Miniaturization of analytical devices has been an ongoing trend to improve the performance of analytical tools. Microdevices make many different types of analysis, including chromatography, electrophoresis, and DNA studies, possible. Such microdevices reduce sample consumption, cost, time to results, and also yield better performance and portability. Previously, these microdevices have been made of silicon and glass, but polymers have a few advantages and have become increasingly popular as an alternative material. The use of epoxy-polymer SU-8 has been studied for analytical microfluid applications. X-ray imagers and electrophoretic displays are examples of devices that can be made using SU-8. The lithographic process can be made simpler using SU-8 instead of silicon and glass. This process enables a high yield of microfluidic devices with a wide range of channel dimensions both laterally and cross-sectionally. SU-8 has been shown to be biocompatible. It is chemically stable, no background has been noticed from the material itself in analytical applications and it has been shown to be compatible with most chemicals applied in analytical applications. The transparency of the material enables optical detection as well. However, some fluorescence signal is emitted from SU-8 itself. Drawbacks of the material include a relatively high coefficient of thermal expansion (CTE) that may cause stresses to wafers if SU-8 is used with materials with widely different CTE values at elevated temperatures. However, the good patterning ability of SU-8 enables wafer-level batch fabrication of accurately defined microfluidic components.

In this project, we have fabricated microfluidic devices using SU-8 as an intermediate layer on Pyrex glass. The device will be tested with various flow patterns, such as shear and rotational flow, to transport and manipulate nanoparticles and biomolecules. Figure 1 shows the basic process flow of microfluidic channels on Pyrex glass and the layout of five cross microfluidic channels with electrodes. To increase the photolithography and bonding quality, Pyrex 7740 2 × 2 cm slides were cleaned by RCA1 cleaning. After that, the sample was patterned for electrode metallization by lift off. The microfluidic channels are formed in patterned SU-8. To seal the microfluidic channels, a very thin layer of SU-8 was spin coated on a 150 μm thickness cover slide. This cover slide had fluidic inlets fabricated by laser drilling. Finally, both glasses were bonded together to seal the channels using thermo-compressing at a certain temperature and pressure binding after UV flood exposure of the cover slide. Figure 2 shows the cross-sectional views of the microfluidic channels and reservoir after bonding. To test the bonding quality, water was loaded into the reservoir holes and channels. Figure 3 shows the optical micrographs of fabricated microfluidic channels before (a) and after (b) loading water.

Figure 1. Process flow of microfluidic channel device using SU-8 on Pyrex glass.

(a) Photosensitive coating and patterning on a Pyrex glass
(b) Ti/Au deposition and Liftoff
(c) SU-8 coating and patterning
(d) SU-8 coating on cover slide

(a) Bonding of microfluidic channels

(a) (b)

Figure 2. SEM images of cross-sectional view of reservoir holes and microfluidic channels.

(a) (b)

Figure 3. Comparison images of microfluidic channels before (a) and after (b) loading water.
microfluidic devices before and after the liquid was loaded.

The fabricated devices were used to manipulate charged particles in microfluidic channels under different electric field patterns applied externally. When an electric field is applied, the charged liquid in the electric double layer is displaced by the electric field, generating electro-osmotic flow. We use the COMSOL software to simulate the flow patterns under different biasing conditions. Figure 4 shows the electro-osmotic flow patterns of extensional (Figure 4a) and rotational flow (Figure 4b) of the center of a 5-cross channel device. A force is imposed on the positively charged solution close to the wall surfaces, and the fluid starts to flow in the direction of the electric field, generating extensional flow and rotational flow in the channel. After bonding the 5-cross microfluidic channel devices, the channels were filled with nanoparticles. Figure 5 (a) shows that the bonding was good enough to guide the nanoparticles to the channels without any leakage. Figure 5 (b) shows an optical image of 5-cross microfluidic channels with embedded electrodes. Currently, experiments are being performed to observe the expected flow patterns in the channels under different externally applied electric field patterns.

**Publications**


**Figure 4.** Simulation results of (a) extensional flow and (b) rotational flow.

**Figure 5.** (a) A fluorescent image of 5-cross microfluidic channels filled with 700 nm polystyrene particles; (b) an optical image of 5 cross microfluidic channels with embedded electrodes filled with DI water.