JNRID || ISSN 2984-8687 || © October 2025, Volume 3, Issue 10

Alternative Method For Manufacturing Microchannels With A PDMS-Sio2 Structure.

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Abstract - Multiple methods and techniques currently exist for fabricating microchannels using polydimethylsiloxane (PDMS). The most commonly used method for manufacturing microchannels is known as soft lithography. This method involves transferring a pattern or design with an engraved relief from one material to another surface. However, these casting dishes or trays present some cost problems. This paper presents a combination of techniques for obtaining microchannels with PDMS by using a hollow plastic plate with tape around the bottom. This method facilitates the separation of PDMS microchannels cured with the master mold, reducing PDMS consumption.

Index Terms - Polydimethylsiloxane (PDMS), Reactive Ion Etching (RIE).

I. INTRODUCTION

In recent years, great advances have been made in the manufacture of structures and devices with micrometric dimensions, such as micro-actuators, micro-sensors, laser sources, photodetectors, optical switches, and optical waveguides. Its applications have spread to different areas such as Chemical and Biological Sciences, and now it is possible to manufacture and implement devices capable of controlling and modifying its properties almost in real time by means of fluids [1, 2]. Today, systems known as Lab on a Chip have emerged. This term refers to the development of systems with integrated components and devices on a micrometer and nanometer scale (micro/nanobiosensors, micro actuators, microfluids, microchannels, etc.). For example, integrated devices that use microchannels with PDMS have the advantage and ease of changing their optical properties by simply replacing one optofluid with another, in addition to being able to modify the shape of the device to improve its functionality.

In this context, PDMS is the most commonly used material in the manufacture of optofluidic devices, as it allows complex microchannel structures to be obtained. The microchannels are developed by using a “master mold” as the basis for multiple replicas of the same device. Sealing PDMS technique with other materials usually employs the oxygen plasma and soft lithography, especially for rapid prototyping and manufacturing devices that allows economic. In order to make chips or any other device with PDMS, usually pours an un-cured PDMS mixture onto a Petri dish or an aluminum foil tray containing the patterned master (or a silicon wafer with microchannels), and then cures for 2 hours at 95°C. A relatively high consumption of PDMS is often required for these molds, as a considerable amount of PDMS will leak into the space between the wafer and the Petri dishes due to capillary forces during PDMS pouring. In addition, PDMS leakage under the wafer can cause it to tilt, resulting in variations in the thickness of the PDMS mold from one side to the other. Furthermore, these molds are generally disposable supports for containing the PDMS, which increases the cost of manufacturing the microchannels. For these reasons, this document proposes the use of a combination of methods described in [1, 4] to reduce manufacturing costs, using a hollow plastic plate with a tape surrounding its lower edge.

II. MASTER MOLD

The first step is to obtain a master mold using soft lithography [1, 2], as shown in figure 1, (a) spin coating a silicon wafer with SU-8 photoresist, (b) UV exposure with a clear field mask, (c) development of SU-8 master mold. The master mold (d) is checked with a microscope (e) and the thickness is checked on the profiler in different sections (f).

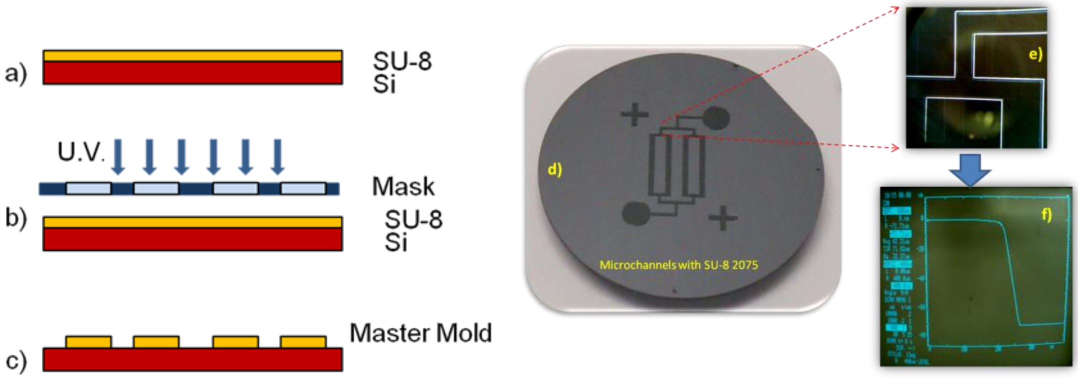


Figure 1. - A layer of SU-8 2075 (MicroChem Corp.) with the thickness of 70 µm was spin-coated and patterned.

III. PDMS PREPARATION

Mix the PDMS according to the manufacturer's instructions (fig. 2.a). The bottom opening of the hollow plate is sealed with adhesive tape to provide a support for the mixed PDMS, whose diameter must be larger than that of the master wafer. Place the master mold in the holder, and, carefully, apply a pressure to attach it to the tape, preventing any gaps from forming at the interface (fig. 2.b). PDMS (Dow Corning Corp., Sylgard polymer base: curing agent = 10:1) was poured into the SU-8 mold and cured at 80°C for a time of 1 hour 30 minutes (fig. 2.c). Once the master mold with SU-8 and the microchannels with PDMS (Fig. 2.d) are ready, they are separated from the mold, the PDMS is cut so that it can be aligned with the glass sample, and a hole for the metal connector is drilled, through which the device fluids will be introduced. The next step is to fabricate the microchannels with PDMS and seal them with a glass plate or a wafer coated with silicon oxide.

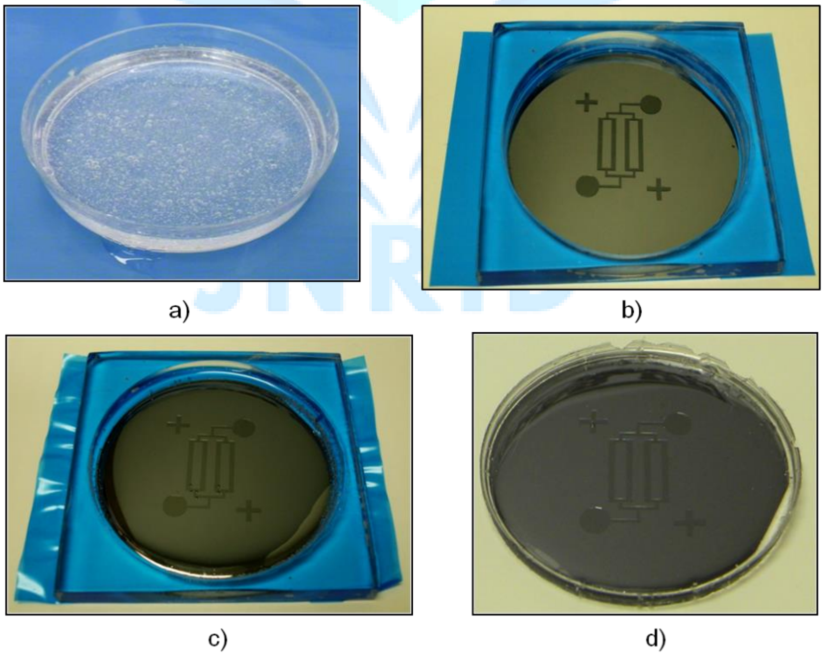


Figure 2. - Method for obtaining the mold for microchannels with PDMS.

IV. MICROCHANNEL SEALING

After removing the PDMS excess, the material to be sealed (glass, SiO_2 or PDMS) is placed in a RIE (reactive ion etching) chamber. The RIE process consists of a cylindrical vacuum chamber controlled by computer, whose base is electrically isolated from the rest of the team, and with which it is possible to apply an oxygen plasma. The plasma is generated by a magnetic field oscillating at a frequency of between 13 and 14 megahertz. Following the procedures for opening the RIE chamber due to vacuum loss, the materials are removed, taking care not to contaminate the exposed surfaces. The samples to be sealed are aligned and pressed together, PDMS with glass or PDMS with the SiO_2 wafer.

The samples are now taken and placed in a press to apply a weight of approximately 1.235 kg. from 12 to 15 minutes on a hot plate at 95 °C (fig. 3), after this time, the microchannels are removed from the press and left to cool at room temperature. From the moment the microchannels are separated from the master mold until we join them after plasma treatment, there is a maximum time limit of 10 minutes. Once this time has elapsed, the PDMS will not seal properly and, in principle, only one chance will be available.

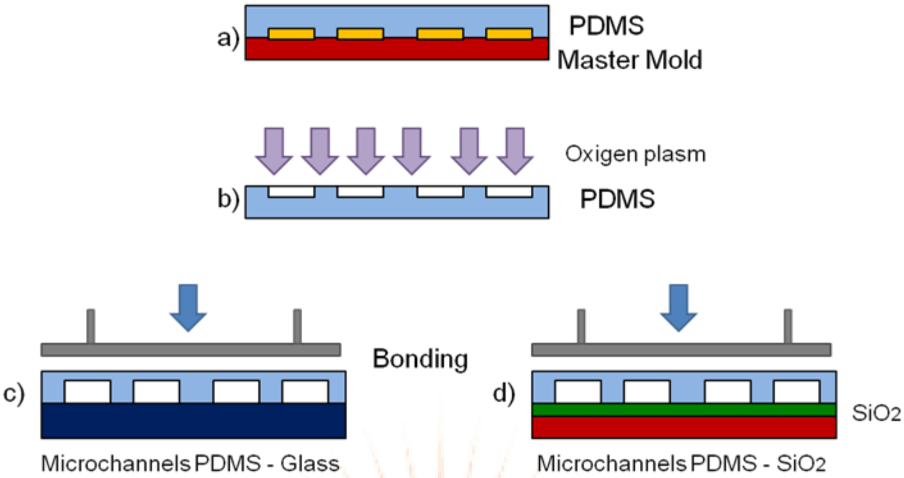


Figure 3. - Fabrication of microchannels (a) Pouring PDMS on the mold, peeling off the PDMS part, (b) surface treatment of PDMS in oxygen plasma, (c) bonding PDMS with glass and (d) bonding PDMS with SiO_2 wafer.

If the tests are successful, proceed to attach and seal the connectors with hoses to finally obtain the microchannels (fig. 4). With this method, we tested microchannels sealing glass and PDMS, and PDMS with a silicon wafer, which had been deposited SiO_2, achieving a reduction in manufacturing time and curing temperature as well as better adhesion and PDMS sealing with the wafer. PDMS (Dow Corning Corp., Sylgard polymer base: curing agent = 10:1) was poured into the SU-8 mold and cured at 80°C for a time of 1 hour 30 minutes. In addition, this technique can be used to manufacture different devices, such as phantoms and microfluidic channels, for example. Phantoms that simulate the optical characteristics of tissues and are used to mimic the distribution of light in living tissues for biomedical applications [3].

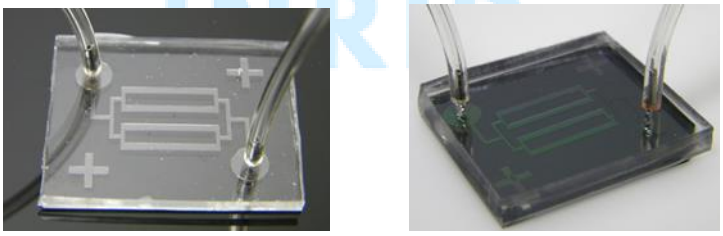
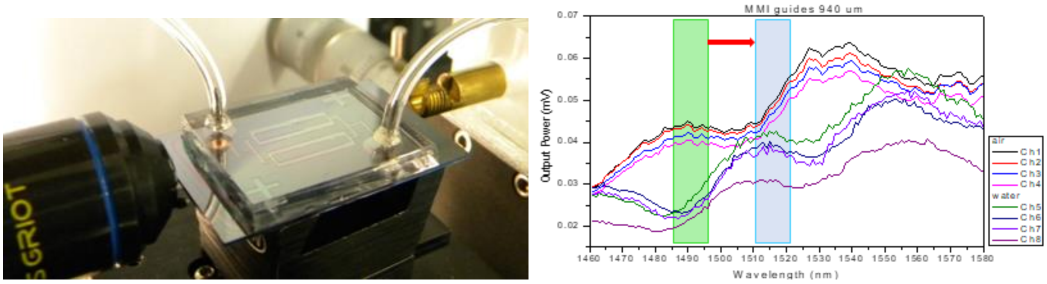

a) b)

Figure 4. – a) Obtaining microchannels with PDMS-glass and b) PDMS-SiO2.

Figure 5 shows a device manufactured using this technique [4], in which there is a device with an array of sensors whose sensing mechanism is based on multimode interference (MMI). This device is relatively simple and inexpensive, but very sensitive to small changes in the refractive index. This demonstrates its potential for label-free biochemical sensors. Depending on the response of the MMI sensor, we can make the sensor to detect changes in wavelength.



a) b)

Figure 5. – a) PDMS-SiO2 microchannels, b) Comparison of spectral responses of integrated MMI sensors with microchannels.

V. CONCLUSIONS

An alternative method for obtaining and sealing the microchannels is described in sections II, III, and IV. A technique was also used whereby a thin layer of PDMS was removed using RIE to reactivate the PDMS surface and provide multiple opportunities to correctly bond the microchannels to the glass or SiO2 wafer. Additionally [4], connectors and flexible hoses were installed to verify the seal and introduce test fluids, obtaining a permanent seal.

VI. ACKNOWLEDGMENTS

To CONAHCYT and the National Institute of Astrophysics, Optics, and Electronics (INAOE) for the resources provided to develop this work. To Professors Daniel May Arrioja and Javier Sánchez Mondragón for their excellent advice.

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