Self-rolled polymer film: a promising route to microfluidic devices

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We present a new route for the fabrication of specialized micro-capillaries, based on the phenomenon of thin polymer films self-rolling. Self-enrolment is a well-known instability driven by stress inhomogeneity in thin film. Such folding of flat surfaces – which can be previously treated chemically or patterned topographically– into a tube present a great potential of application in microfluidics as the patterning of channel inner surfaces becomes of greater importance for a lot of practical aspects.

We investigate the case of PDMS-based bilayer. The instability is driven by PDMS swelling in solvent vapors. The second layer – responsible of the inhomogeneity - can be another harder material. We present two different cases where i- the hard layer is another thin film polymer deposited on the pdms and ii- the hard layer is made by the oxidation of the pdms layer itself. This last case is of main interest since it is the way used for soft-lithography. In Figure 1, we report the inner diameter of self-rolled films as a function of the total bilayer thickness: tubes as small as 25µm are achieved. We believe that those systems are a great alternative for the fabrication of cheap and highly specialized capillaries.

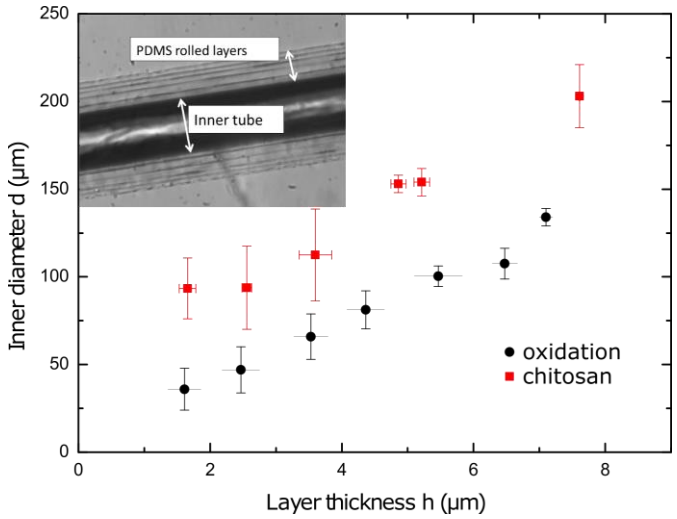

Fig1. Inner diameter vs total layer thickness for two different cap layers.Inset. Optical image of rolled systems embedded in pdms.

Moreover, in order to understand the rolling process, it is important to investigate the surface material mechanical properties of to-be-rolled bilayers. We develop a new experimental method based on a recent indentation model of composite materials which allows to fully characterize the mechanical property of the polymer bilayers [1].

In conclusion and to illustrate the potential of the method, we make geometrical patterning of the flat polymer. After rolling 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.

[1] Sarrazin, B., Brossard, R., Guenoun, P., and Malloggi, F. Soft Matter (2016). DOI: 10.1039/C5SM02133B

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