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Innsbruck July, 7th, 2010

Subject: Short scientific report - COST-STSM-CM0601-6116

Spatial-temporal evolution of STM – triggered reaction fronts analyzed by STM and XPS techniques

The present mission which was carried out form 1st of June till 30th of June at the laboratories of Prof. Roberto Otero, LASUAM, Universidad Autónoma de Madrid, Ciudad Universitaria de Cantoblanco, Madrid, Spain was investigating Pentaeritritol by means of STM and XPS techniques. During the STM in July 2009 it could be shown that Pentaeritritol deposited onto Cu (110) in amounts less than a monolayer self-assembles at the surface in two different configurations, an hexagonal close-packed phase at low temperatures, and a "stripped" phase at higher temperatures. In the pursuit of STM-induced lithography, one of the milestones is to trigger chemical reaction of molecules by means of STM techniques which is also the topic of the COST ECCL network. When depositing onto the cold surface and scanning with the STM cooled down, (temperature approximately -40°C), hexagonal islands could be observed (see figure 1). By heating the sample to above room temperature all islands on the surface appeared in the so-called stripped phase (see figure 2), implying that a morphology change is induced by temperature. Scanning the sample at room temperature an intermediate state is observed. Islands appear in both phases ether the hexagonal or the stripped one. Measurements where investigated using $V_{Bias} \approx$ -1,3V and I≈-0,2nA as scan parameters.

Using the cold sample at approximately -40°C that only contains of hexagonal islands the same morphology changes occurred induced by a STM tip. Interestingly, the transformation did not occur simultaneously in all of the island areas, but this change happened in a time-frame in which it is possible to observe the transformation step by step by dynamic STM measurements. By applying voltage ramps at a position somewhere in the hexagonal island, the island was triggered to change

the morphology into the stripped phase. After the applied voltage ramp the parameters were changed back to the normal scanning parameters. The morphology change went on till the complete island was changed. If the sample was cooled down even more the energy deposited into the island by applying a voltage ramp was not sufficient to change the island.

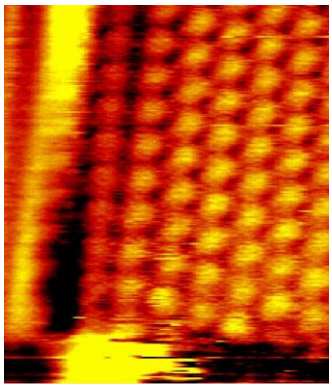

Figure 1: Hexagonal phased island of self-assembled pentaeritriltol molecules
55x64 ÅxÅ, I: -0.200 nA, V_{Bias}: -1358.0 mV

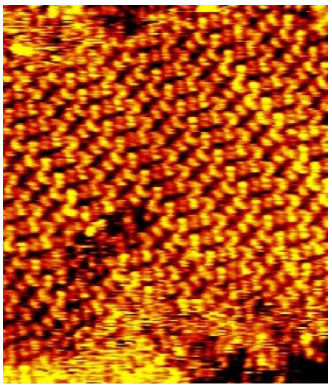

Figure 2: Stripped phase
164x192 ÅxÅ , I= -0.140 nA, V_{Bias}= -1358.0 mV

To get a closer look into the character of the chemical transformation underlying the observed morphology changes, XPS measurements were carried out. The sample was measured at room temperature, were coexistence of hexagonal and stripped phase is found by STM, to get the XPS-spectra of molecules self-assembled in both phases. The measurement had to be done without a long time-averaging process, as radiation was foun to trigger further chemical reactions for longer exposures. . The XPS data for the hexagonal phase was gathered by cooling the manipulator with liquid nitrogen. Further analysis that will be done within the next few months will clarify the chemical state of the hexagonal phase, the stripped phase and a new “chain” phase that appears after X-Ray irradiation. This work will be carried out in collaboration between the host and the home institute.

Since the results look promising it is planned to write them up in a paper. Also further collaboration is planned.