FLEXIBLE MICROFLUIDICS - A NEW APPROACH TO WEARABLE DEVICES

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Abstract: *Flexible microfluidic devices have emerged as an important field of research due to its operation potentialities not achieved by traditional rigid microfluidics. The sensing relies not only on its detection ability but also on the capacity of the microdevice to adapt to surface changes promoted by the motion. In this work we describe the construction and tests of a flexible device for hydrodynamic focalization. A Silicon (Si) substrate covered with SU-8 thick film submitted to lithograph by laser was used as mold for the generation of the channels. A custom made plasma jet equipment was use for bonding two PDMS (polydimethylsiloxane) structures (3 mm thickness PDMS generated by traditional molding and a commercial PDMS film with thickness of 250 µm) for the construction of the flexible microfluidic device. The device proved to be suitable for liquid manipulations on curved surfaces, indicating its potentiality for wearable flexible microfluidics.*

Key-Words*:* *flexible microfluidics; wearable devices; atmospheric pressure plasma; PDMS.*

Introduction: Sensible systems used in flexible devices are, in many cases, composed by solid particles packed inside the micro-channel. Carbon-based and metallic nanomaterials are examples of this kind of active sensing elements. Nevertheless, additional processes are required in order to generate conductive tracks in the device, including gravure, inkjet and screen printing [1]. Despite all these approach with solid materials, non-toxic conductive liquids have been used in microfluidic devices for several flexible applications, including robot sensing mechanism. Liquids are fundamentally more deformable than solids and represent the ultimate limit in mechanical deformability. In this work we propose a simple fabrication method of flexible microfluidic device based only on PDMS instead of a PDMS/glass traditional device.

Experimental: The flexible PDMS/PDMS device was constructed using the similar apparatus used for rigid PDMS/glass device construction. A 3-inch silicon substrate was submitted to spinning leading to a 50µm thickness SU-8 layer (MicroCheam SU-8 50) over the Si surface. The SU-8 was patterned by laser writer (Heidelberg µPG 101 - Lamult - IFGW - Unicamp) for channel design and configuration. After the development process, 300µm width lines with a negative channel topography were generated. The substrate was then introduced in a mechanical support constructed to retain the liquid PDMS (before solidification) and to support the small hoses used for liquid injection and removal [2]. Finally, after the peeling, the PDMS solid structure, as well as a PDMS film was exposed to the atmospheric pressure plasma jet treatment for bonding. Atmospheric plasma has demonstrated a good silanization capacity of the PDMS surface. PDMS/PDMS as well as PDMS/glass surfaces can be bonded righty after plasma process as the curvature angle (wettability) is drastically altered for a short period of time. The atmospheric pressure plasma jet used in this work is a combination of a dielectric barrier discharge (DBD) with a jet transfer technique [3,4]. In this configuration (fig.1a), a primary plasma discharge is generated inside a conventional DBD equipment and one end of a flexible plastic tube, with a flexible conducting wire (Cu) inside it, is attached to the opening of the device´s body. In this way, a plasma jet is generated remotely at the other end of the plastic tube. It is important to note that the tip of the Cu wire does not touch any part of the DBD device and only the primary plasma touches it. In our experiments no plasma formation was observed along and inside the plastic tube, that is, the plasma jet that leaves the plastic tube starts to form at the end of the conducting wire. The use of the flexible tube allows the plasma to be swept over the surface of the sample to be treated, thereby making it possible to treat a large area of material in a practical way.

The main parameters of the plasma jet are: plasma power ~10mW, gas temperature and vibrational temperature equals to (350 ± 25) K and (3000 ± 50) K, respectively and gas flow rate equals to 3.2L/min. The frequency of operation of the plasma jet was 60 Hz and Helium was used as the working gas. After the plasma treatment, the two parts of the microfluidic device were pressed against each other immediately and then subjected to the pressure of a mass of 4kg for 12 hrs.

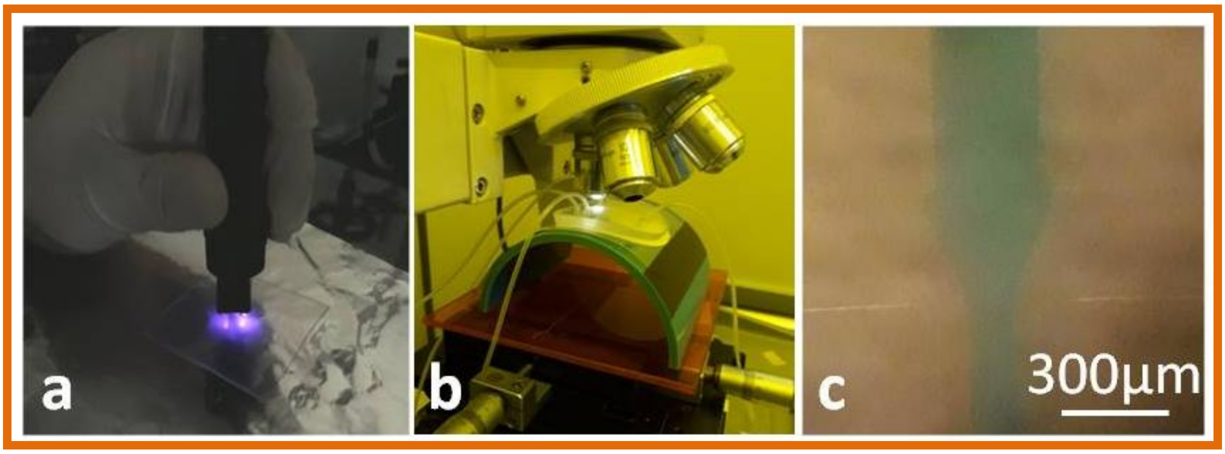

Fig 1. (a) PDMS surface treatment by atmospheric jet pressure plasma jet treatment; (b) Flexible device under optical microscopy inspection; (c) Microscopy image of the hydrodynamic focalization.

Results and discussion: After plasma treatment and bonding, the device was attached to a curved surface (diameter ~100mm) for open liquid flow tests (fig 1b). A hydrodynamic focalization (fig 1c) was successfully conducted by the use of one syringe pumps (NE-4000 - New Era Pump System, Inc.). The device presented no leaks and proved to be suitable for liquid manipulations on curved surfaces. This is an important indication that this type of device can be used for wearable flexible microfluidics.

Conclusion: A flexible microfluidic devices based only on PDMS was successfully constructed using a custom made atmospheric pressure plasma jet for bonding and device sealing. The same mold (Si/SU-8) and instruments traditionally used for rigid devices (PDMS/glass) were successfully used here. The rigid glass plate was substituted by a thin commercial PDMS foil (250μm) allowing the construction of flexible devices with almost the same materials, time and instruments required for rigid devices. No leaks were observed during the device tests, proving the efficiency of the plasma process. Hydrodynamic focalization was successfully performed indicating high potentiality for flexible microfluidic devices.

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