NANONIS APPLICATION NOTE

TRAPPED 2D FREE e^- GAS of Cu(111) WITHIN REGULAR ARRAY of QDs: STS STUDY

Two dimensional quantum confinements at surfaces have always been a challenge for the scientists, mainly because of the difficulties to produce regular nanopatterns that can trap electronic states. One possibility of analyzing such structures is Scanning tunneling Microscopy (STM) and Spectroscopy (STS) at low temperature.

We made use of our Omicron LT-STM piloted by the Nanonis STM control system to investigate a porous molecular network adsorbed on the Cu(111) surface. The network is fabricated from perylene derivatives (DPDI) which undergo a thermal dehydrogenation on the Cu surface [1]. Each pore of the network confines the surface state of the Cu substrate and can be described as a 0D quantum dot. STS was used to probe the local electronic density of states. We set up the digital lock-in detector integrated in the Nanonis controller and recorded spectra inside a pore (black spectrum in Figure 2b) and on the bare metal (red spectrum). In contrast to the typical onset of the surface state (red), the black spectrum exhibits a peak at -0.22 V which can be assigned to the confinement of the surface state electrons inside the pores [2]. At this bias voltage, the dI/dV signal (differential conductance) and topography were recorded simultaneously (Figure 2a). Angle-resolved photoemission spectroscopy supports these results and indicates the formation of an electronic band induced by the periodic influence of the molecular network on the surface state electrons.

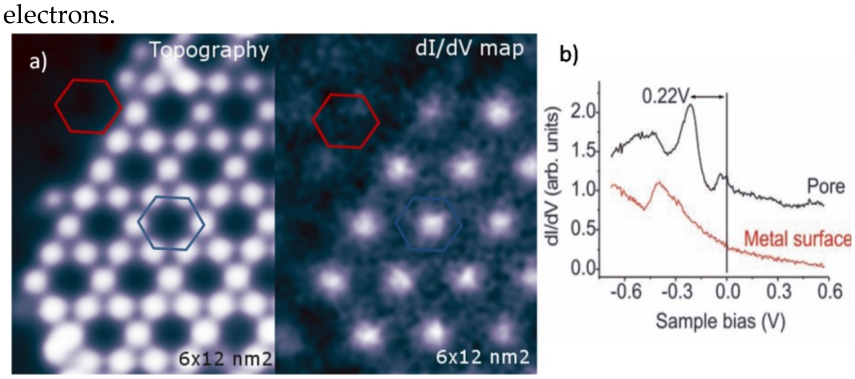

Figure 2. a) Topography and dI/dV map at 5 K and V =210mV, lock-in: Vrms = 8mV, f = 513 Hz b) STS spectra obtained at 5 K on the clean Cu surface (red) and inside a pore of the dehydro-DPDI network (black). The spectra the pores exhibit a maximum at –0.22 V, which is attributed to a confined surface state.

Our findings may open the way to controlled structures of porous networks, with defined coupling degree between molecules and the surface, such that the fabrication of nanopatterns with predefined band structures in new metamaterials.

Reference:

[1] *Meike Stöhr et al., Angew. Chem. Int. Ed. 44,* (2005) 7394.

[2] *Jorge Lobo-Checa et al., "Band Formation from Coupled Quantum Dots Formed by a Nanoporous Network on a Copper Surface"* ***SCIENCE*** *325, (2009) 300.*

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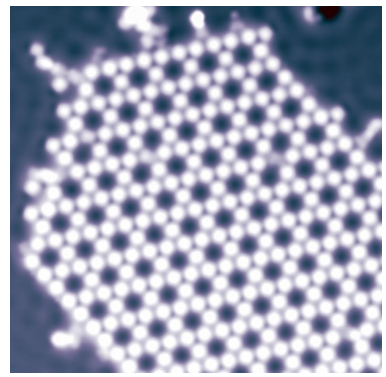

Figure1. Typical STM image for submonolayer coverage of DPDI deposited on Cu(111) after annealling at 500 K. (28x28 nm^2, It=50pA, V=100mV). Network formation with periodicity of 2.55 nm and pore diameter around 1.6 nm. At low tunneling bias voltages standing wave patterns in the Cu surface state can be observed due to the scattering of the delocalized electronic states at the border of the adsorbate ad-layer.

Nanonis Modules in Use:

- Nanonis Base Package
- Internal digital lock-in
- Omicron Adaptation kit

System:

- Omicron LT/STM with Qplus

NANONIS The SPM Application Experts

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