THROUGHPUT THROUGH THIN-FILM FLUIDICS

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ABSTRACT

We demonstrate fluidics realized in thin film plastic foils patterned using roll-to-roll nanoimprinting lithography (rrNIL). Realizing fluidics devices in thin plastic foils opens up for parallel operation in stacked devices. It also provides a convenient format for storage and distribution of the devices.

KEYWORDS: devices, plastic foil, fabrication, fractionation

INTRODUCTION

Although the small size is crucial to the success of microfluidics, it also constitutes a problem, specifically with throughput in terms of amount of handled material per unit time. Device designs and materials as well as sample properties such as *e.g.* maximum shear stress for cells put a limit on the pressure differences, flow rates and electric field strengths that can be applied.

One alternative way of solving the problem is to stack several devices on top of each other. In this way the benefits of microfluidics are preserved since each device is still on the micro scale, while at the same time the large number of devices working in parallel ensures adequate throughput. On the other hand, using conventional approaches to microfluidics implemented on silicon or glass wafer substrates, with a large number of devices in one stack the overall thickness of the stack may become impractically large.

Here we address this problem by implementing a fluidics device on a thin polymer film. With a thickness of about 0.1mm for each device, a stack of a hundred devices would result in a final overall thickness of just 1cm.

EXPERIMENTAL

In this work we have used a custom made roll-to-roll nanoimprinting lithography (rrNIL) machine [1] to transfer a pattern from a Ni-shim [2] to a 95 µm thick cellulose acetate (CA) film (*Figure 1*). For sealing by lamination, a 0.2 µm thick TOPAS 9506 film on CA was used [3, 4]. The printing speed was kept at 0.3 meter/minute.

Characterization of the device was partly made in a standard epifluorescence microscope together with vacuum pumps for sample transport.

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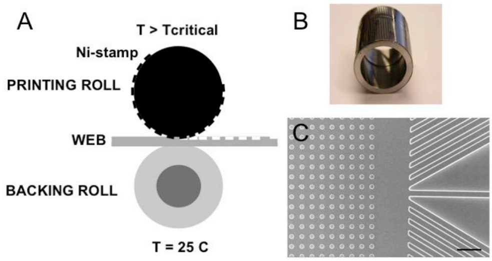

Figure 1. Roll-to-roll imprinting process for a fluidic device, where the device is imprinted into a polymer thin film. (A) In the imprinting step, the backing roll is kept at 25 ^{o}C, the printing roll is kept at 107±3 ^{o}C, and the pressure is 9±1 MPa. (B) Nickel stamp on printing roll. (C) Detail of nickel stamp. Scale bar 50µm.

RESULTS

The resulting devices are shown in *Figure 2*. To test the wetability of these devices, they were first simply dipped in water, and within a few seconds they were readily wetted by capillary action. By mounting a device in a chuck and applying a pressure difference over the device, the pumping of a suspension of fluorescent microbeads through the device could be demonstrated (*Figure 3*).

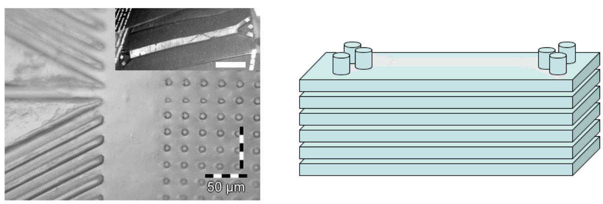

Figure 2. Actual device. (LEFT) Optical micrograph of a selected area of an imprinted device (scale bars 50µm). Inset shows entire device (scale bar 20mm). (RIGHT) To improve throughput, the idea is to stack multiple devices on top of each other and access the devices through a common single set of reservoirs.

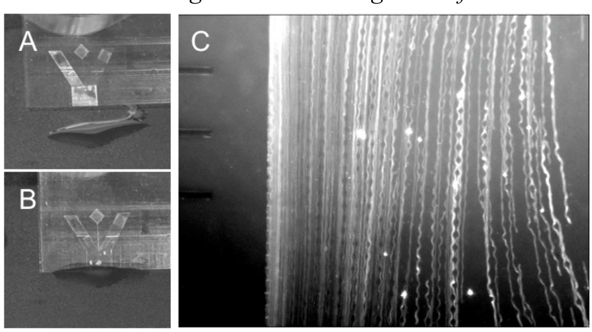

Figure 3. Wetted devices. (A) Before and (B) after wetting by capillary action. (C) Pressure driven flow of fluorescent microbeads flowing in the device as observed in an inverted epifluorescence microscope.

CONCLUSIONS

We have shown that rrNIL for producing patterned surfaces can be used for low-cost and efficient fabrication of fluidic devices. Further work is needed to optimize material choice and sealing procedures since we found that cellulose acetate as used in our preliminary experiments was not fully adequate due to its absorption of water.

Thin substrates opens up for parallel use of multiple devices stacked on top of each other (*Figure 2* RIGHT), so that advantages of microfluidics can be combined with the high throughputs of larger scale fluidics. Another benefit of rrNIL, is that it potentially can be used to make an arbitrarily long device although making seamless Ni-shims still remains a challenge. In fractionation devices such as those based on deterministic lateral displacement (DLD) [5], a long device translates into high Péclet numbers, *i.e.* high-resolution fractionation with a large degree of separation in space compared to the dispersion of the sample stream due to diffusion. This is especially important for devices operating with large periodicities (small row-shift fractions, ε) [6] with the purpose of sorting small nanoscale particles using devices with relatively large, easy-to-make, microscale obstacles.

Finally, the definition of fluidics devices in thin plastic films allows the user to conveniently store devices rolled up for easy transportation to difficult to reach locations. Once a device is needed, one would cut a piece from the roll and attach it to a pump or simply dip it in a drop of sample.

ACKNOWLEDGEMENTS

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