In-situ study on the growth and decay of oxide quasicrystals

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A new member in the family of 2D materials are two-dimensional oxide quasicrystals (OQCs). These OQCs develop in 2D layers spreading from 3D $BaTiO_3$ or $SrTiO_3$ islands on Pt(111) and exhibits a sharp twelvefold diffraction pattern [1,2]. The structure formation process includes the growth of an amorphous wetting layer, which can either develop further into the OQC or into long-range ordered periodic structures, the so-called approximants. Insights into this process are derived from combining the findings of scanning tunneling microscopy (STM) and low-energy electron diffraction (LEED) measurements with in-situ low-energy electron microscopy (LEEM) studies for the case of $BaTiO_3$ [3]. Figure 1 summarizes the findings of the in-situ LEEM studies.

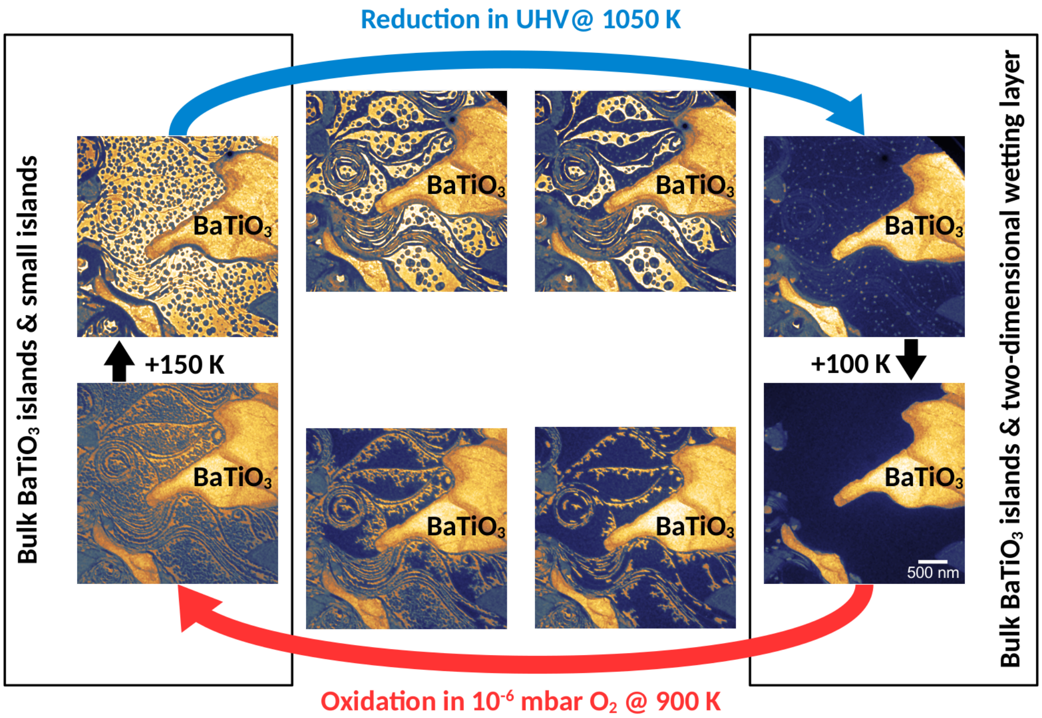

Fig. 1: In-situ LEEM images showing the reversible transition from 3D $BaTiO_3$ islands into the two-dimensional wetting layer. Image size 3.5x3.5 μm².

The formation of a reduced wetting layer from $BaTiO_3$ islands is observed upon UHV annealing at 1050 K. At slightly higher temperatures, the long-range ordered 12-fold symmetric structure of the OQC is formed. Besides the details of the quasicrystalline growth process, the in-situ LEEM studies reveal the high-temperature stability of this new phase. At temperatures around 900 K, re-oxidation in an oxygen atmosphere converts the OQC film back into 3D $BaTiO_3$(111) islands. The dynamics of this re-oxidation process are extracted from the LEEM images. The rate limiting step on this conversion process is the dissociation of oxygen molecules at the Pt sites that are released by the wetting layer.

References:

[1] S. Förster, K. Meinel, R. Hammer, M. Trautmann, and W. Widdra, Nature 502, 215 (2013).
[2] S. Schenk et. al., *J. Phys.: Condens. Matter* ***29***, 134002 (2017).
[3] S. Förster et al., *Ann. Phys.* ***529***, 1600250 (2017).