STUDY OF FRICTION AND LUBRICATION AT THE NANOMETER SCALE BY MECHANICAL DIODE - - ULTRASONIC FRICTION FORCE MICROSCOPY

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Microscopic friction has received an increasing interest with the development of scanning probe techniques and nanoscience. Friction influences Atomic Force Microscopy (AFM) measurements and related techniques. Knowledge of nanotribology is crucial in order to describe the manipulation of molecules.

Recently, a novel family of AFM techniques which use ultrasound excitation is being developed. Among them, Ultrasonic Force Microscopy (UFM) has already demonstrated its capability to provide information about the nanoscale elastic and adhesive properties of materials. UFM is based on the mechanical diode effect for the detection of surface ultrasonic vibration [1, 2]. It consists in monitoring the ultrasonic-induced cantilever deflection, UFM signal, when normal ultrasonic vibration of sufficiently high amplitude is excited at the tip-sample contact (see Fig. 1). This ultrasonic-induced deflexion occurs due to the nonlinearity of the tip-sample interaction forces, and to the inertia of the cantilever .

Usually, friction studies at the nanoscale are addressed using Friction Force Microscopy (FFM). A new technique , Mechanical Diode-Ultrasonic Friction Force Microscopy (MD-UFFM) has been recently proposed for the study of friction and lubrication at the nanoscale [3]. MD-UFFM consists in monitoring the ultrasonic-induced modification of the cantilever torsion when the tip is scanning over the sample surface at low velocities, and lateral ultrasonic vibration of sufficiently high amplitude is excited at the tip-sample contact, (see Fig.2). The MD-UFFM signal can be explained by means of a lateral mechanical diode effect [3]. MD-UFFM provides additional information than the obtained by FFM. It allows us to study the sample dynamic shear elasticity, viscoelasticity and friction at the nanoscale. Variations of the sample shear subsurface properties can also be addressed. In addition, MD-UFFM permits the analysis of the elastohydrodinamic response of ultrathin liquid layers located at the tip-sample contact.

Currently, we are performing MD-UFFM experiments on Octadecylamine on mica Self-Assembled Monolayers (SAMs) [4]. Recent results from our lab have demostrated that UFM can be performed on this system without damaging the molecular layer [5].

In the poster we will describe in detail the techniques of UFM, and MD-UFFM, and compare results obtained by both techniques with topographic and friction images recorded in the absence of ultrasound.

Referencias:

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Figuras:

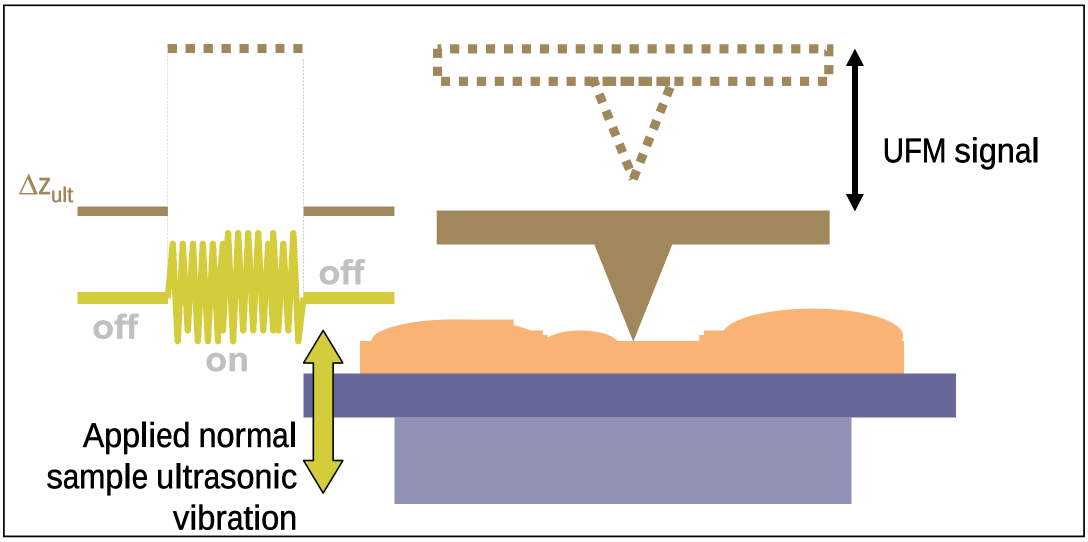

Figure 1. Detection of normal sample ultrasonic vibration in UFM

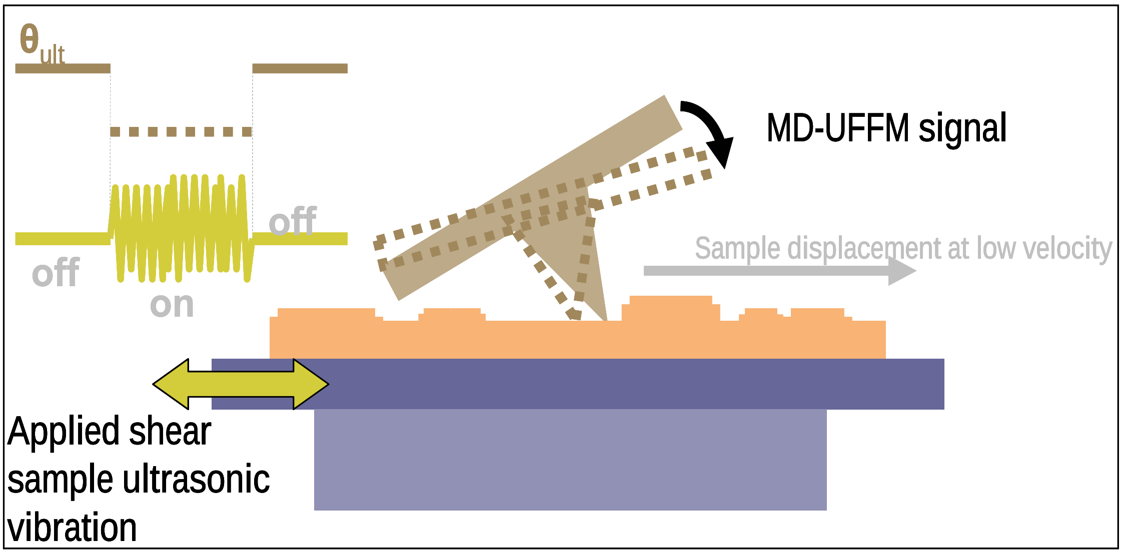

Figure 2. Detection of shear sample ultrasonic vibration in MD-UFFM