Self-rolled microsystems: A promising route toward fully functionalized and low cost micro-capillaries

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Spontaneous rolling occurs when there is a normal stress inhomogeneity in a thin film. Typically, this occurs in bilayer systems where each layer is subject to a different strain (figure a).

We focus on the application of those self rolled microsystems to lab-on-chip technology. Hence, we propose new methods to induce the spontaneous rolling of polymeric films, more precisely polydimethylsiloxane (PDMS).

A working method is to harden the surface of a PDMS thin film, either by adding a layer of material (e.g. 60 to 200nm of chitosan) or by hardening the surface by plasma oxidation (from 10 to 100nm of glass like material [1]). The film is then cut to define the final shape of the system, which is then exposed to solvents in liquid or gaseous phase[2]. As the swelling of PDMS occurs, the flat configuration of the film is not an equilibrium anymore and spontaneous rolling occurs (figure b). 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. Capillaries of inner diameter between 10 and 1000 microns can be obtained.

Such a process has multiple advantages: First, the inner surface of the capillary is accessible before rolling and can be properly functionalized topographically or chemically (figure c) by lithographic technics, and characterized. Secondly, the formation of the channel itself is not a lithographic process. Thus the fabrication of patterned channels can be done with only one lithographic step, which implies a great economy in terms of means and efforts.

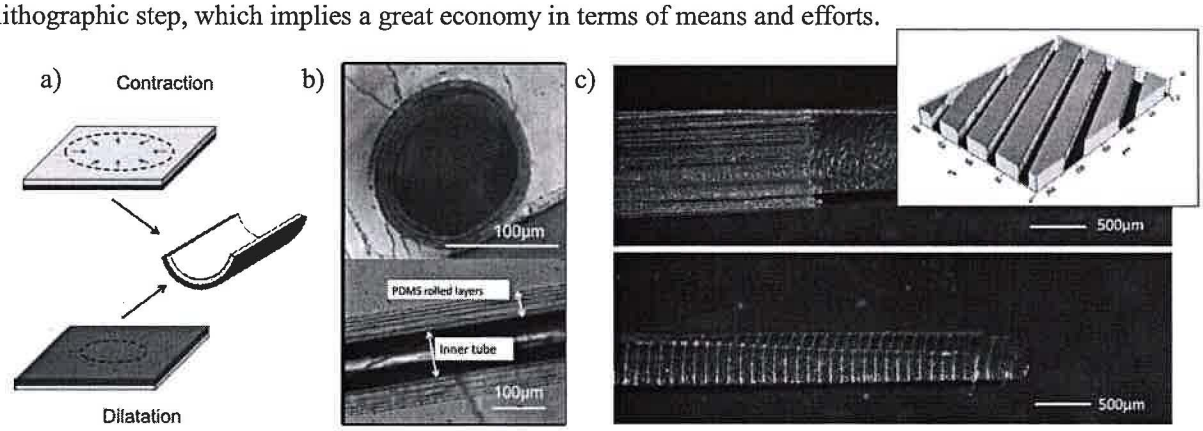

Figure: a) Two types of rolling of a bilayer systems. Either the clear layer shrinks (top) or the dark layer is swollen by a solvent (bottom). b) Optical images of rolled systems embedded in PDMS. *Top*: The axis of the tube is normal to the picture. *Bottom*: The axis of the tube is in the picture plane. c) Example of topologically patterned self-rolled system. The pattern is made of lines 50 to 75µm wide with a depth of 3 to 12 µm shown in the inset. The top pictures shows lines parallel to the tube axis. The bottom picture shows lines normal to the tube axis.

[1] Sarrazin, B., Brossard, R., Guenoun, P., and Malloggi, F. *Soft Matter* , **12**, 2200-2207 (2016)
[2] Gomez, L. P. C., Bollgruen, P., Egunov, A. I., Mager, D., Malloggi, F., Korvink, J. G., and Luchnikov, V. A. *Lab on a Chip* **13**(19), 3827–3831 (2013).