LIGA process

The LIGA process was developed at the IMT (then Institute for Nuclear Engineering), in the early eighties under the leadership of Prof. Dr. E.W. Becker and Dr. W. Ehrfeld. LIGA is an acronym standing for the main steps of the process, i.e., deep X-ray lithography, electroforming, and plastic molding. These three steps make it possible to mass-produce microcomponents at a low-cost. They will be briefly characterized below.

Deep X-ray Lithography and Mask Technology

Deep X-ray lithography allows structures of any lateral design with high aspect ratios to be produced, i.e., with heights of up to 1 mm and a lateral resolution down to 0.2 µm.

The walls of these structures are smooth and parallel to each other. The very sophisticated structures of this type can be produced lithographically only by a highly penetrating, intense, and parallel X-radiation supplied by a synchrotron.

The structural information is compiled by means of a CAD system and then stored on a mask meeting the special requirements of hard X-radiation; the „transparent" carrier of the mask is a very thin metal foil (e.g. titanium, beryllium), while the absorbers consist of a comparatively thick layer of gold. Synchrotron radiation is used to transfer the lateral structural information into a plastics layer, normally polymethylmethacrylate (PMMA), by „shadowing". Exposure to radiation modifies the plastic material in such a way that it can be removed with a suitable solvent, leaving behind the structure of the unirradiated plastic (the „shadowed areas") as the primary structure. The development process and the ensuing electroforming process impose stringent requirements on the process technology because of the high aspect ratios and the resultant narrow, deep grooves in the structure.

Electroforming

The spaces generated by the removal of the irradiated plastic material can be filled with metal by electroforming processes. In this way, the negative pattern of the plastics structure is generated as a secondary structure out of metals, such as nickel, copper and gold, or alloys, such as nickel-cobalt and nickel-iron. This technique is used to produce microstructures for direct use, but also tools made of nickel and nickel alloys for plastics molding.

Plastics Molding

Plastics molding is the key to low-cost mass production by the LIGA process. The metal microstructures produced by deep X-ray lithography and electroforming are used as molding tools for the production of faithful replicas of the primary structure in large quantities and at low cost.

At the IMT, vacuum embossing of plastics is the main technique used to mold microstructures. Micro vacuum embossing has been advanced in important respects at the IMT and now represents an interesting alternative to injection molding for special applications.

The materials used in plastics molding range from thermoplastics with very special optical properties (plexiglass = PMMA, polycarbonate) to materials particularly resistant to chemicals (epoxy phenol resins, polyvinylidene fluoride (PVDF), and other fluoropolymers) to polymers of high temperature resistance (such as polysulfones, polyether ketones).

The embossing technique allows microstructures of metals or plastics to be made directly on top of the appropriate electronic evaluation circuit, i.e., to be integrated in a quasi-monolith without changing their electronic properties. The enormous advantage of this integration technique lies in the combination of the LIGA technique with silicon microelectronics as well as micromechanics in manufacturing industrial products. In this way,

microsystems can be produced which avoid, on the one hand, the drawbacks of inflexible monolithic integration and, on the other hand, the high costs of hybrid structures.