TUNED EPITAXY OF OXIDE HETEROSTRUCTURES

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Epitaxial growth of high-T_c superconducting $YBa_2Cu_3O_7$ (YBCO) films and heterostructures on MgO substrates and buffer layers is used for making highly sensitive superconducting quantum interference devices (SQUIDs), high-Q microwave resonators, electrical power transmission cables, current leads, fault current limiters, transformers, generators, motors and energy storage devices. For such applications, it is usually important to align the *c*-axis of the YBCO film normal to the substrate surface and to ensure an absence of in-plane-misoriented grains in the films. However, degradation of the MgO surface due to exposure to air leads to the growth of 45° in-plane-misoriented YBCO grains, reducing the critical current and increasing noise and the spread of parameters in oxide heterostructures and devices made with such films. For tilted MgO substrates, surface degradation also leads to a deviation of the *c*-axis of the YBCO film from the substrate crystallographic direction and its alignment with the substrate surface normal. Here we demonstrate that ion beam etching (IBE) of the MgO surface eliminates the growth of misoriented grains and aligns the *c*-axis of the film with the substrate crystallographic direction (Fig.1).

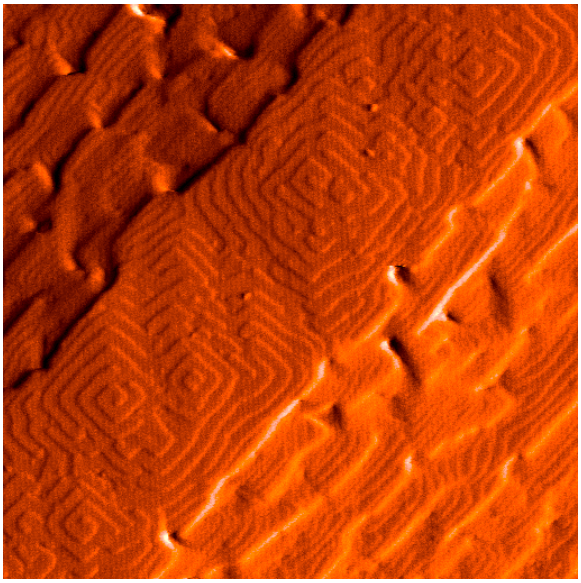

Figure 1: AFM image of a 140 nm thick YBCO film deposited on IBE-cleaned trapezoidal feature on a (100) MgO substrate with a 600 nm wide top and about 3 degree slopes. The AFM scan area is 2 μm x 2 μm. The growth spirals on the YBCO film show the orientation of its crystallographic directions: the direction of the *c*-axis of the YBCO film is normal to the terraces of the growth spirals. Here, we show that the *c*-axis of the YBCO film on an MgO surface refreshed by IBE follows the substrate crystallographic direction, which deviates from the substrate surface normal on the slopes. Exposure of the MgO surface to air before deposition of the YBCO film changes the growth mode of the YBCO film from epitaxial to graphoepitaxial.

By controlled exposure of the IBE-refreshed surface of the MgO substrate to air or hydro-carbons, it is possible to tune the coupling strength between the substrate and the YBCO and to change the growth of the YBCO film from epitaxial to graphoepitaxial. This approach can be used to achieve a controlled deviation of the film *c*-axis from the substrate crystallographic direction and its alignment with the substrate normal, while avoiding the formation of in-plane-misoriented YBCO grains.