PDMS BASED NEGATIVE PHOTORESIST FOR MICROFLUIDIC APPLICATIONS

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ABSTRACT

We report on the development of a simple formulation of polydimethylsiloxane (PDMS) based material used as negative photo resist for microsystems and microfluidic applications. The method to covalently link PDMS to silicon wafers is detailed together with the lithographic process and the mechanical properties after cross-linking.

KEYWORD: PDMS, Photolithography, Actuator.

INTRODUCTION

In the literature, Sylgard 184 is the material most often used to design silicone devices. Because of its chemistry, it cannot be photopatterned directly. Papautsky has described last year a method to inhibit the crosslinking process under an irradiated zone [1]. However, this method is very sensitive to changes in process parameters such as temperature. Therefore, it is hardly reproducible. Dow Corning sells PDMS that can be photopatterned but only after several steps and for thicknesses between 6 and 50µm [2]. Depending on the application, this range is not large enough. Other authors have presented non commercial polysiloxanes that are UV-sensitive, but these imply specific syntheses [3]. Finally, the closest method compared to ours is the one developed by Lötters, but he had to carry out the crosslinking in the absence of oxygen and did not present any detailed characterization of the polymer [4,5].

EXPERIMENTAL

SiO_2 surface of a silicon wafer was first treated by O_2 plasma. An acrylate bearing alkoxysilane was then reacted. In a second step, a mixture containing RMS-083 (Figure 1) as the polymer and Irgacure 2100 as the photoinitiator (2% w/w) was spin-coated and photopatterned to obtain thicknesses from 30 to 300µm.

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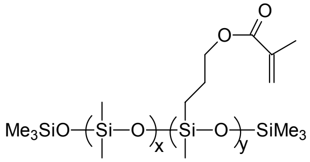

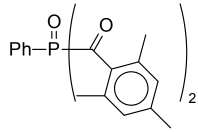

RMS 083

y/(x+y)=0.07-0.09

Irgacure 2100

Figure 1: Structures of the molecules used

Irradiation time varied from 2 to 15 minutes, depending on the machine used (EVG 620, MA6, irradiation at 365nm) and the thickness wanted. No adjustment of the machine was necessary and no purge of the system was carried out before irradiation.

Development was performed in hexane or methylisobutylketone (MIBK). Patterns as large as 500µm or as small as 3 microns could be obtained very easily (figure 2).

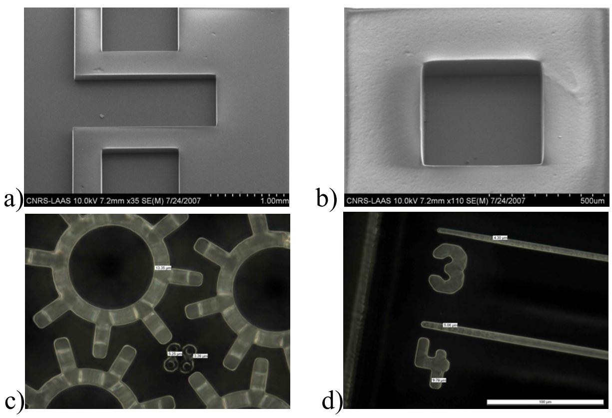

Figure 2: Patterns of RMS083. a) square cavities (1mmx1mmx125µm). b) square cavity (500µmx500µmx70µm). c) notched wheels (internal diameter: 85µm, circle width 13µm, thickness 27µm). d) lines of 3 and 4 µm

RESULTS AND DISCUSSION

To enhance polymer adhesion during photolithography, the SiO_2 surface of a silicon wafer was first functionalized with an alkoysilane bearing acrylate function and was successfully characterized by XPS and contact angles measurement. The RMS 083 was spin coated and photopatterned by photolithographic process, and was therefore anchored covalently on the wafer by the acrylate function of the RMS 083.

This material has been used in the elaboration of two different systems. First, it has been incorporated in a microactuator where cavities of 500µm were needed to encapsulate an energetic material RMS083 constituted the wall of the cavities. These were sealed by applying a PDMS membrane (figure 3). Secondly, the polymer has been assessed in the elaboration of microfluidics channels in non drastic conditions.

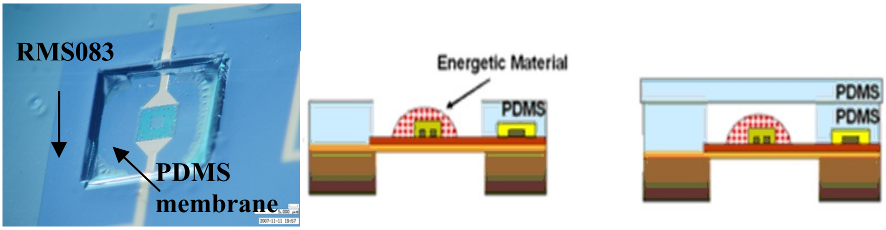

Figure 3: Schematic drawing of the microactuator and picture of the final device

The mechanical properties of the cured PDMS based material were assessed by piezorheometry which has the advantage of being the only technique specifically designed for thin films characterization. The results obtained on a 100 µm thickness sample showed that the material is gel-like with a Young's modulus of 0.45 MPa (assuming E = 3G'), which is slightly lower than Sylgard's which is usually described around 2MPa.

CONCLUSIONS

RMS 83 proved to be a very interesting PDMS for photopatterning as very good resolutions were obtained, and micro-actuator devices could be easily made. But it is crucial that the wafer surface is correctly functionalized with the adequate chemical function.

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REFERENCES

[1] "Photodefinable polydimethylsiloxane (PDMS) for rapid lab-on-a-chip prototyping " A.A.S. Bhagat, P. Jothimuthu, I. Papautsky, Lab. chip., **9**, 1192 (2007).
[2] http://www.dowcorning.com/content/etronics/etronicspattern/etronicspattern_photoov.asp.
[3] "A photocurable poly(dimethylsiloxane) chemistry designed for soft lithographic molding and printing in the nanometer range" K.M. Choi, J.A. Rogers, J. Am. Chem. Soc., **125**, 4060 (2003)
[4] "The mechanical properties of the rubber elastic polymer polydimethylsiloxane for sensor applications" J.C. Lötters, W. Olthuis, P.H. Veltink, P. Bergveld, J. Micromech. Microeng., **7**, 145 (1997)
[5] "Polydimethylsiloxane, a photocurable rubber elastic polymer used as spring material in micromechanical sensors, J.C. Lötters, W. Olthuis, P.H. Veltink, P. Bergveld, Microsystem Tech., 64 (1997).