M2 internship and PhD thesis (2022)

# Understanding the debonding criterion of a microscopic fibril of soft polymer

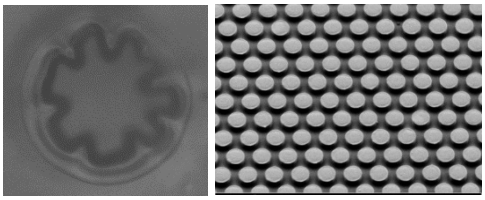
Laboratoire de Physique des Solides & Laboratoire FAST, Orsay

Contacts: christophe.poulard@u-psud.fr
ppcortet@fast.u-psud.fr

Webpages: https://equipes2.lps.u-psud.fr/mmoi/
http://www.fast.u-psud.fr/~ppcortet/

The quantitative prediction of the adhesion strength and detachment dynamics of Pressure Sensitive Adhesives (PSA) from the material properties is a scientific challenge, at the frontier between fracture mechanics, rheology and polymer physics. It also constitutes a major improvement lever for industrial applications. During the debonding of PSA, fibrils of adhesive material appear and are stretched until debonding from the substrate. In the current description of soft polymer adhesion, a key missing element to build a predictive model is the understanding of the individual detachment criterion of the fibrils of adhesive material that develop during the debonding process.

The Master 2 Internship and the PhD thesis will be dedicated to the understanding of the debonding process of a fibril of soft adhesive material. The PhD student will explore experimentally the debonding criterion of a single microscopic fibril of adhesive material, varying the substrate-adhesive surface interaction, the bulk properties of the substrate and of the adhesive, and the geometry. The diameter of the microscopic fibril will be controlled using a microscopic pillar as substrate (see left figure). In a second stage of the thesis, the PhD student will also investigate how substrates patterned with microscopic 3D topography (see right figure) can be used to control the bonding and debonding of a soft adhesive via the control of the density and size of the adhesive material fibrils.



**Left: Top view of the substrate/adhesive contact exhibiting digitations of the contact line. Pillar diam. 300µm. Right: PDMS surface with a hexagonal array of cylindrical pillars obtain through e-beam lithography. Pillar diam. 4µm.**

From a practical point of view, the micro-patterned substrates will be produced using laser and electronic lithography. The PhD student will develop and use a micro-traction experiment and a peeling experiment both allowing very fine measurements of the detachment force as well as high resolution imaging of the detachment process. It is also planned to access experimentally the deformation and the stress fields inside the adhesive material during debonding via microscopic optical methods which measurements are crucial to progress in the understanding of the dissipation mechanism explaining the level of adhesion. Beside the development and realization of experiments, the PhD student will be fully involved in the data analysis, in their modeling and comparison to existing theoretical formalism.

Applicants should have received a high-level education in soft matter physics. The M2 internship and the PhD thesis will be realized at Laboratoire de Physique des Solides and laboratoire FAST, both hosted by Université Paris-Saclay.