Versatile technique for polydimethylsiloxane (PDMS) microchannels bonding on plastic and metal

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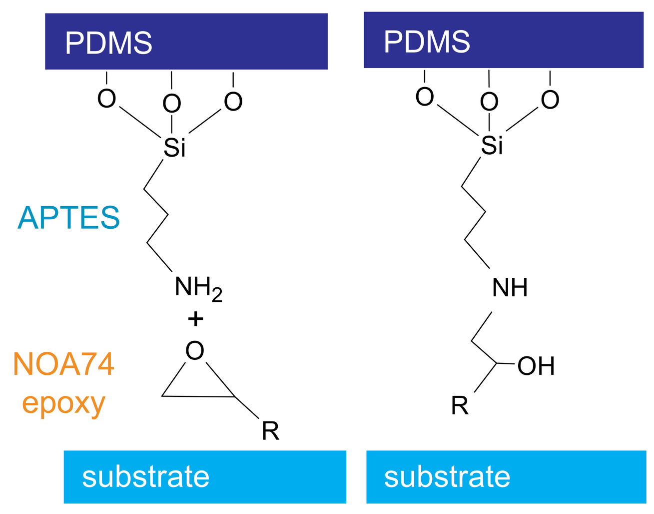
1. PDMS sealing for lab-on-chips

Lab on chips (LOCs) are devices which embed and automatize on a small chip surface (mm^2-cm^2) many operations that are usually performed by trained personnel in specialized facilities. These operations include adding/mixing reagents, manipulating biological materials, performing analyses [1]. It is, therefore, crucial to achieve a proper sealing of the microfluidic components, in order to allow injection and routing of liquids, avoid contamination and protect the surface during device operation. To this end, polydimethylsiloxane (PDMS) is ubiquitously used, owing to its low cost, easy and fast fabrication, and optical transparency [2]. However, permanent PDMS bonding on different substrates is not trivial, owing to the low energy of the PDMS surface. To date, a reliable process for PDMS bonding on various substrates is still lacking.

Here, we present a versatile technique for PDMS microchannels bonding on plastic and metal surfaces. By functionalizing the PDMS surface with (3-aminopropyl) triethoxysilane (APTES) a covalent bonding can be established with the epoxy groups of the commercial NOA74 UV-curing glue (Norland Optical Adhesive, Norland Products). This process allows the tight sealing of PDMS on several substrates.

2. Our idea: epoxy glue and APTES

NOA74 is a **UV-curable epoxy glue** which is transparent, it has low viscosity (~ 90 cps) and excellent adhesion to metal, plastic and glass. It can, therefore, provide a **strong bonding with several substrates**. However, the PDMS surface is not wetted by this glue. Thus, a direct bonding of the bare PDMS surface with NOA74 is not feasible.



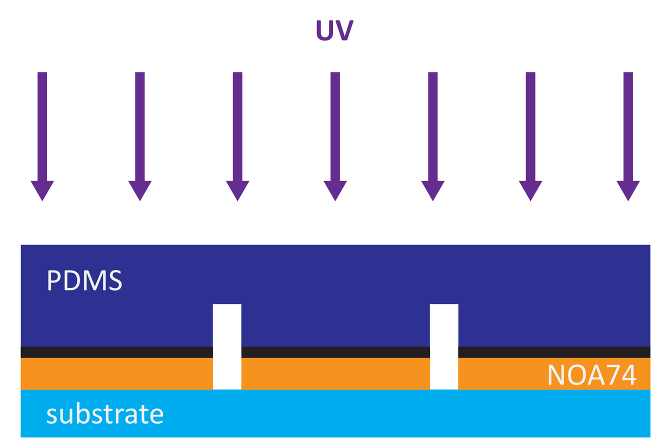
1. substrate cleaning

2. PDMS functionalization with APTES

3. NOA74 spinning on glass

4. PDMS wetting with NOA74

5. PDMS-substrate contact and UV curing



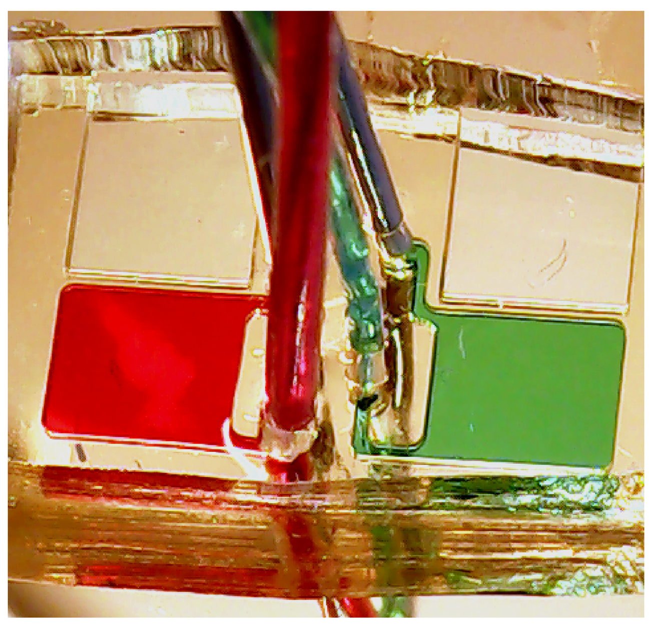
In order to create a strong bonding between NOA74 and the PDMS surface we functionalized the **PDMS with APTES**, providing amine groups which will further crosslink with the NOA74 epoxy groups [3]. As a result of the **APTES-epoxy crosslink**, a strong bonding is achieved between the PDMS and various substrates.

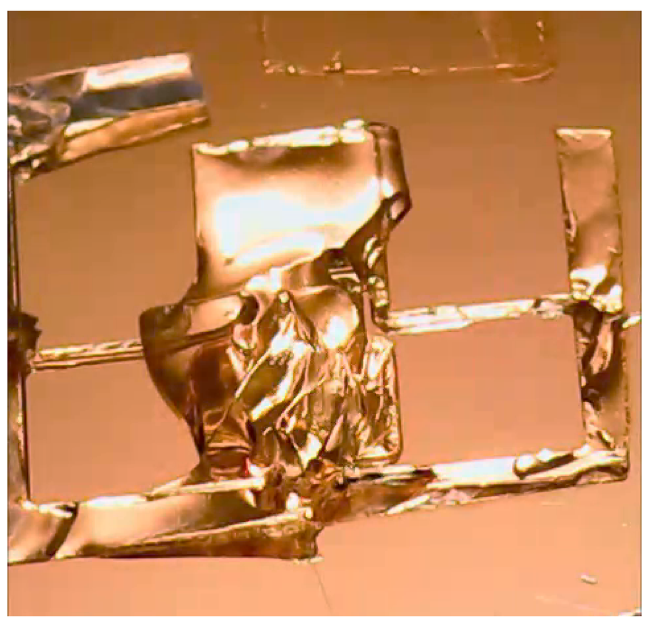
The process starts with the substrate cleaning. Then, PDMS is functionalized with APTES (1% APTES in water, 20 min at room temperature) after a plasma oxygen activation of the PDMS (25 W, 1 min). Next, NOA74 is spun on a glass slide (2000 rpm, 1 min) in order to create a thin and flat layer for the PDMS wetting (5 s). As last, PDMS and substrate are put in contact and the glue is cured under an optical lithography UV-lamp (20 mW/cm², 1.5 h).

3. Leakage test and process characterization

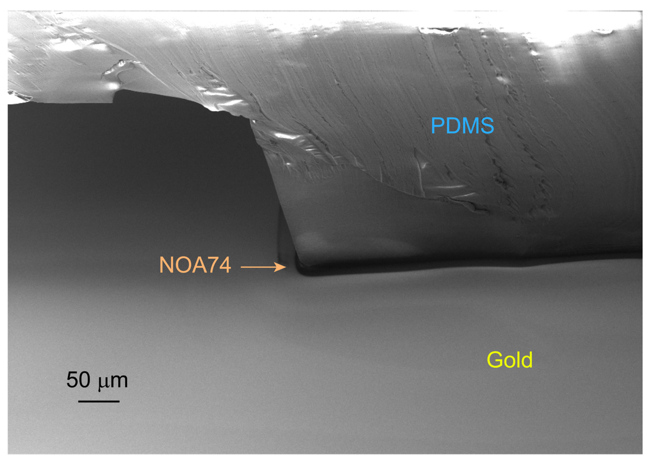
Leakage tests have been performed by injecting dyes into the bonded PDMS microfluidic network. The microchambers (3 mm side, 350 μm thick) are separated by a 300 μm wide wall, and connected to the inlets/outlets by a 300 μm wide microchannel.

A FLUIGENT® MFCS pressure pump has been used to route the fluid through the microfluidic network. Pressures from **10 mbar to 70 mbar** have been exploited for fluid routing, showing **no leakage** evidence.





In order to test the bonding strength, nitrogen has been fluxed into the microfluidic network with pressures from **500 mbar up to 2 bars. No evidence of leakages or microchannels damages have been observed.** The microfluidic network could be removed only by ripping it apart by hands. In the electron micrograph a thin NOA74 layer is seen at the interface between the PDMS and gold surfaces. **Several substrates have been tested** (listed below) all giving qualitatively the same results.



List of tested substrates

gold
glass
poly(methyl methacrylate) (PMMA)
polystyrene (PS)
polyethylene terephthalate (PET)
cyclic olefin copolymer (COC)

4. Conclusions

Here, we have presented a versatile technique for PDMS microchannels bonding on plastic and metal surfaces. This process involves the use of a UV-curable epoxy glue (NOA74) for the creation of a strong and stable bonding between PDMS and the substrate. The PDMS microchannel is functionalized with APTES after plasma O_2 activation, to create a covalent bonding with the epoxy groups of the glue, therefore providing an irreversible sealing of the device. Leakage tests are performed with dyes showing no leakage as well as no channel clogging. Pressure can be applied up to 2 bars without any separation of the bound surfaces. Several substrates have been tested all giving qualitatively the same results. As a remark, a plasma O2 treatment of the substrate is preferable but not required, allowing a strong sealing even in cases where such a surface treatment is not feasible (*e.g.*, functionalized surfaces, plasma-sensitive substrates). The versatility of this technique, along with its low complexity, makes it appealing for a great variety of applications in developing LOCs, allowing an unprecedented capability of bonding PDMS with gold surfaces.

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NeuroSens group site
web.nano.cnr.it/neurosens

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