

The formation of 2D oxide quasicrystals and their use as template for molecular adsorption

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When approaching the two-dimensional limit, oxides are known to exhibit strong variations in their structures and properties as compared to the respective bulk materials [1]. One of the extreme examples are the two-dimensional oxide quasicrystals (OQCs), which have been discovered for reduced perovskite oxides on Pt(111). OQCs have been reported for BaTiO₃ and more recently also for SrTiO₃ [2, 3]. Under reducing conditions, these long-range ordered dodecagonal structures are formed in two-dimensional wetting layers at the interface to the threefold Pt(111) substrate, which has been studied in detail using scanning tunneling microscopy (STM), low-energy electron diffraction (LEED), X-ray photoemission spectroscopy (XPS), and in-situ using low-energy electron microscopy (LEEM) [1-4]. Atomically-resolved STM images reveal the formation of a Niizeki-Gähler tiling. The Ti atoms seen by STM exhibit an arrangement in squares, triangles, and 30° rhombs with a common edge length of 6.85 Å for the case of BaTiO₃.

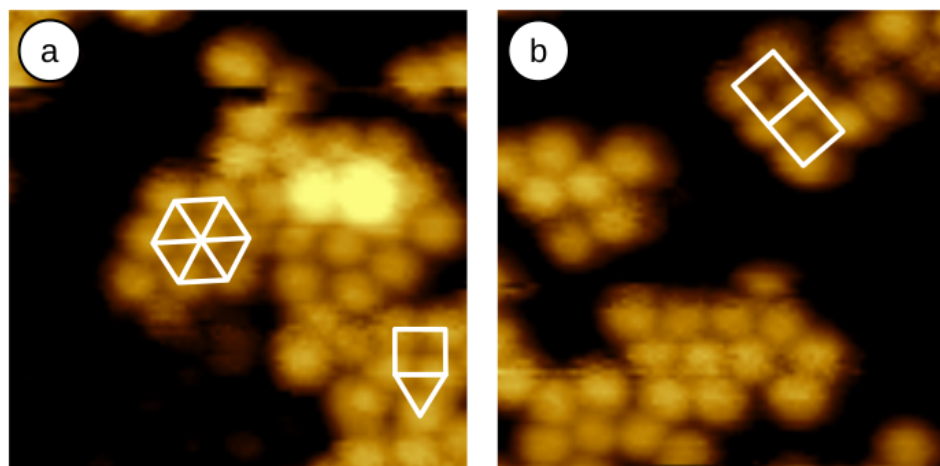


Figure 1: STM images of C₆₀ adsorbed on the BaTiO₃-derived OQC. (a, b) 12x12 nm², 66 pA, 2.5 V.

Due to the complexity of quasicrystalline materials, studies on the relation between aperiodic order and physical properties are challenging. Therefore, quasicrystal surfaces have been tested as templates for the growth of two-dimensional single element quasicrystals formed by molecular adsorbates. Previously, C₆₀ and Pentacene were reported to exhibit quasicrystalline networks on icosahedral Al-based QCs and Ag-In-Yb [5, 6].

Here we report the first adsorption studies on the BaTiO₃-derived OQC using C₆₀ molecules. Their van-der-Waals diameter of 10 Å matches roughly the distance between two neighboring squares in the dodecagonal tiling. Different coverages of C₆₀ have been deposited on the OQC at room temperature and 150 K, respectively. When deposited at room temperature C₆₀ molecules form hexagonal islands at the OQC surface or absorb at step edges, which indicates a weak interaction with the OQC template. With increasing coverages, second layer islands are formed well before the monolayer is completed. At

temperatures of 510 K C_{60} thermal desorption sets in. Below 150 K, the diffusion of individual C_{60} molecules is strongly suppressed and small C_{60} islands are formed upon adsorption as shown in Fig. 1. Besides local hexagonal C_{60} arrangements, we find local C_{60} structure with quadratic arrangement. The latter also being combined into local triangle-square tilings which are analysed with respect to dodecagonal versus hexagonal alignment.

1. S. Förster & W. Widdra, in *Oxide Materials at the two-dimensional limit*, edited by F. Netzer & S. Fortunelli (Switzerland: Springer), 2016, pp. 360-380.
2. S. Förster, K. Meinel, R. Hammer, M. Trautmann, W. Widdra, *Nature* **502**, (2013), 215.
3. S. Schenk *et al.*, *J. Phys: Condens. Matter* **29**, (2017), 134002.
4. S. Förster *et al.*, *Ann. Phys.* **529**, (2017), 1600250.
5. J. A. Smerdon *et al.*, *Nano Lett.* **14**, (2014), 1184.
6. V. Fournée *et al.*, *ACS Nano* **8**, (2014), 3646.

Financial support by the Deutsche Forschungsgemeinschaft DFG through the SFB 762 "Functionality of Oxidic Interfaces" is gratefully acknowledged.