Self-rolled polymeric thin film: toward fully functionalized microsystems

F. Malloggi, Rémy Brossard, V Luchnikov, P. Guenoun

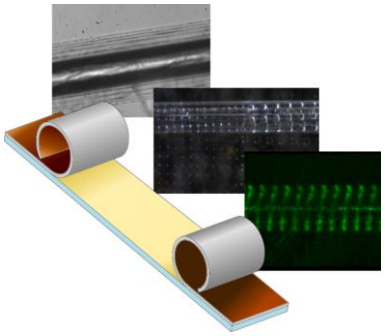
SELF-ROLLED POLYMERIC THIN FILM: TOWARD FULLY FUNCTIONALIZED MICROSYSTEMS

Florent Malloggi*,[1] Rémy Brossard,[1] Valeriy Luchnikov,[2] Patrick Guenoun,[1]

[1]LIONS-NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay, Gif sur Yvette, France;
[2] Institut de Science des Matériaux de Mulhouse, UMR 7361 CNRS-UHA, 15 rue Jean Starcky, Mulhouse, France

Keywords: microfabrication, 3D microfluidics, self-rolling, functionalization, microtube, lab in the tube

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.



Schematic of the rolling process. Pictures of 3D functionalized microtubes

Spontaneous curvature is a well-known instability [1] which occurs in films with gradients of stress along the normal axis. We focus on the application of those self-rolled microsystems to lab-on-chip technology [2]. 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.
Thin films of PDMS are either coated by a layer of hard material or have their surface hardened by plasma oxidation [3]. They are then driven out of equilibrium by selective solvent swelling resulting in a tubular rolled-up system (figure 1).
We demonstrate topographical and chemical patterning, respectively by embossing and microcontact printing. In both cases, the pattern covers the whole surface of the tube, which typically cannot be obtained with standard techniques [4].
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.

[1] Timoshenko, S. et al. J. Opt. Soc. Am 11(3), 233–255 (1925).
[2] Smith, E. J., Xi, W., Makarov, D., Mönch, I., Harazim, S., Quiñones, V. A. B., Schmidt, C. K., Mei, Y., Sanchez, S., and Schmidt, O. G. Lab on a Chip 12(11), 1917–1931 (2012).
[3] Sarrazin, B., Brossard, R., Guenoun, P., and Malloggi, F. Soft Matter, 12, 2200-2207 (2016).
[4]Brossard, R., Luchnikov, V., Guenoun, P., and Malloggi, F. Polymer Physics Polymer Physics 55, 721-728 (2017)