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Novel methods to pattern polymers for microfluidics

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Abstract

We present two novel methods for the preparation of arbitrary microscale patterns of polymers on surfaces with pre-defined topography. While photosensitive polymers are used commonly together with optical lithography, the methods presented can be used for non-photostructurable polymers and where spin-coating cannot be performed. As demonstrator of the viability of the proposed fabrication process, they have been applied for the definition of hydrophobic barriers on a microfluidics network, which is dedicated to selectively dispense liquid to a spotting device consisting of 12 silicon microcantilevers.

Keywords: Liquid spotter; Microfluidics; Hydrophobic barriers; Soft-lithography; Ink-jet

1. Introduction

Microfluidics technology allows manipulating and transporting liquid at the micrometer scale by the suitable patterning of surfaces and by combining hydrophilic and hydrophobic areas [1]. Microfluidics technology can be based either on silicon-based technology (robust, reliable and highly developed) [2,3] or on polymer-based technology (faster, more flexible and simple) [4,5]. We present here the fabrication of a microfluidics network by the combination of silicon and polymer technologies. The network is dedicated to selectively supply liquid to a novel nanospotting device called Bioplume (Fig. 1a) [6,7].

Bioplume is an array of silicon microcantilevers that can deposit drops with suitable control of the position and the size and homogeneity of the drop. More properties of Bioplume deal with its parallel deposition (multiple depositions with a single load), its compatibility with different materials and a large range of feature size [8]. The fabricated Bioplume chip has 12 microcantilevers, 10 of them are dedicated to dispense liquid and the other two are piezoresistive cantilevers to allow alignment of the array with the substrate. Each cantilever incorporates a channel and a reservoir for liquid deposition and storage that is loaded by capillarity action.

An important challenge regarding the performance of the fluidic network relies in the fact that the cantilevers are very close one to the other. When they are dipped in the dispensing holes, the liquid overflows due to volume displacement causing cross contamination between adjacent holes. The proposed solution to this issue is the fabrication of hydrophobic barriers between holes. These barriers will stop the liquid displaced while cantilevers are dipping and also will keep the liquid confined in the areas defined by them.

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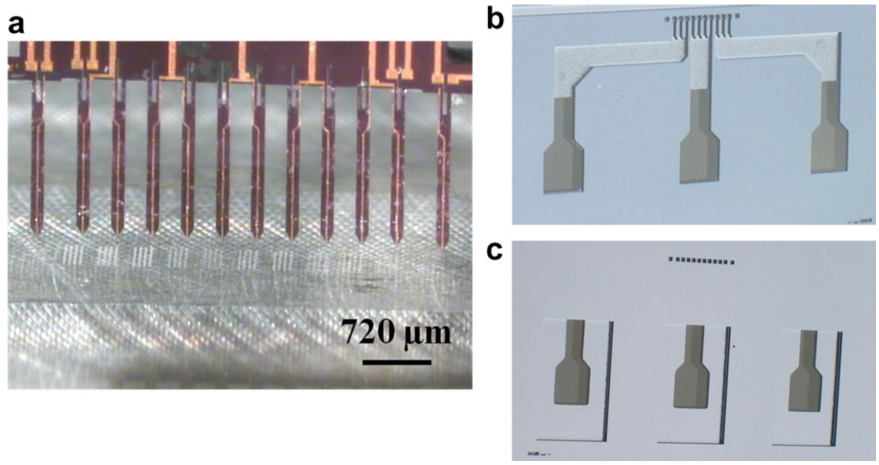

Fig. 1. (a) Array of silicon microcantilevers (Bioplume) just while performing the deposition of liquid drops. The separation between needles is of 120 μm. (b) Image of the back side of the fabricated microfluidic chip. Pyrex is covering the reservoirs, channels and dispensing holes. (c) Front side, the liquid can be easily pipetted to the reservoirs.

2. Fabrication of microfluidic chip

The fluidic network consists of 10 dispensing holes for the 10 depositing cantilevers plus two more holes for the alignment cantilevers. Each dispensing hole is 200 μm long, 100 μm wide and 525 μm deep, the separation between them being of 120 μm. Three reservoirs which allow easily pipetting supply the liquid to the dispensing holes. The channels drive selectively the liquids from the reservoirs to the dispensing holes.

For the fabrication of the microfluidic network standard silicon technology has been used. Starting with a double polished side silicon wafer, 30 nm of thermal SiO_2 is grown on both sides of the wafer and a 1 μm thick Al layer is deposited. A lithography step defines the reservoirs, channels and dispensing holes. Several reactive ion etching processes anisotropically etch subsequently the Al, the SiO_2 and 350 μm into silicon (using Bosch process) to define the channels. The design of the reservoirs and the dispensing holes are also patterned in the back side and they are dry etched until the through-wafer hole is defined. Finally the Aluminum and the oxide layers are removed by wet etching in HF, and the wafer is anodic bonded to a pyrex wafer (1000 V, 400 °C). Pyrex covers the dispensing holes, the channels and the reservoirs.

In Fig. 1b and c the front and the back view of the silicon and pyrex microfluidic chip without the hydrophobic barriers are shown. The size of the chip is 20 mm wide and 12 mm long.

3. Fabrication of polymer hydrophobic barriers

In order to avoid liquid intermixing, polymer-based barriers were defined between the dispensing holes. As the fabrication of the microfluidics chip involves a final high temperature step (anodic bonding), definition of the polymer barriers is not possible during the fabrication process. It is also not possible to define them after the fabrication process by photolithography because the resist deposition by spinning would clog the channels avoiding the liquid flow. In consequence, we have explored two novel methods for polymer structuring, which are presented below.

3.1. Ink-jet printing

The first method is based on ink-jet printing, which is a computer controlled drop-on-demand dispensing of micro-

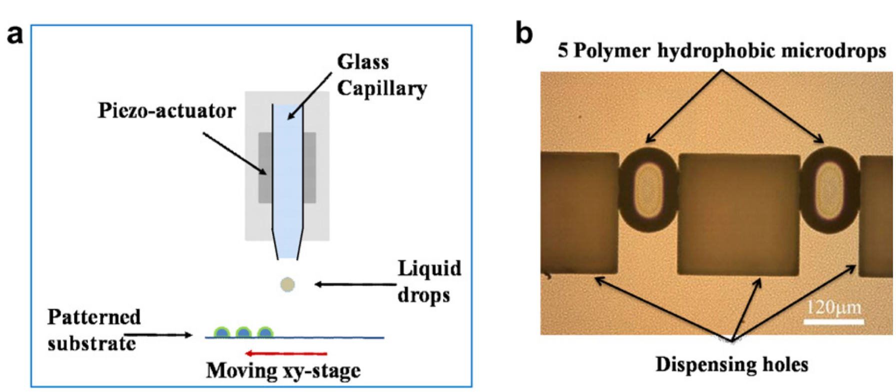

Fig. 2. (a) scheme of the ink-jet set-up (b) and ink-jet printed microdrops in between openings of the channels.