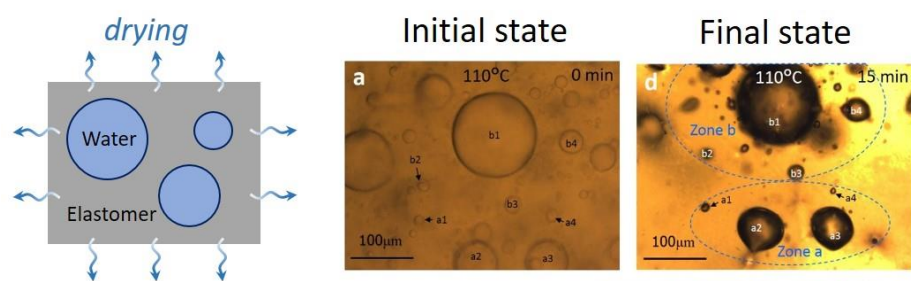


## Open PhD position offer

### Synthesis and drying of model porous elastomers

Porous elastomers are a new class of synthetic materials, with a remarkable combination of compliance and compressibility. They are very promising for acoustic metamaterials, gradient lenses and soft actuation. However, for pore diameters in the 0.1 - 100  $\mu\text{m}$  range, their fabrication is limited by the problem of capillary and adhesive collapse which may lead to complete loss of porosity. The aim of this project is to propose innovative fabrication methods for porous elastomers, by understanding how pores collapse and the solvent cavitates during drying.

In our recent collaboration between SIMM (A. Kovalenko) and Navier labs (M. Vandamme), we studied the drying of water-saturated porous polydimethylsiloxane (PDMS) elastomers using optical microscopy and porosimetry techniques. In particular, we were interested in the case of closed porosity (no "windows" between pores) in which the transport of water is possible only via the pervaporation through the PDMS. The microscopic visualization of pores in thin samples with porosity  $\phi = 5\text{-}10\%$  showed that drying leads to strong shrinkage and creasing of their surface. The next stage depends on the pore size and temperature. For large pores ( $d > 20 \mu\text{m}$ ) we observe their reopening via cavitation, i.e. the formation of water vapor bubbles. For smaller pore diameters, at  $60^\circ\text{C}$  the pores remain collapsed for at least 24 hours of observation while at  $110^\circ\text{C}$  some of them reopen through cavitation. Interestingly, for polydisperse pores the cavitation has been found to be cooperative: cavitation in the largest pores leads to reopening of small pores in a neighboring zone of the sample. However, in order to build a comprehensive picture of the drying, we need to synthesize model porous polymers with precisely controlled porous structure.



*Internship: Phu Tuan Anh Nguyen*

In this PhD project, the student will fabricate water-saturated porous elastomeric materials with pores having controlled size and volume fraction. By choosing appropriate surfactant and emulsification conditions, he will formulate monodisperse and polydisperse inverse water/monomer emulsions and subsequently polymerize the monomer phase. He will test PDMS oligomers and acrylate monomers which give soft elastomers with controlled cross-linking density. Further, we will develop new experimental tools to visualize the drying of the samples at the scale of one pore and study the influence of the external mechanical stress and temperature on the pore reopening. If interested, he will also participate in modelling deformation and fluid transport in porous materials under capillary and adhesive stresses. From a practical point of view, the project aims to propose protocols which minimize pore collapse without using expensive methods such as supercritical drying.

We are looking for an enthusiastic candidate with experimental skills in material science, polymers, physical chemistry or mechanics. Good academic records are mandatory. The candidates are evaluated by the jury of the ED397 (the details and the calendar can be found here: <http://www.ed397.upmc.fr/en/phd-proposals-to-be-granted.html>). Please contact the project supervisors first by sending an application email which should include a CV, a copy of last year academic records, a motivation letter and contact information of at least two referent persons.

**Contact:** Artem Kovalenko, [artem.kovalenko@espci.fr](mailto:artem.kovalenko@espci.fr).

References:

- (1) Kovalenko, A et al. *Soft Matter* **12**, 5154–5163 (2016) [DOI: 10.1039/C6SM00461J](https://doi.org/10.1039/C6SM00461J)
- (2) Milner, M. P. et al. *Soft Matter* **13**, 6894–6904 (2017). [DOI: 10.1039/C7SM01258F](https://doi.org/10.1039/C7SM01258F)
- (3) Jin, Y. et al. *Nat Commun* **10**, 143 (2019). [DOI : 10.1038/s41467-018-07990-5](https://doi.org/10.1038/s41467-018-07990-5)