Pessac, February 21, 2005

Report of the short visit to the Istituto Nazionale per la Fisica della Materia (INFM). February 2005

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Surface etching by off-normal incidence ion sputtering can be used to pattern surfaces.[1] Studies using a scanning tunneling microscope revealed that ion bombardment produces repetitive structures at nanometer scale, creating wave-like surface structures (ripples). This phenomenon seems to be related to the interplay between ion erosion and diffusion of vacancies, which induces surface re-organization.[2] The properties of the resulting non-equilibrium surfaces will depend on the sputtering conditions. Surface etching by ion sputtering has been investigated during the last ten years at the National Institute for Physics of Matter INFM (Genoa, Italy), in substrates of different chemical nature.[3] In the present project we attempt to establish a protocol for the development of nanoscale features on mica surfaces by etching by ion sputtering, for their subsequent use in Surface Forces Apparatus (SFA) experiments on simple liquids.

The main purpose of the short visit was to optimize the conditions of production of nanopatterned mica surfaces, to be used as confining walls in Surface Forces Apparatus (SFA) experiments. A protocol for the production of suitable patterned surfaces was established. This protocol involves the following steps. First, the cleaving of the mica surfaces to obtain sheets of 3 to 7 microns thick and 8 to 12 mm of size. This was done following well-established procedures used in Surface Forces Apparatus experiments.[4] Second, the sputtering of the surfaces by off-normal incidence ion sputtering at different angles of incidence and exposure time. Argon ion beam sputtering was performed in an Ultra High Vacuum (UHV) chamber, with a defocused electron cyclotron resonance (ECR) plasma ion source (Tectra). The ion energy was fixed to 0.8keV, and the ion flux was about 400 μAcm^{-2}. The time of exposure and the angle of incidence of the beam onto the surfaces were varied to obtain ripples (figure 1a-b) or amorphous surfaces (figure 1c). Mica surfaces were nanostructured on areas of several square centimetres, much larger than the typical contact areas used in conventional SFA experiments (of few thousand square micrometers). We observed that the shape of the sample holder largely modifies the final surface modification obtained. This is likely to be related to the temperature of the sample during the sputtering process. Given the short duration of the visit, this aspect was not explored in great detail. It was also determined that changing the time of exposure of the surfaces to the Ar+ ions increased both the wavelength and the amplitude of the surface structures obtained. Similar results have been reported before for etching by ion sputtering of surfaces of different chemical nature.[5] It is likely that the mica surfaces are being amorphized by the incident

ions, loosing some specific properties associated to the crystalline phase: this will be investigated in detail in the weeks to come.
In total, twenty-seven surfaces were prepared following the above-mentioned protocol. Some of these surfaces will be tested as confining walls on SFA experiments with simple liquids during the visit of Dr. Renato Buzio (National Institute for Physics of Matter INFM, Genoa, Italy) to the Centre de Recherche Paul-Pascal, CNRS (Bordeaux, France) (20/02 to 21/03/2005). The goal is to perform for the first time SFA experiments involving controlled nanoscale roughness on mica surfaces.

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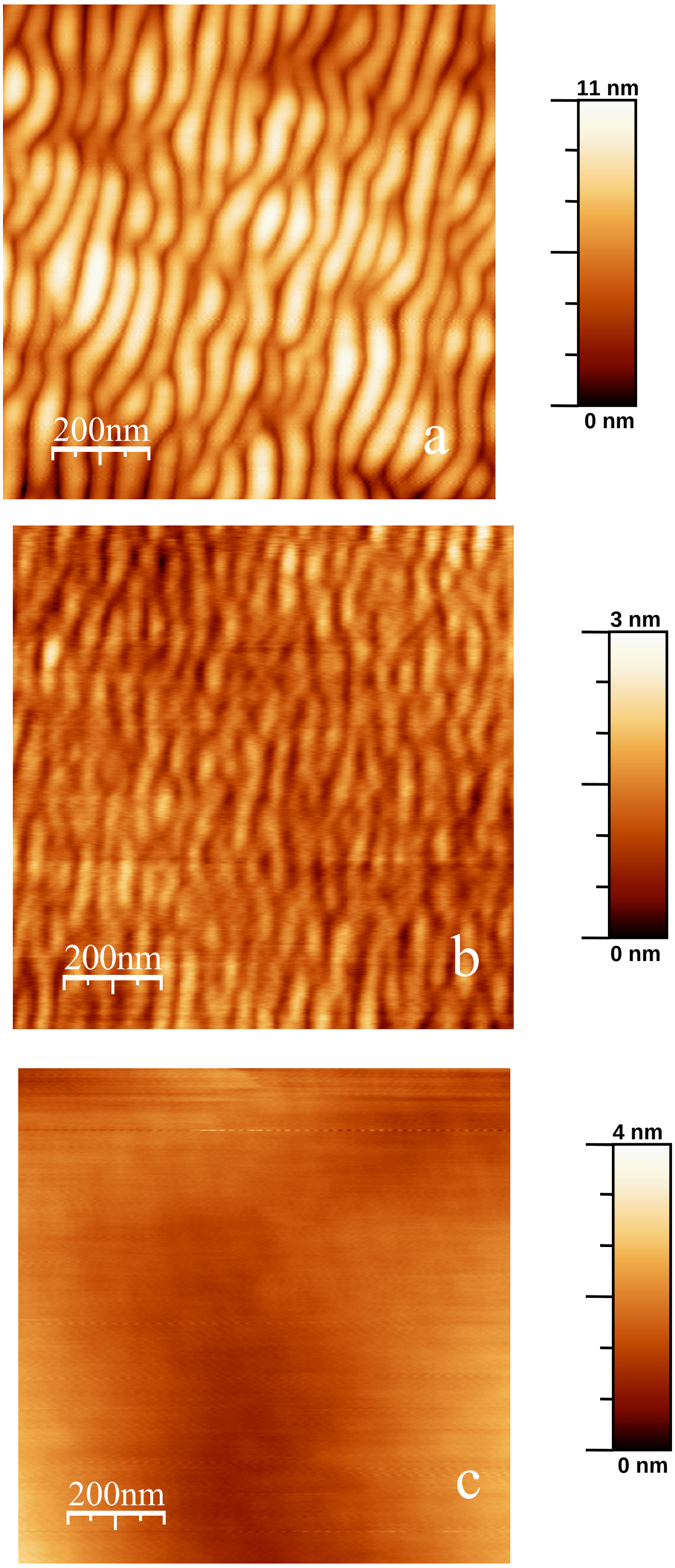

Typical surface morphologies after surface etching by Ar+ ion sputtering of mica surfaces originally smooth at the molecular level. The incidence angle of the ion beam and the etching time were (a) 35° and 25 min, (b) 35° and 10 min, and (c) 90° and 10 min. All surfaces were sputtered at E_{ion}=0.8keV, j_{ion}=400 µA cm^{-2}. Atomic Force Microscope images were measured in tapping mode.