Understanding friction elementary mechanisms at the nanoscale

The apprehension of friction mechanisms at the nanometer scale, known as nanotribology, is of huge interest for both scientific and technologic fields. On the fundamental side, friction is a universal phenomenon that is manifested in many natural behaviors such as earthquakes, land-slides and granular physics. On the technological side, the emergence of miniaturized mechanical systems and nanotechnologies requires reducing friction in order to improve the system autonomy, durability, and to minimize their economical and environmental costs. However, phenomena involved in friction mechanisms are far from being well understood. The development of Atomic Force Microscopy (AFM) offers new opportunities for a better understanding of the elementary mechanisms of friction at the nanometer scale. The principle of an AFM is to scan the sample surface with a very sharp tip, with a back and forth displacement, while measuring the normal and friction force between the tip and the sample. It offers the possibility to generate a nano-scale mono-asperity contact between the AFM tip and the sample.

Recently, we have developed at the Laboratoire Roberval (Université de Technologie de Compiègne) within a collaboration with the Institute of Molecules and Materials of le Mans (Université du Maine), two new AFM modes called initiation of sliding (Fig.1) and circular mode (Fig. 2). The principle of these modes is to generate oscillating contacts at high frequency generating oscillating signals that could be easily exploited These modes exhibit many advantages for friction and wear measurement compared to commercial AFM modes. The principal one is to perform very fast and accurate measurement of the friction force as a function of the load (at constant sliding velocity) or friction force as a function of the sliding velocity (at constant load) allowing measuring adhesion, friction and wear [1-5].

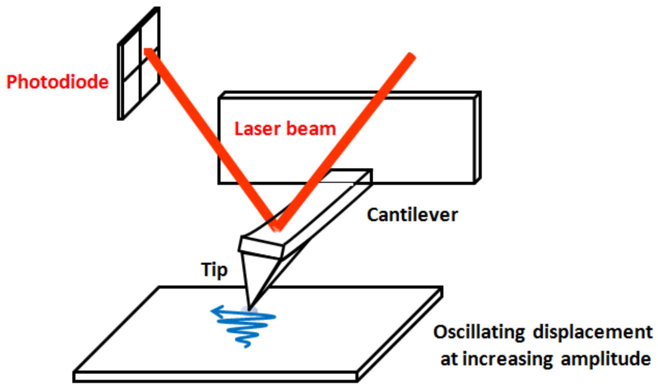

Fig. 1: Principle of the AFM initiation mode. The tip is in contact with the sample and animated by a sinusoidal displacement of increasing amplitude. The experiment allows to explore transition between shear of the contact and sliding at increasing sliding velocity

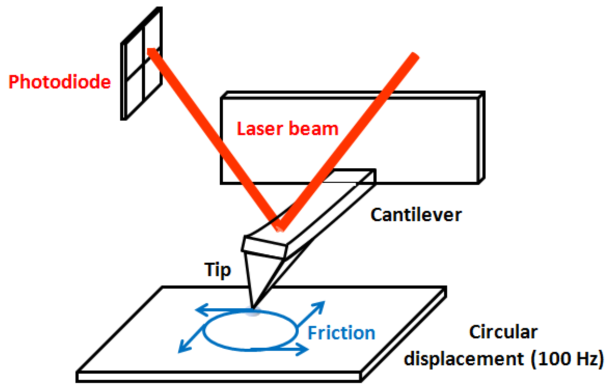

Fig. 2: Principle of the AFM circular mode. The tip is in contact with the sample and animated by a circular displacement. Normal and friction forces generate flexion and torsion of the cantilever that are detected by the deviation of the laser beam

The objective of this PhD is thus:

- To use these two modes to study the tribological behavior of model contact and more precisely, to study the influence of sliding velocity on the friction force and adhesive force.
- To describe and explain the evolution of the friction law as a function of the experimental conditions (nature of the material, % humidity)
- To compare experimental laws with theoretical models

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