SU-8 Intermediate Layers Wafer Bonding for Microfluidic Devices Fabrication

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Abstract

Adhesive wafer bonding is a technique using a polymer layer as bonding layer. One particular material which currently raises a high interest is SU-8, an epoxy-based negative resist material. Due to its properties SU-8 is a serious candidate for microfluidic devices for medical applications. The use of SU-8 adhesive wafer bonding enables fabrication of fluidic reaction chambers with volumes from nanoliters to microliters range, as well as channels in the micrometers - tens of micrometers size range.

Introduction

EC funded project OPTOLABCARD aims to develop an innovative instrument able to carry automatically microbiological health hazard control by Retro Transcriptase Polymerase Chain Reaction (PCR), from sample preparation to optical detection. This instrument will consist of a handheld base unit and a disposable cartridge (labcard). The labcard will be made on a plastic substrate and microfluidic channels will be made out of SU-8 resist. The base unit contains all electronics and optical components needed for analysis.

The microfluidic device consists of few process chambers linked through a microchannels network containing bifurcations and crossways, so an accurate and reliable fabrication process is required for fabrication. This novel fabrication process is based on successive bonding and releasing steps that allow us to stack several patterned SU-8 layers. The uniformity and cross linking level of the SU8 in the photolithography process have been optimized to obtain a strong bond.

Since some biological compounds are very sensitive to temperature, it is necessary to achieve a low temperature bonding process. For example, DNA probes do not stand temperatures higher than 50°C. Therefore, if reagents need to be stored or immobilized in reservoirs, and then sealed by bonding, a low temperature bonding process is required.

Results and Discussion

Two types of processes were considered for SU-8 wafer bonding: direct (thermo-compression) bonding of SU-8 and plasma activated wafer bonding. Up to the current stage of the project the main process was thermo-compression bonding.

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One of the reasons for choosing SU-8 for fabricating the micro-channels structure is the ability to pattern directly the material by photolithography. However, due to the high accuracy of the pattern specific process conditions were applied.

Figure 1 shows the stack setup used for bond process characterization. The stack consists of a base wafer that has SU-8 structures (fully cured, 50-100µm high). The lid wafer is coated with a thin (2 - 4µm) SU-8 layer which was not exposed and cured (layer is not crosslinked). As glass transition temperature (T_g) of non-cured SU-8 is 55°C, wafer bonding process rely on the reflow of the not crosslinked SU-8 layer for bonding.

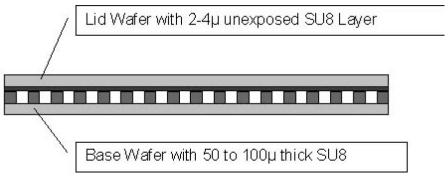

Figure 1. Test bonding setup for SU-8 wafer bonding.

The process conditions for bonding were: temperature – 50°C, contact force – 30kN (wafer size – 100mm). After bonding the non-cured SU-8 layer was UV exposed through the glass lid wafer. Bond strength achieved was very high: after mechanical separation of the two bonded wafers SU-8 pattern was found on both wafers, showing separation occurred exclusively due to SU-8 cracking.
An important process step subject to optimization is SU-8 patterning prior to bonding. By standard puddle developing an SU-8 thickness of 250µm require a development time of about 20 minutes. Such process times are a major concern when considering high volume manufacturability of such devices at low cost.
One method considered for improving SU-8 patterning is megasonic-enhanced development using a megasonic area transducer (schematical setup shown in fgure 2).

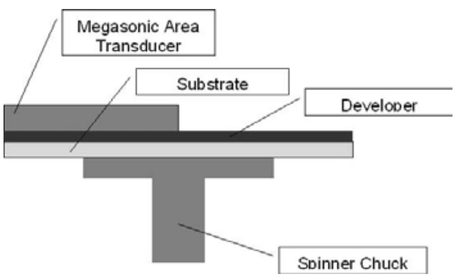

Figure 2. Schematical drawing showing the development setup based on megasonic area transducer.

Developer fluid dispensed on SU-8 layer forms a meniscus between SU-8 surface and transducer acting as coupling media for the acoustic waves. The megasonic energy transferred to SU-8 is expected to accelerate the development rate of the SU-8.
Preliminary tests shown an important decrease of process time: for the SU-8 thickness mentioned above the development time decreased from 20min to about 6min.
Megasonic development is still under evaluation, major improvements are expected not only in reducing development time for large structures but also an improvement of small size high aspect ratio features fabricated in SU-8.

Conclusions

SU-8 became during last years a very interesting material for disposable microfluidic devices with medical applications.
This work reports results in SU-8 patterning and wafer bonding for a lab card application.

Acknowledgements

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