How do patterns emerge on soft and squishy matter ?

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Hydrogels may swell drastically when brought in contact with solvent, as driven by gradients of osmotic pressure, resulting in a change in volume that depends on the swelling ratio. For poly-N-isopropylacrylamide gels (PNIPAM), the ratio of wet-to-dry volume is usually a few hundred percent. However, grafting hydrogel films onto a rigid substrate geometrically constrains the swelling. In this case, swelling-induced in-plane stresses can lead to the formation of a surface pattern.

We study the formation of patterns observed at the surface of PNIPAM-hydrogel films grafted onto silicon wafers, with dry thickness varying from 10 nm to 5 µm. After crosslinking, swelling of the hydrogel network in a good solvent, combined with subsequent drying in ambient air, gives rise to a plethora of different morphologies. Among them, we can see creases and more complex shapes that depend on the wet/dry state of the sample, as shown in fig. 1. We observe that both the dry and wet wavelengths of the pattern scale with the initial dry thickness, with a logarithmic correction involving a relevant length scale. The choice of this length scale may involve the pore size or the elasto-capillary length, depending on sample thickness. The agreement between the resulting correction and the experimental data gives clues for explaining the underlying mechanism of pattern formation.

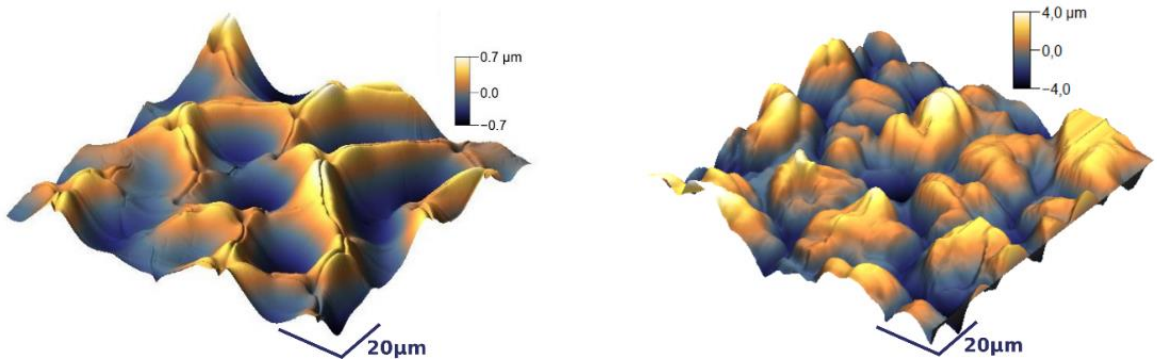

Fig. 1: Surface pattern of two surface-grafted hydrogel films. Left: dry; average thickness 4.5 µm. Right: in water; average dry thickness 2.1 µm; average wet thickness 8 µm.

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