LTDS Laboratoire de Tribologie et Dynamique des Systèmes	**PhD Thesis** January 2017	INSTITUT CARNOT Ingénierie@Lyon	cnrs

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Optimization of Sliding Precursors by surface patterning in flexible microelectronic-inspired systems.

Scientific background:

Polymer substrates coated with stacks of thin layers (metallic, oxide or organic) are increasingly used in many industrial applications such as flexible opto- and microelectronics (screens, OLED, photovoltaic, artificial skin, mechanical gripper, intelligent clothing, etc.). In many of these applications, these coated systems are close to the surface and are subjected to contact stresses. If the case of static contact is relatively well treated in the literature, it can be seen that the problem of the onset of slipping in these systems is little or not addressed. Nevertheless, this problem is of major interest, notably in the biomimetic mechanical gripping or artificial skin systems which are booming in recent years.

Project description :

The project proposed here focuses on the study of slipping precursors in patterned interfaces. It is financed by Carnot Institute Ingénierie@Lyon and its goal is to use and optimize surface patterning to disrupt the rupture dynamics of an interface within a contact to allow the emergence and detection of precursors to slipping sufficiently in advance before global slipping. To achieve this goal, we will take advantage on the complementarity of two laboratories specialized in tribology in Lyon area (LTDS and LaMCoS). The problem will be tackled by coupling an experimental point of view and relevant numerical simulations at different scales. The experimental study of intermittent rupture dynamics in sheared interfaces (i.e. the analysis of slipping precursors) patterned by textured magnetron thin films will be conducted in parallel with a theoretical study of the strain fields for different contact configurations: single- and multi-contact, with or without adhesion. The results will make it possible to identify a relevant parameter the analysis of which will allow anticipating the macroscopic slipping in a contact.

Objectives of the thesis :

The aim of the PhD thesis that is proposed here is mainly to address the experimental part of the project. It will consist in seeing if we can adapt recent results in fracture mechanics and plasticity of heterogeneous media to tribological problems related to the onset of slipping in interfaces. Links between tribology and fracture mechanics are becoming more numerous recently since it has been shown that the initiation of friction exhibits a singularity similar to the one observed at the tip of a crack. Here, we would like to see if it is possible to go further in this analogy between friction and fracture by extending it to the case of heterogeneous interfaces. For this, we will design model coated systems inspired by flexible electronics. We propose to study by an optical method (see figure below) the intermittency in dynamic rupture of sheared heterogeneous interfaces between two patterned transparent solids (soft or flexible substrates) and compare the results to relevant numerical simulations at different scales (continuous scale for global contacts and molecular dynamics simulations for detailed analysis of adhesion loss). Thus, model experiments will be performed on

increasingly complex and heterogeneous model materials to feed simulations to validate or improve their predictions and to better understand the role of surface disorder (heterogeneous friction coefficient) on the emergence of slipping precursors. The final objective will be to propose an optimized patterned surface (in analogy with strong pinning in fracture) to disrupt the dynamics of the interface rupture and thus allow the emergence and detection of slipping precursors early enough before global slipping.

This thesis, mainly located in LTDS, is an upstream experimental research project with a strong will to tackle practical industrial problems in the emerging areas of flexible electronics, remote surgery and haptic grip (robot, prosthesis ...). Its final objective will be to develop a demonstrator for the automatic detection of slipping.

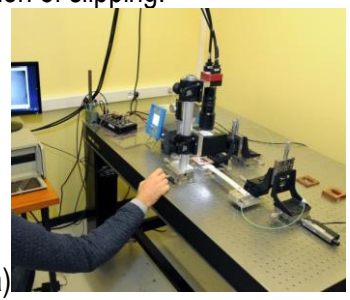
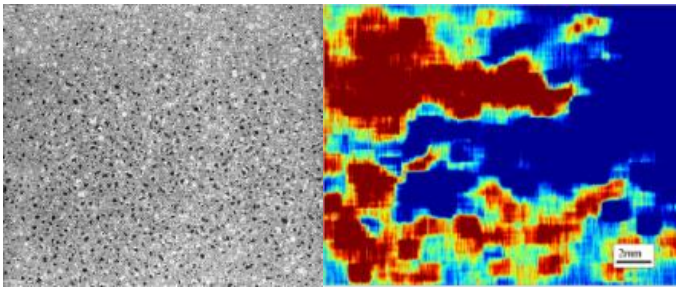
(a)  (b) 

Figure 1 : (a) View of a tribometer with in situ visualization of contacts by fast camera. (a) In situ views of micro-contacts (black) in a rough PDMS/Glass interface and mapping of local micro-slipping events (in red) in the transient friction phase.

Available material ressources :

Many experimental set-ups available in LTDS laboratory can be mobilized for this project. This includes many devices for friction tests, coating devices (magnetron PVD) and characterization systems (microscopy (optical, SEM, AFM ...), camera, fast camera ...) and numerical facilities. Other specific experimental set-ups, existing or to be constructed, are possible.

Profile of the candidate : Student in physics and / or mechanics, with a pronounced taste for experimentation. Mechanical skills in fracture, tribology and / or mechanics of thin layers would be appreciated.