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Polymer MEMS: From Microbiodegradables to Microfilters to Microcombustors

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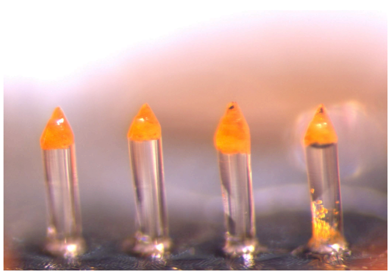
Introduction

Although micromachining and MEMS originated within the silicon and integrated circuit community, more recently as new and wider applications for MEMS have been forthcoming, new materials and fabrication technologies have been developed. IN particular, polymer MEMS have gained great popularity in the past several years. Specific advantages of polymer MEMS include potential for low cost, biocompatibility, light weight, and compatibility with many clean room / MEMS processes. The purpose of this paper is to introduce several wide-ranging topics within the polymer MEMS area, in order to illustrate the large potential for these materials within MEMS.

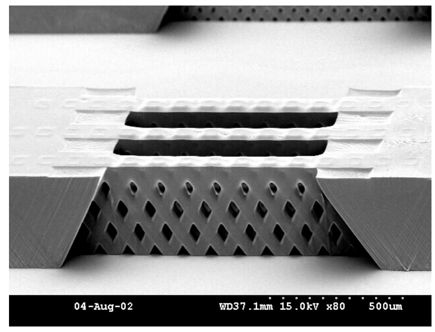
Biodegradable microstructures



A fabrication approach was developed for the production of micromachined biodegradable microstructures, and its application illustrated in two areas: biodegradable microneedles for transdermal drug delivery, and biodegradable ratcheting surgical ties for blood vessel surgery. We fabricated solid polymer microneedles out of polyglycolide, polylactide and their copolymer using a micromolding technique that created needles with beveled tips. Polymer microneedles (approximately 100 micron diameter) were strong enough to be inserted into cadaver skin without breaking. Polymer microneedles impregnated with both low- and high- molecular weight model compounds to simulate drug release were fabricated and inserted into full thickness cadaver skin. Quantitative measurement of model compound release as a function of time was obtained. The fabrication technology was also utilized to produce more mechanically complex biodegradable microstructures: cable ties for surgical ratcheting. These devices were successfully integrated with blood vessel tissue. The change in the mechanical properties of these devices under physiological conditions was investigated and shown to depend on the chemical and physical properties of polymer, implant temperature, and chemical environment.

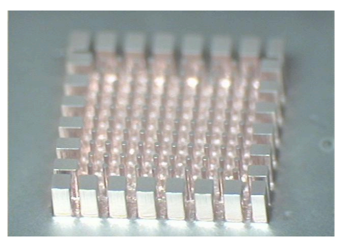
Micromachined polymer filters

Microfilters are essential parts of microanalysis systems, e.g., for cell sorting and sample injection filtering. Microfilters in combination with multiple analysis streams can also enhance mixing in low Reynolds number flow. A number of approaches to microfabricated filters



have been presented, including planar channels of varying dimension and three-dimensional projected structures such as pillars extending into the flow channels. In this work, a multidimensional, vertical screen filter system is developed in which structures analogous to the mesh of a window screen are extended vertically through the cross-sectional area of a flow channel. Vertical screen structures can be achieved using a single lithographic mask and without the need for stacking or lamination. This approach allows much finer mesh apertures over larger vertical heights than previous approaches. Filters are formed in the same fabrication step simultaneously with the fluidic channels themselves, thereby eliminating filter sealing issues, and the filter mesh size can be easily controlled by changing geometrical dimensions in the filter mask design. Screen heights of up to 400 microns with aperture sizes of 10 microns or less can be achieved in a simple, multiexposure fabrication approach.

Polymeric microcombustors



Recently, our group has become involved with a project in which the generation of relatively large impulses of force for short durations, with short total actuator lifetimes, is required. Micromachined polymeric combustors for conducting fuels are an ideal approach: the igniter/combustor fabrication is greatly simplified; over a large range of operation, the burn rate of fuel in the overall combustor can be decoupled from the chemical reaction rate by increasing or decreasing the volume density of igniters; and the combustor housing can be made of a low-temperature, low-cost material such as SU-8 epoxy, with integral conducting electrodes, since heat transfer from an external igniter is no longer required to initiate reaction. An array of high-aspect-ratio electrodes were patterned from SU-8 by multiple-exposure. The devices were filled with 3.97 mm^3 of conductive Glycidyl-Azide-Polymer (GAP). Nozzles with varying sizes are fitted on the microcombustors. Approximately 600mN was generated within 20ms.. The easy fabrication and low cost/weight of these microcombustors or gas generators lend themselves to disposable, one-use, or short duration applications.

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