Biomimetic Lipid Membranes Patterning with FluidFM

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The creation of biologically inspired artificial membranes on substrates with custom size and in close proximity to each other not only provides a platform to study biological processes in a simplified manner, but they also constitute building blocks for chemical or biological sensors integrated in microfluidic devices.[1,2] Scanning probe lithography tools such as dip-pen nanolithography (DPN) or Microchannel Cantilever Spotting (µCS) have opened a new paradigm in this regard, although they possess some inherent drawbacks like the need to operate in air environment and the limited choice of lipids that can be patterned.

The recently developed FluidFM technology has emerged as scanning probe lithography (SPL) technique which combines the accuracy of force control positioning and the versatility of microfluidics.[3] A microsized channel patterned in an AFM cantilever creates a closed fluidic channel that allows dispensing locally any chosen solution, while the applied force with the tip is controlled through a standard AFM laser detection system. In this work, we propose the use of the FluidFM to fabricate biomimetic membranes without losing the multiplexing capability of DPN but gaining flexibility in lipid inks and patterning environment.[4] See Figure 1.
We shed light on the driving mechanisms of the FluidFM-mediated lithography processes in air and liquid (Figure 2). The obtained results should prompt the creation of more realistic biomimetic membranes with arbitrary complex phospholipid mixtures, cholesterol, and potential functional membrane proteins directly patterned in physiological environment.

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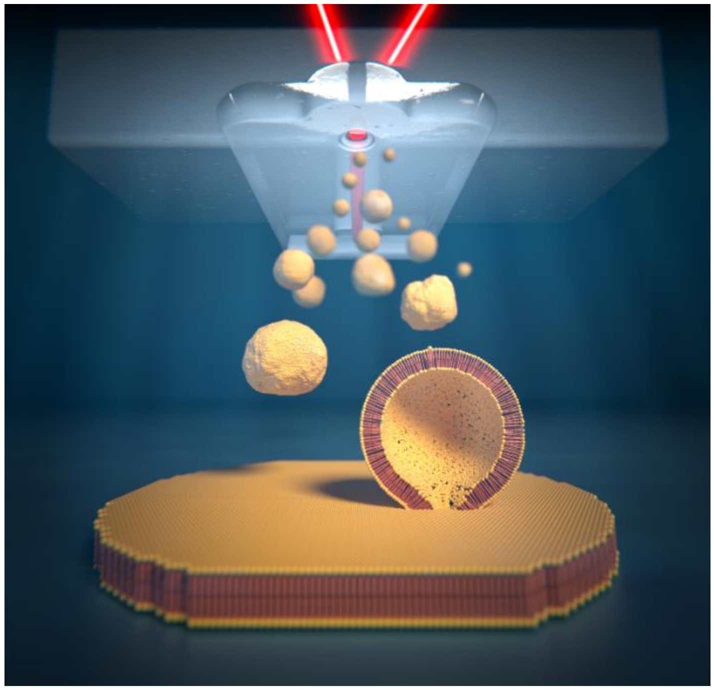

Figure 1: Illustration of the phospholipid patterning process using the FluidFM technology. The cantilever is immersed in aqueous media and the vesicles are pushed out of the nozzle and fuse upon contact with the surface, forming bilayers.

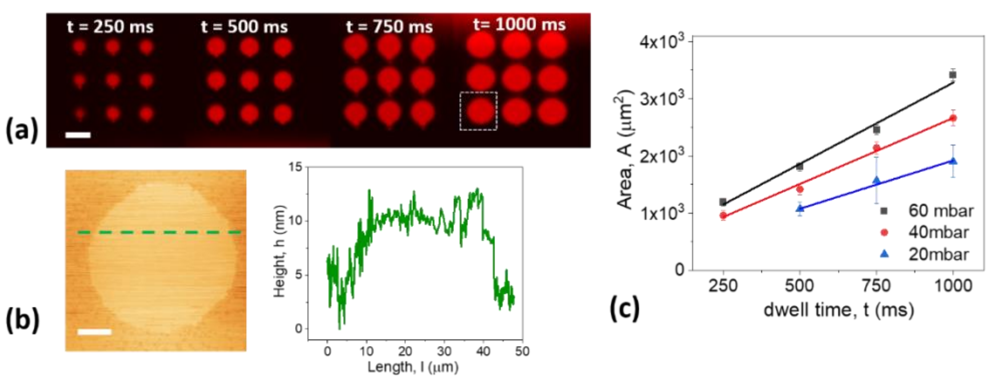

Figure 2: (a) Fluorescence microscopy image of a sequence of lipid patch prints at increasing increasing pulse length and pressure fixed at 50 mbar. Scale bars equal 40 µm. (b) AFM image obtained in liquid of the lipid patch inside a frame in a, with its corresponding profile showing a height indicative of a single bilayer. Scale bars equal 10 µm. (c) Linear dependence of the size of the patterned lipid patch on the pulse length for different applied pressures.