Self-rolled polymer film: A novel approach to microfluidic devices

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SELF-ROLLED POLYMER FILM: A novel approach to microfluidic devices

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LIONS-NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay, Gif sur Yvette, France

We present a new route for the fabrication of highly specialized micro-capillaries, based on the phenomenon of thin polymer films self-rolling. Before rolling, the surface can be patterned (chemically, topographically), permitting the fabrication of inexpensive fully functionalized capillaries.

Spontaneous curvature is a well-known instability [1] which occurs in films with gradients of stress along the normal axis. Recently, this effect was used to fabricate tubes as a self-assembly process [2].

We focus on the application of those self-rolled microsystems to lab-on-chip technology. We propose methods to induce the spontaneous rolling of polymeric films, more precisely polydimethylsiloxane (PDMS). The advantage of such system is three-fold: *i* - Those systems are inexpensive to design. *ii* - The inner surface of the capillary is accessible before rolling and can be properly functionalized and characterized. *iii* - The formation of the channel itself is not a lithographic process. The fabrication of patterned channel are done with only one lithographic step, which implies a great economy in terms of means and efforts.

Spontaneous rolling occurs when there is a stress inhomogeneity in a thin film. One method is to harden the surface of a PDMS thin film, either by adding a capping of material or by hardening the surface by plasma oxidation [3]. The film is then exposed to solvents in gaseous phase. The flat configuration of the film is not an equilibrium anymore and spontaneous rolling occurs. The inner diameter of such systems can be controlled by changing the solvent, the nature of the top layer or the thickness of the whole system.

In order to illustrate the potential of the method, we propose the geometrical patterning of surface before rolling obtained with simple embossing-like methods. We obtained capillaries as small as 70 microns with 13 microns deep patterns over the whole inner surface of the tube, which typically cannot be obtained with standard techniques. Other types of patterning such as chemical functionalization or electrode deposition are currently in development.

To conclude spontaneous curvature effect can be used for the inexpensive auto-assembly of micro-capillaries. The inner surface of those is fully accessible before the rolling occurs and can be easily functionalized.

The main remaining challenge of this technique is the integration of the rolled-up system in a larger microfluidic systems. Methods are developed to obtain soft lithographic / self-rolled hybrid systems in order to make use of the advantages of both processes. We believe in the potential of this method for the design of cutting edge microfluidic technology.

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