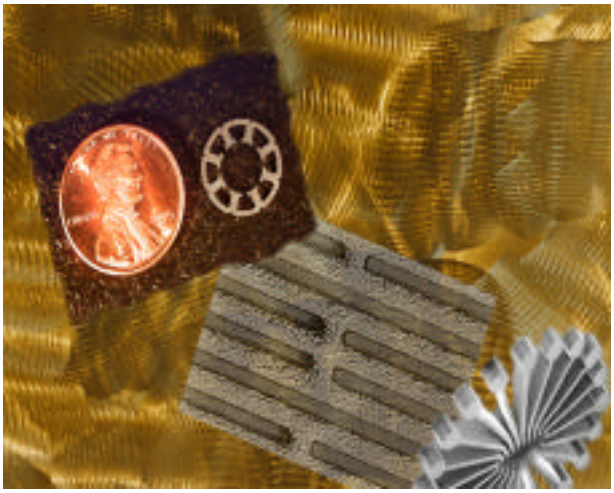
LIGA Micromachining

Fact Sheet

Plastic, Metal, and Ceramic Microparts



Sandia National Laboratories has developed a complete capability to produce metal microparts using the LIGA process, and has active R&D in the areas of plastic and ceramic replication.

LIGA is an acronym from the German words that mean Lithography, Electroplating, and Molding. It is ideally suited for making parts with depths significantly greater than nominal lateral dimensions, parts that require a particularly smooth or straight side wall, and parts from metals, metal alloys, plastics, or ceramics. In general, LIGA parts are in a size range between surface silicon micromachining and precision machining.

The LIGA process uses synchrotron radiation to create a pattern in an x-ray resist, usually polymethylmethacrylate (PMMA). The use of synchrotron radiation allows lateral feature sizes that are as small as a few microns in dimension, and straight and smooth vertical side walls that can be as tall as several millimeters.

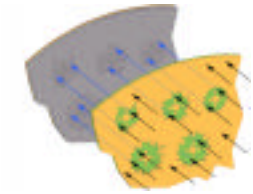
Once the PMMA is exposed, it is chemically developed and used as a mold for electroforming metal or metal alloys.

The electroformed LIGA mold can be used as a master mold to create plastic or ceramic microparts, or the metal parts can be the finished product.

Standard Metal Microparts

The standard Sandia process for making metal LIGA microparts includes the layout of CAD files for a three- or four-inch diameter mask. Once the mask layout is completed, a chrome mask is ordered from a commercial vendor.

This chrome mask is used to create a LIGA mask. Our typical LIGA mask is about 10-15 microns of gold patterned on a 100 micron silicon wafer. This mask and substrate are exposed to synchrotron radiation. Sandia operates, in conjunction with the West Coast LIGA Group, dedicated beamlines at both the Stanford Synchrotron Radiation Laboratory and the Advanced Light Source at Lawrence Berkeley National Laboratory. In addition, Sandia also occasionally uses the dedicated LIGA beamline provided by Brookhaven National Laboratory.



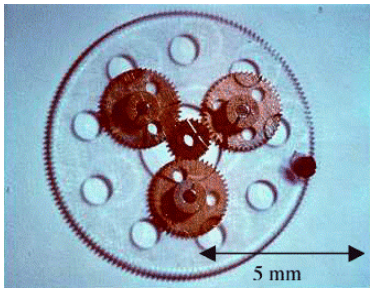
After synchrotron exposure, the PMMA resist is brought back to Sandia for chemical development, electroforming, and planarization. All process steps, except the initial chrome mask fabrication, are conducted by Sandia personnel.

Metals and metal alloys that have been electroformed in PMMA molds to date include nickel, copper, gold, nickel iron, nickel cobalt, and dispersion-strengthened nickel.

LIGA Micromachining

At the present time, our standard process allows nominal lateral feature sizes of about 10 microns, and heights up to 3 mm. The turn around time is approximately six weeks.

Plastic and Ceramic Replication



In an effort to provide a greater variety of material and design options, Sandia has an on-going R&D effort in plastic and ceramic replication. We currently have an operational hot embossing process which allows us to replicate LIGA or other micromolds in plastics such as PMMA, polycarbonate, polypropylene, polyolefin, and liquid crystal polymers. Our ceramic replication effort is focused on using nanoparticles in a polymeric matrix as the mold filling material. We have successfully made microparts from alumina and $MnFe_2O_4$ nanoparticles, allowing LIGA microparts to be used for high temperature applications or magnetic functions.

Process R&D

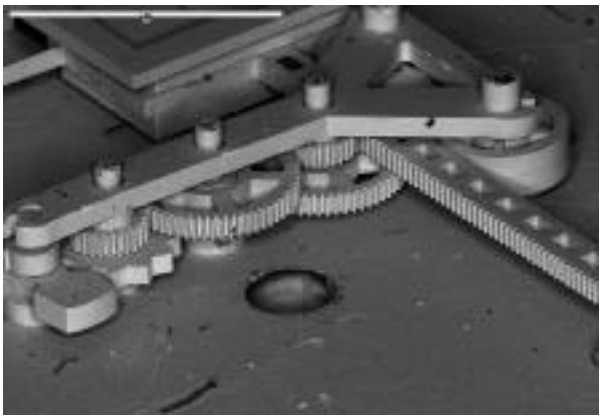
Sandia has an active program in improving the LIGA processes to allow higher quality, higher yield, and lower cost. We have developed coupled models of the synchrotron exposure and development steps that allow optimum mask design taking into account desired side wall tolerance. This modeling effort also allows process time optimization for the exposure and development steps.

Experimental studies to improve and more fundamentally understand the PMMA adhesion to the substrate, the development process including utilizing megasonic agitation, the electroforming process, and the planarization process are also underway. In addition we are exploring metrology techniques and characteristics of the finished product.

Accomplishments

Sandia's primary internal interest in LIGA is for small, rugged weapon components. We have designed and fabricated an 8 mm diameter by 3 mm thick electromagnetically -driven millimotor with a torque output goal of 1.5 milliNewton meters. Another Sandia LIGA design is aimed at developing a smart environmental sensing device that senses acceleration, opens up a light path and activates a LIGA fabricated gear train.

Sandia has also conducted LIGA processing for a number of commercial entities to fabricate a variety of microparts that require LIGA features such as sidewall smoothness, material options, or high



precision. In addition to the commercial partners, Sandia works closely with other national laboratories and universities on LIGA technology.

Status

Sandia is interested in continuing to be a leader in LIGA and LIGA-like micromachining technologies. We currently will work with interested parties to prototype hardware, as well as in a more complete design and process development role. We are also willing to license our process steps to help others interested in establishing LIGA capabilities get a quick start. Finally, we are establishing an intellectual property portfolio of exciting results available for licensing.

For more information contact:
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