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PDMS laser Thermal Processing for Fabrication of 3D micro structure

Mohammadreza Riahi[a*], Atefeh Ghaffari[a], Fatemeh Karimi[a]

[a]*Physics department, K.N.Toosi University of technology, Tehran,1541849611, Iran*

Abstract

In this article 3D printing of structures with a new method called selective laser baking (SLB) of PDMS is presented. PDMS Base is mixed with its hardener and poured into a container. Before it is hardened which occurs after several hours, a CO2 laser selectively exposes different areas on the surface of the PDMS mixture according to the pattern of a slice of a 3D model designed on the computer. Once exposed, PDMS heats up and hardens, producing a cured layer of PDMS which is attached to a base. The base lowers in the container and a new layer of uncured PDMS is spread it. The laser exposes new areas again and hardens them. This process is repeated until the whole structure is fabricated.

Keywords: CO2 laser; 3D printing ; PDMS; Baking.

1. INTRODUCTION

Poly Dimethyl Siloxane (PDMS) is a material which has a wide variety of applications specially in micro technology e.g. microfluidics (Friend. et al. 2010, Jessamine et al. 2002) Transparency, gas permeability and moldability in micro scale are the most important specifications of this material. Molding from a lithographic pattern is the most conventional technique for fabrication of PDMS structures (Cheuk- Wing Li et al. 2003, Fainman et al. 2009, Urbanski et al. 2006).

In some cases 3D structure of a micro structure device is necessary to be fabricated with PDMS. For this reason, such parts need to be 3D printed. Unfortunately direct 3D printing with PDMS is not possible except for some limited methods. For example direct material extrusion technique has been performed for fabrication of support free structures with PDMS. Adding photosensitive materials to PDMS has also been

* Corresponding author. Tel.: +98-912-4901508; fax: +98-21-23064218.
E-mail address: mr_riahidehkordi@kntu.ac.ir.

performed to make a photo-paternable PDMS for 3D printing with DLP and SLA techniques. A review on PDMS 3D printing is also published earlier (Huang et al 2017).

2. Materials and Methods

2.1. Curing of PDMD by baking

If PDMS is baked, the curing procedure speeds up. To investigate this, three mixtures of PDMS with it's hardener was prepared and put in an oven and baked in different temperatures. Fig. 1 shows the diagram of curing time versus baking temperature. As shown in this figure, by increasing the temperature, the curing time decreases

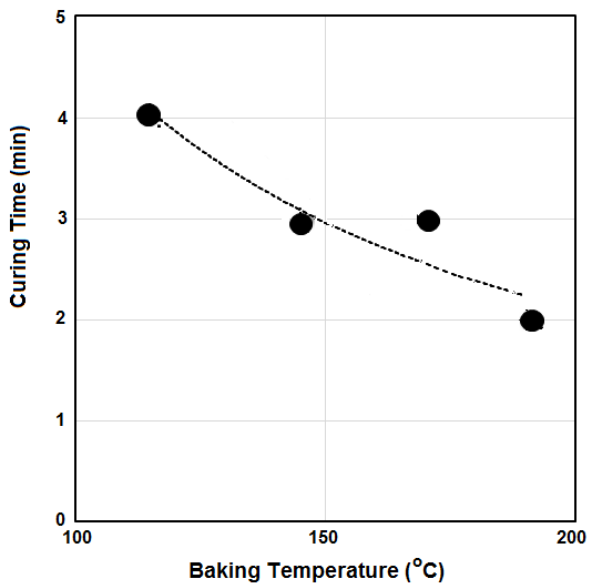

Fig. 1. Dependence of the curing time of three mixtures of PDMS to temperature. To prepare PDMS, raw PDMS was mix with hardener in 10:1 ratio

2.2. 3D printing with SLB

To 3D print a part, PDMS portion is prepared. But before it is hardened in a few hours, as shown in figure 2, a CO2 laser emission exposes desired locations on the surface of the mixture according to the pattern of the model which has been designed and sliced in computer. Absorption of the laser, heats up the exposed area. Increasing the temperature, accelerates the curing procedure and cause the PDMS mixture to be cured and hardened immediately. After this process, a new layer of PDMS mixture is deposited on the surface of the previous cured layer. The CO2 laser, again selectively exposes this new layer according to the second slice of the model. The exposed area is cured again and attaches to the previous layer. This process is repeated until the 3D whole model is fabricated.

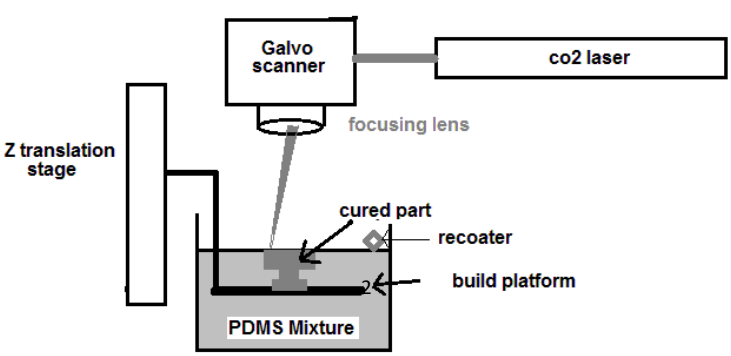

Fig. 2. 3D printing setup for Selective Laser Baking (SLB) technique

Figure 3 also shows a printed part with SLB 3D printing technique.

Fig. 3. 3D printed part with Selective Laser Baking (SLB) technique.

2.3. Resolution of the printing

The resolution of the 3D printing technique depends on the spot size of the laser beam on PDMS surface. In our experiment a ZnSe lens with 60mm focal length was used. The beam waste of the laser was also 5mm. in with this focusing optics, resolution of 260 micrometer was achieved. Figure 4 shows a micro channel printed by this technique

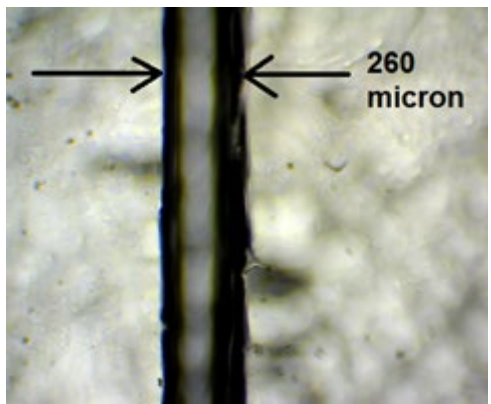

Fig. 4. 3D printed part with Selective Laser Baking (SLB) technique.

3. discussion and conclusion

A new 3D printing technique called Selective Laser Baking (SLB) was presented in this article for the 3D printing of PDMS structures. PDMS is mixed with its hardener and is exposed to a CO2 laser before it is cured by itself. The thermal effect of the CO2 laser increases the temperature and cures the exposed area. PDMS mixture was introduced layer by layer and selectively cured by CO2 laser exposure.
A minimum feature size of 260 micrometer was achieved in this experiment. Better resolutions can be achieved with better focusing optics. Resolutions down to the wavelength of the laser are theoretically possible.

In addition to PDMS, every two part polymer which can be accelerated by temperature can be used for 3D printing with this technique. Polymers with thermal polymerization procedures can also be 3D printed with this technique.

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