-in. thin-wall sections, and a highly polished surface embedded with twelve 0.009846-in.-diameter lenses. Delicate features and embossed details completed the component. Our results with various RP technologies follow:

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WHAT'S THIS?
When you see a code like this, take a photo of it with your smart phone (iPhone 3G-S gives best results) and, using software from *www.neoreader.com*, you will be connected to relevant content on *machinedesign.com*

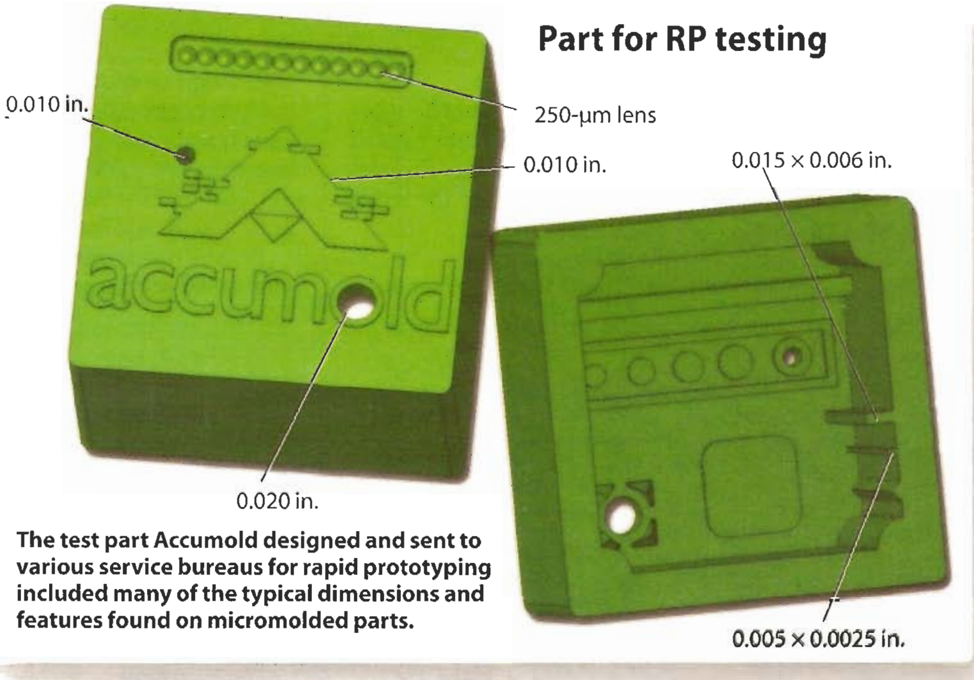
Stereolithography (STL) uses liquid UV-curable photopolymer resin subjected to a UV laser beam. The UV laser traces a cross section of the part, hardening the resin and bonding it to the just-completed layer below. This process continues until the machine builds the complete 3D model. Excess resin is drained and the model placed in a UV oven for final curing. The model is finished by smoothing the "stair-step" surface.

Capabilities: Tolerances are ±0.005 in. for the initial inch, and 0.0015 in. for each additional inch; layer thicknesses are 0.002 in.; resins can made to mimic a wide array of production plastics such as ABS, polypropylene, and polycarbonate. Some materials are quite soft and flexible, ranging from 45 to 80 Shore A.

Pros: The method can produce parts quickly; no tooling required; inexpensive for low volumes.

Cons: Limited materials and colors; generally considered brittle; might not produce all fine features; parts often limited to dimensional representation and not actual functional intent.

Conclusion: STL is not the best way to get prototypes for micromolded parts.



The test part Accumold designed and sent to various service bureaus for rapid prototyping included many of the typical dimensions and features found on micromolded parts.

3D printing (inkjet printing). This method is similar to the inkjet printers many of us have on our desks today. But instead of dropping tiny spots of ink on paper, this process uses tiny droplets of thermoplastic and wax. It also forms cross sections layer-by-layer into complete and complex 3D parts.

Capabilities: 0.0010-in. accuracy; 0.005-in. minimum feature size; 0.0005-in. minimum layer thickness; smooth surface finish.

Pros: Can produce parts reasonably quickly when compared to hard tooling; no tooling required; inexpensive for low volumes.

Cons: Limited material availability; might not produce all micro features; parts often limited to dimensional representation and not actual functional intent; generally considered brittle.

Conclusion: Despite decent accuracy and smooth surface finish, the limited material choice may make this a poor option. We could not find a vendor that felt confident its process would be successful with our test part.

3D printing (3DP — **Z Corp.**) The other common use of "3D printing" is similar to the inkjet technique. An MIT-developed process, 3DP distributes a powder and binder to form prototypes.

Capabilities: 0.0035-in. layer thickness.

Pros: Can produce parts quickly; no tooling required; can print in color; inexpensive for low volumes.

Cons: Surface finish not as smooth as with other methods; micro features are lost; brittle parts.

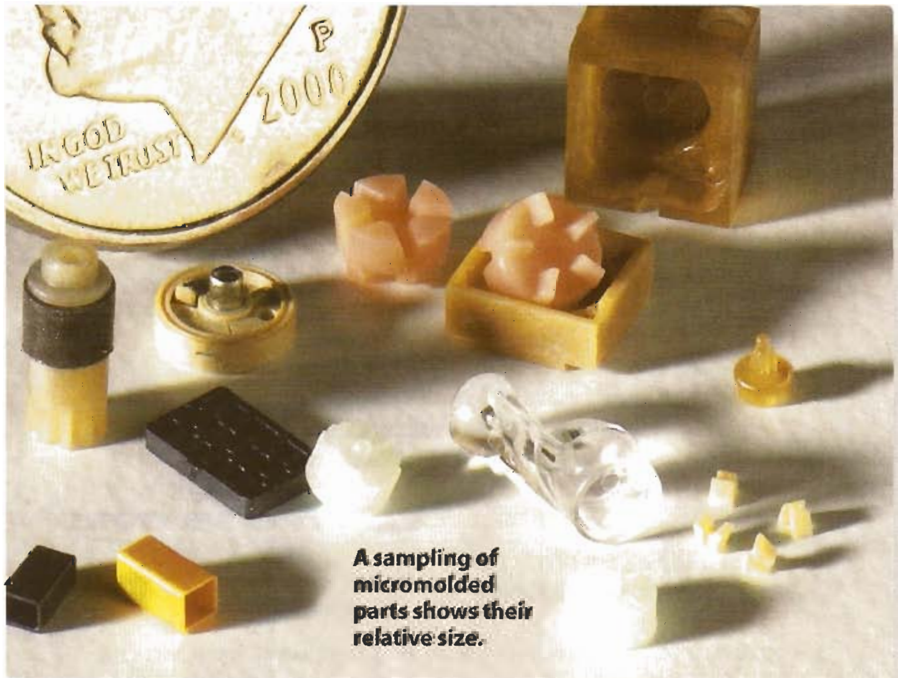
Conclusion: Depending on what features are needed, this process may or may not work.

PolyJet is similar to SLA, but it produces much thinner layers and cures parts in-line while layering. A jetting head accurately builds each layer 0.0006-in. thick (about one-fifth that of STL layers).

Capabilities: A variety of photosensitive resins are available; 0.004 to 0.01-in. accuracy (varies according to geometry, part orientation, and print size); layer thickness can be as small as 16 micron.

Pros: Can produce parts quickly; high resolutions; no tooling required; inexpensive for low volumes.

Cons: Might not produce all micro features; doesn't



A sampling of micromolded parts shows their relative size.

represent actual molded part.

Conclusion: We were told this process would be superior to SLA, and according to the manufacturer's stated capabilities it should be. But many of the fine features were lost and only in some of our samples did the larger through-hole appear.

Fusion-deposition modeling (FDM). Here, coiled modeling material is extruded through a nozzle. The machine can be programmed to deposit material both horizontally and vertically along the cross sections of the part to form the shape. FDM is a trademark of **Stratasys Inc.**

Capabilities: ± 0.003-in. accuracy; 0.007 in. for higher surface finish and feature detail.

Pros: Production-grade material selection, ABS, Ultem, and polycarbonate; no tooling required; can produce parts quickly; inexpensive for low volumes.

Cons: Might not produce all micro features.

Conclusion: No vendor we asked attempted to produce this part with this process. One shop originally quoted our part but after further review recommended a different process due to the part size and features.

Selective laser sintering (SLS) uses a high-temperature laser to melt and fuse, or sinter, powdered plastics or metal into the 3D part. When compared to other methods, SLS has a wide range of material choices including filled thermoplastics.

Capabilities: 0.004-in. layers.

Pros: Closer to productionlike materials than SLA; stronger finished parts than SLA; no tooling required; can produce parts quickly; inexpensive for low volumes.

Cons: Might not produce all micro features.

Conclusion: Not a strong contender when accuracy or finer features are needed.

Cast urethane molds, sometimes called rapid tooling, are produced by forming an impression of a solid part, usually produced by one of the other rapid-prototyping methods, with a room-temperature vulcanizing (RTV) rubber mold. The mold is split and can reproduce 10 to 20 parts before it begins to break down.

Capabilities: ±0.005 in. for the first in., ±0.002 in. on every inch thereafter; 0.002 to 0.004-in. layer resolution.

Pros: Much higher resolutions than additive processes; high-quality surface finish; parts similar to injection molded parts.

Cons: Part changes require a new cast.

Conclusion: The cast urethane

process is only as good as the prototype part made via some other process by which to cast the impression in the urethane. Obviously, from a micro view point, this might not be of any help even if it can reproduce high-resolution parts. You've got to have a part to make a part. We didn't attempt this process because it requires a first part.

Micromachining shapes stock materials like resin through processes such as CNC, micro, laser, or screw machining.

Capabilities: accurate to 0.00008 in.; repeatability 0.000008 in.

Pros: High resolution; wide material selection.

Cons: Slower process; expensive piece-parts; part details limited by cutting tool profiles.

Conclusion: From the micro viewpoint, machined plastic parts can work well. We also attempted laser machined parts but were told they could not be made with that method directly.

Rapid injection molding uses injection-mold tooling made from aluminum. Molds can be produced fairly quickly and make a good source for RP and low-volume production.

Capabilities: Relativity tight tolerances; good repeatability.

Pros: Inexpensive tooling, fast turnaround for tooling; can produce a fairly large volume of parts; produces actual injection molded parts; wide range of production materials.

Cons: Can be limited in feature or size capabilities; requires tooling; changes often require retooling.

Conclusion: This process can be a good alternative to standard hard tooling but not all rapid injection molders are set up to handle small parts.

Standard Micro-Mold hard tooling produces the exact same part as a full-production mold but speeds the process up while lowering its cost.

Capabilities: 2-micron tolerances; high repeatability.

Pros: High resolution; capable of high volumes; wide range of production material; produces actual production parts; supports insert molding; gives designers good manufacturing-process insight.

Cons: Slower process; can be more expensive; tooling required; changes often require retooling.

Conclusion: This is the best method to produce a part to spec, however, it's not technically a rapid process.

When all is said and done, each part to be micromolded should be evaluated individually to determine the best prototyping process. Every RP method has its place. **MD**