Adhesive tape peeling over soft micro-textured substrates

Hélène Piot-Durand[1,2], Loïc Vanel[2] & Stéphane Santucci[1]

[1] Univ Lyon, Ens de Lyon, Université Claude Bernard Lyon 1, CNRS, Laboratoire de Physique, 46 Allée d'Italie, 69364 Lyon Cedex 07, France.

[2] Univ Lyon, Université Claude Bernard Lyon 1, CNRS, Institut Lumière Matière, 10 rue Ada Byron, 69622 Villeurbanne cedex, France.

helene.piot-durand@ens-lyon.fr

The simultaneous control of the adhesion strength and the detachment dynamics of soft adhesive materials is a key improvement lever for gluing and sealing applications in various industrial domains. The most common approach to optimize adherence and debonding processes involves usually chemical modifications of the polymeric adhesive layer and/or of the substrate interface.

We propose to investigate another possibility by introducing physical modifications of the substrate, changing notably its topography, but also its elastic properties and interfacial energies. Therefore, we have performed a thorough experimental study, where a pressure-sensitive adhesive tape (PSA) is peeled from a transparent substrate, at a constant imposed velocity, over a very wide range of driving velocities, from a few μm/s up to a few m/s. For those largest peel velocities, the detachment front of our PSA presents usually a "stick-slip" propagation, alternating periodically, slow and fast phases, and accompanied by drop in the effective adhesive energy [1][2][3][4].

Taking advantage of the transparency of the substrate, we could directly visualize the detachment process, and simultaneously monitor the force needed to detach the adhesive tape. We could prepare our own substrates, using different materials : glass and Plexiglas (PMMA) plates, PDMS layers of various thicknesses and elastic moduli (either adsorbed at an interface or in bulk), UPVC films (corresponding to the adhesive tape backing), leading to different levels of their interfacial energies and stiffness. We furthermore could produce micro-textured surfaces using either a micro-milling machine or lithography techniques [5]. We opted to pattern regular grooves of a few microns deep and wide, regularly spaced of a few microns in either PDMS or PMMA samples.

Our first results show that the combined deformation of the substrate and adhesive enhance the adhesion strength and affects the detachment front dynamics by shifting the velocity threshold of appearance of the "stick-slip" instability. Moreover, depending on the texture of the substrate, we also demonstrate the possibility of controlling the microscopic instability of the detachment front by again shifting its velocity threshold of appearance, or by forcing the value of the amplitude of rapid micro-slips phases.

Références

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