

PHASE TRANSITION OF A CONFINED 2D MOLECULAR LAYER REVERSIBLY TRIGGERED BY THE TIP OF A SCANNING TUNNELING MICROSCOPE

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Experimental results on reversible phase transition of a confined 2D molecular layer are presented. The local probe of a scanning tunneling microscope is used for switching between a liquid and a solid phase of the confined 2D molecular layer.

Reversible phase transitions, e.g. in magnetism, superconductivity and materials, are the basis of many technological applications e.g. for read-write data storage. The knowledge about the phase behavior of systems of reduced dimensionality is of fundamental interest for the development of such applications in the field of micro- and nanotechnology. Reversible triggering of phase transitions at a local scale may allow to locally control structural, optical, mechanical or electronic properties.

We investigated confined 2D layers of large polar molecules chloro-[subphthalocyaninato]boron(III) (SubPc), deposited on Ag(111).

The adsorption and the two dimensional (2D) self-assembly of SubPc has been studied in detail by combined scanning tunneling microscopy (STM) and photoelectron spectroscopy at room temperature [1]. For increasing coverage percentages of the first monolayer, a versatile phase behavior was observed. A time evolution analysis of a 2D solid-gas equilibrium between a honeycomb-pattern and a 2D lattice gas phase, demonstrates that SubPc on Ag(111) appears as a good model system for molecular adsorption and diffusion [2]. For a coverage of a full monolayer a well ordered 2D hcp superstructure is formed over large terraces. In the laterally confined regions, as e.g. given by the steps surrounding a vacancy island, a featureless fluid phase of the molecules is observed by STM. Confined regions of pre-defined size have been produced on purpose by Ar⁺ defects on Ag(111) before molecule exposure. The threshold for spontaneous nucleation at room temperature is found at a diameter of the substrate vacancy island of around 80 nm. Contiguous layers of the 2D solid phase are observed on the extended terraces surrounding the vacancy islands (Fig.1a). In a series of detailed experiments, reversible STM probe induced transitions between the 2D molecular fluid and the hcp phase were performed successfully for chosen diameters of the substrate vacancy islands of about 40 to 80 nm. Within a chosen vacancy island, nucleation of the hcp structure becomes possible by scanning a small subregion (Fig1b) of the island at positive sample bias. The opposite 'denucleation' bias allows the transition back to the fluid form. Both phases show long term stability (checked up to 1h) at room temperature under identical imaging conditions (Fig 1a,c). This new reversible phase transition is related to a molecular property, the dipole moment, which interacts with the local electrical field of the tip. The controlled switching of the local structure can be used to change mechanical, electrical, or optical layer properties. The system will be further exploited in the

context of ultra-high-density storage devices and nanoscale material science. It is an interesting model system for the study of the phase behaviour of confined systems [3].

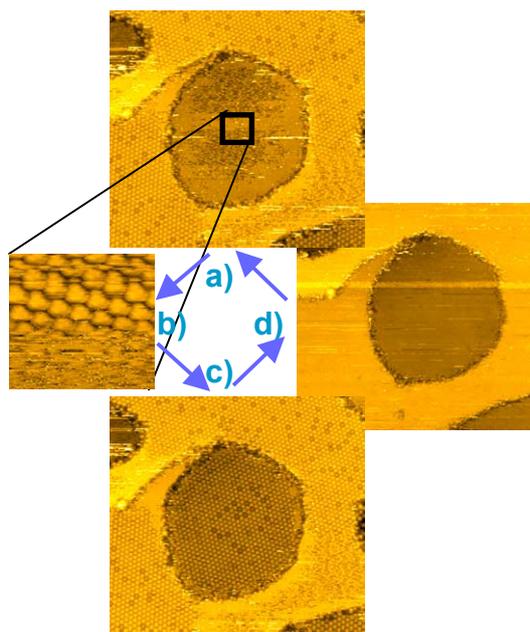


Fig. 1: Phase transition reversibly triggered by the tip of an STM: STM images of SubPc/Ag(111) in a vacancy island of monatomic height. a) overview of liquid phase (no order). During scan in a small subregion (b), the molecules order in an hcp pattern (c), while scanning at negative bias (d) erases the structure resulting again in the fluid phase (as a). Tunnel parameters: a), c) 90 nm x 90 nm, $I=10$ pA, $U=1,2$ V, b) 11 nm x 11 nm, $I=10$ pA, $U=1,2$ V, d) 90 nm x 90 nm, $I=10$ pA, $U= -1,2$ V. All images were acquired by scanning from bottom to top.

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