

Fabrication of Polymer-Based Microfluidic Devices using LIGA

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Polymers are rapidly evolving as the material of choice for various microfluidic devices due to several advantages associated with their use including, great diversity in material properties to suite a particular application, high flexibility in the choice of micromanufacturing process, low cost of the material and the low temperatures required for thermal assembly of the device. We have developed LIGA-based methods for constructing molding dies that can be used to fabricate polymer microfluidic devices using either hot embossing or injection molding. The LIGA process involves a photolithographic step to pattern the microstructures onto a plating base, electroplating raised structures on the plating base and finally, embossing or molding parts from these metal electroforms. LIGA lithographic patterning can be done with either X-rays or UV light, with the choice of light predicated on the size constraints associated with the microstructures. For example, X-ray LIGA can be used to fabricate parts with lateral dimensions down to 10 nm and aspect ratios exceeding 100:1, while UV LIGA can be used to pattern parts that have lateral dimensions of $\sim 5 \mu\text{m}$ and aspect ratios approaching 20:1. In Figure 1 is shown an array of microstructures filling a fluidic via that possess $5 \mu\text{m}$ lateral dimensions and are $50 \mu\text{m}$ tall (aspect ratio = 10:1).

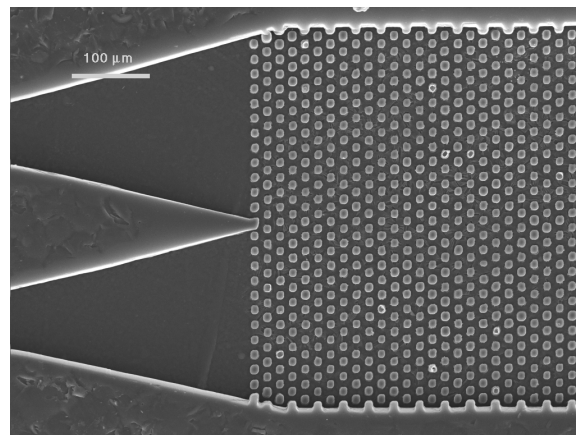
In this presentation, we will discuss the processing steps we have developed for producing molding dies using either X-ray or UV LIGA techniques and the microdevices that can be prepared from these techniques. The devices we will discuss include an electrophoretic unit with integrated contact conductivity detector, high surface area microreactors, and a continuous flow PCR device for amplifying nucleic acids. All of these devices were fabricated from either polycarbonate or poly(methylmethacrylate) (PMMA) that was hot embossed using a Ni electroform.

In the first application, a fluidic network of channels was embossed in PMMA for performing electrophoretic separation of polyanionic materials and detected using conductivity detection. An example of an electropherogram of proteins separated and detected using contact conductivity detection is shown in Figure 2. Our second example consists of microreactors that contain high aspect ratio microstructures to increase surface area to allow rapid conversion of targets enzymatically into desired products. In these examples, the reactors are solid-phase reactors, with the enzymes covalently linked to the polymer surface. In our final example, a fluidic via with a length of 2 m was fabricated (width = 50

μm ; depth = $150 \mu\text{m}$) to exponentially amplify nucleic acids using the polymerase chain reaction. In this case, the device was made in polycarbonate, due to its high T_g .

Figure 1. SEM of an array of microstructures embossed into a fluidic via. The substrate material is PMMA and the microstructures are $\sim 10 \mu\text{m}$ in width and $50 \mu\text{m}$ tall.

Figure 2. MEKC separation of a protein mixture in a PMMA microchip consisting of (2) lysozyme, (3) trypsin inhibitor, (4) carbonic anhydrase, (5) ovalbumin, (6) serum albumin, (7) phosphorylase B, (8) β -galactosidase, and (9) myosin detected using



indirect, contact conductivity detection. Benzoic acid (1) was added to the mixture as an internal standard.

