

Title of the presentation:

In-situ and real time scanning probe microscopy of organic ultra thin films

Abstract:

The physics of Organic Field Effect Transistors (OFETs) is strongly correlated with the organization of the organic semiconductor. The optimization of device performance requires a deeper understanding on how the morphology evolves during the growth of the semiconductor. As reported in the literature, charge transport characteristics such as charge carrier mobility [1] and threshold voltage [2] is dependent on the thickness of the active layer of the OFET channel and on the growth condition [3]. In the case of molecular semiconductors, which are deposited on silicon oxide by high- or ultra-high vacuum sublimation, the molecular organization arises from the nucleation and growth phenomena occurring at timescales which are often not easily accessed by standard ex-situ characterization. **We use in-situ dynamic Scanning Probe Microscopy (SPM) to study the early stages of growth of a conjugated oligomer semiconductor, viz. sexithienyl (6T), on a technologically-relevant substrate, native silicon oxide/silicon wafer.** In an ultra-high vacuum chamber ($\sim 10^{-10}$ mbar) a Knudsen cell produces a thermal beam of 6T molecules with a rate of about 1 Å/min. In order to capture the dynamics of local growth of 6T, **a quasi real-time Atomic Force Microscopy (AFM) measurement during growth is employed.** During the AFM measurement, the molecular beam is blocked by a cell shutter which allows us to visualize a static image of the growth process. When the static image is acquired, the tip is retracted to a sufficient distance in order to prevent shading of the molecular beam and the next deposition begins. Non-contact AFM images of the same sample area is acquired every 20% ML, till 5MLs, to be mounted into a movie depicting the growth of the ultra-thin film. In Figure 1 it can be appreciated the evolution of the first layer of 6T at 50°C. A one to one correlation between same islands of different images is clearly visible due to the fact that we are scanning always the same zone. The coexistence of quasi-layer-by-layer and 3D growth modes is observed. By performing the experiment at different temperatures, RT, 50°C, 80°C, 100°C and 120°C, **we have extracted the relevant molecular energy barriers of 6T thin film growth: desorption energy (0.021 eV) and layer-dependent diffusional barriers (0.5-0.4 eV).** An attempt to estimate also the Ehrlich-Schwobel barrier was done to explain the transition from layer-by-layer to islands growth, by using a simple distributed growth model [4]. Unexpectedly, experimental data hint that this transition is possibly governed by rapid roughening to be described by a more complex growth model.

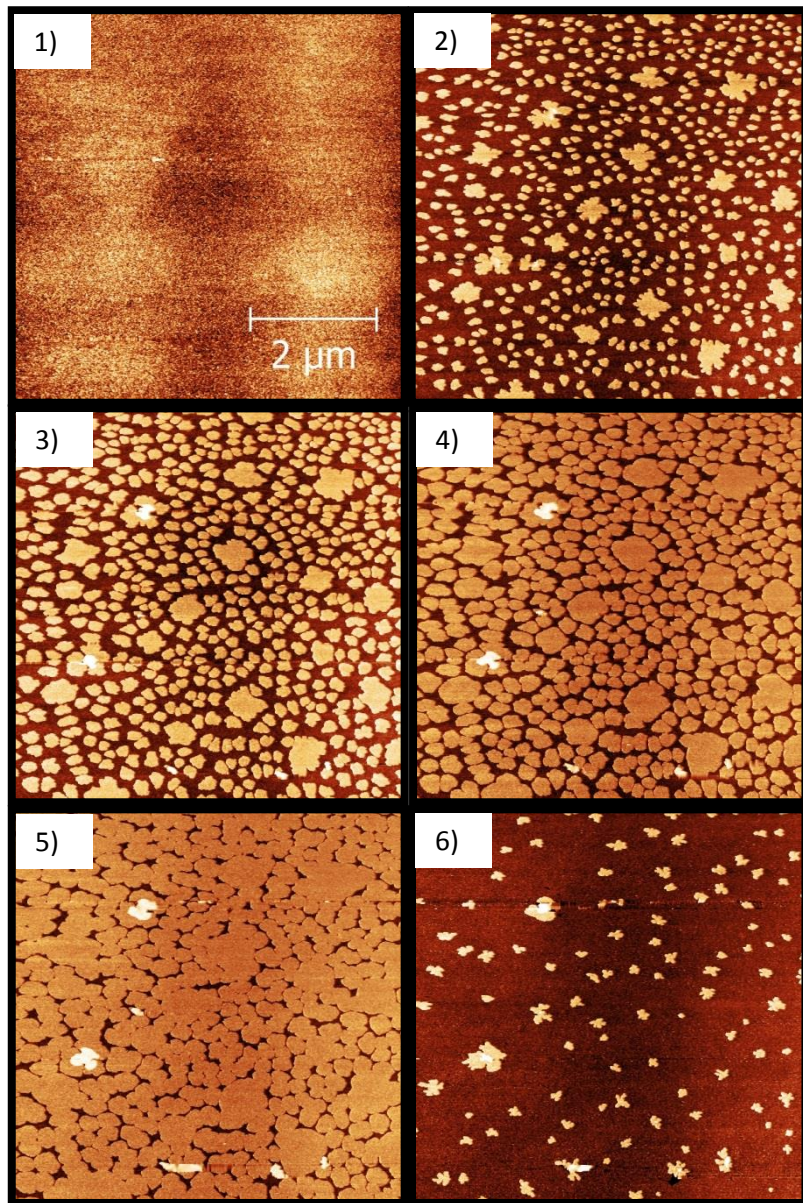


Figure 1. AFM images of 6T on SiO_x, at 50°C, scan size 6 x 6 μm². 1) bare substrate; 2) 0.27 ML; 3) 0.48 ML; 4) 0.74 ML; 5) 0.92 ML; 6) 1.06 ML.

[1] F. Dinelli, M. Murgia, P. Levy et al., *Phys. Rev. Lett.*, **92**, 116802 1-4 (2004).

[2] M. Fiebig, D. Beckmeier, B. Nickel, *Appl. Phys. Lett.*, **96**, 083304 1-3 (2010).

[3] A. Shehu et al., *Phys. Rev. Lett.*, **104**, 246602 1-4 (2010).

[4] P. I. Cohen et al., *Surface Science*, **216**, 222, (1989).