A SU-8 Fluidic Microsystem for Biological Fluids Analysis

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Summary: *This paper describes a fluidic microsystem fabricated in SU-8 for suitable on-chip liquid handling and mixing. Its application is the concentration measurement of biomolecules in biological fluids. The SU-8 fabrication process is a low-cost process, biocompatible, UV lithography semiconductor compatible and not requires expensive masks. Moreover, SU-8 process allows deeps microchannels with very low roughness and suitable for optical absorption measurement.*

Keywords: *SU-8 techniques, fluidic microsystem, biomolecules analysis.*

1 Introduction

The disease prevention and treatment is often performed by optical absorption measurement of several biomolecules parameters in biological fluids, such as urine, blood, serum, plasma or cerebrospinal fluid [1]. The need for rapid and on-line measurement at low concentrations led to the development of biosystems with fluidic, detection and readout systems integrated in a single-chip. The advantage associated with shrinking clinical analyses systems include: improved efficiency with respect to sample size, automation, integration, laboratory safety, response times and costs [2].

The essential ability required for any practical fully integrated chemical analysis systems in a single-chip is to mix two or more fluids thoroughly and in a reasonable amount of time. In microscale fluidic systems the liquid flow is generally laminar, not turbulent. However, as the fabrication of microfluidic device is in planar lithographic design environment, the diffusion in narrow channels is practically the only process for mixing fluids.

In general, the fluidic microsystems are fabricated with HF acid etching techniques (complex, expensive, toxic and dangers) or using micromiller (not good for mass production, high-roughness surface). The SU-8 photoresist has excellent mechanical properties, allows to build deep channels up to 1 mm with very high aspect ratio (typically in order 1:20 and 1:25, but can be about 1:50), very low-roughness surface and good for optical absorption, excellent chemical resistance, very good biocompatibility, UV lithography semiconductor compatible and not requires expensive fabrication masks [3].

2 Model and design

The fluidic microsystem was simulated by a FEM CAD. The mixing process for a uric acid concentration of 40 mg/dl and a flow rate of 2.3 mm s^{-1} is shown in Fig. 1. The normal and abnormal range concentrations in human's urine are 27 mg/dl to 54 mg/dl and 17 mg/dl to 67 mg/dl, respectively. 9.5 µl of reagent enters the mixer by inlet 1 and 0.19 µl of urine sample by inlet 2.

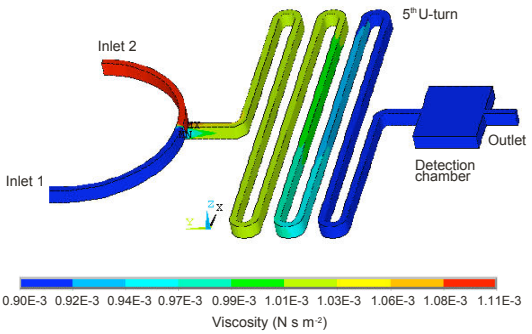

Fig. 1. Simulation flow of the diffusion mixing process for a 40 mg/dl of uric acid concentration in urine. The graphic displays the viscosity profile of the model.

The liquids were introduced at the inlets and fed through the mixer to the outlet. The liquid pressure in the outlet was kept at zero. Driven by the liquid pressure, liquids come across at the U-shape intersection. Incompletely mixed zones are seen in the mixer (Fig. 1). After the 5th U-turn the mixing is complete and homogeneous.

A perspective cross-section of the prototype integrated fluidic die is shown in Fig. 2. The liquids enter and exit the device through inlets and outlet holes drilled in the top glass wafer. The flow in the system is parallel to the glass substrate. The channels are fabricated using a layer of photoresist SU-8 deposited on the glass substrate, which give

the required rectangular deepness shape of the channels.

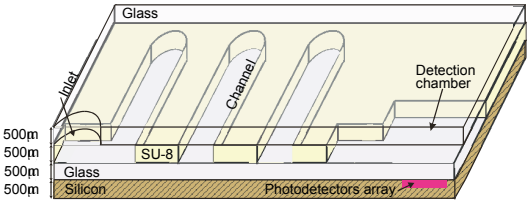

Fig 2. Perspective cross-section drawing of the prototype integrated fluidic die.

3 Fabrication Process

SU-8 is an epoxy based resin photoresiststst and is able to construct microstructures with high aspect ratio and smooth vertical sidewalls. It allows hard temperature process.

A standard lithography is used to develop the microchannels. A negative mask is obtained with a regular transparency foil. The mask layout is shown in Fig. 3.

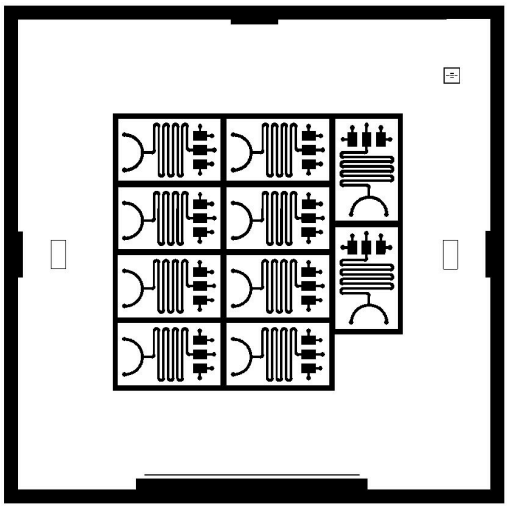

Fig. 3. The SU-8 negative mask for the fluidic microsystem.

The photoresist chosen was SU-8 100. The SU-8 was first spun on a glass substrate at 700 rpm during 100 s. The pre-expose bake was performed by soft bake at 90 ºC during 3000 s, the second spun was done at 700 rpm during 100 s and soft bake during 300 s at 50 ºC. Ramp up to 90 ºC, during 5400 s, and ramp down. The exposure was during 900 s on an Electronic Vision EV-420 mask and bonding aligner. Post-exposure bake during 300 s at 50 ºC. Ramp up to 90 ºC during 1200 s, and ramp down. The Development was during 2700 s in SU-8 developer.

The fluidic microsystem fabricated in SU-8 is shown in Fig. 4. Its deepness is 600 μm and the width is 500 μm.

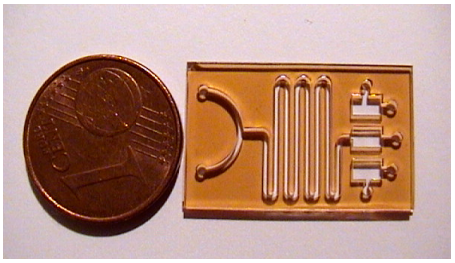

Fig. 4. A photograph of the fabricated SU-8 fluidic microsystem.

4 Experimental Results

The Fig. 5 presents the measurement transmittance for different total protein concentration done with a photodiode placed underneath of the fluidic microsystem.

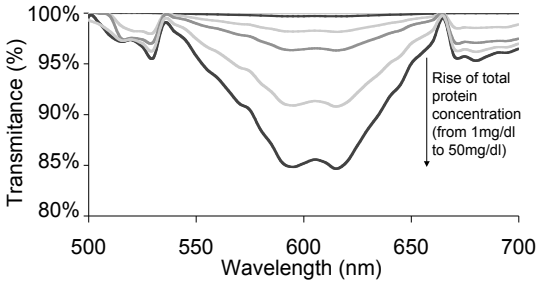

Fig. 5. Measured transmittance spectra for different total protein concentrations.

5 Conclusions

A fluidic microsystem fabricated in SU-8 suitable for measuring the concentration of biomolecules in biological fluids is presented. The SU-8 fabrication process is a low-cost process, biocompatible, UV lithography semiconductor compatible and not requires expensive fabrication masks. The use of SU-8 techniques in the fabrication of fluidic microsystem revealed a promises solution, comparing with other conventional techniques.

Acknowledgments

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References

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