Heavy Ion Tracks Used as Artificial Grain Boundaries in Thin Superconducting YBCO Films

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Many studies have been performed in the past on the creation of pinning centers by heavy ion induced latent tracks (see e.g. [1]) in superconducting oxides. In most of these studies the ion tracks had directions perpendicular or almost perpendicular to the superconducting layers. One experiment using latent tracks almost parallel to a MgO surface has been performed by Baudenbacher et al. [2]. Using preirradiated MgO as substrate for vapor deposition of YBCO films a strong influence on the crystal orientation of the epitaxial layer was found. Thus latent tracks were acting here as a "nano–tool" for so–called graphoepitaxy.

In this contribution we give another example of using ion tracks parallel to the surface for nano–structuring. YBCO films of 40 and 80 nm thickness were epitaxially grown on YSZ (100) substrates with the c–axis direction perpendicular to the surface. Prior to irradiation a 300 nm thick AuO_x mask was deposited by sputtering onto the films with an irradiation window to prevent irradiation damage of the superconductor outside the window. The irradiation was performed with 230 to 285 MeV Au ions and a grazing incidence angle of 1.5^o. The samples were irradiated with a fluence of 10^{11} ions/cm^2 along specific directions in the ab–plane of YBCO. The range of the Au ions was about 10 μm and was sufficient to penetrate the entire thickness of the YBCO film, leading to 1.5–3 μm straight tracks.

HTEM cross–sections (fig. 1) reveal that the tracks consist of an amorphized core region of 12–20 nm diameter with a transition zone to crystalline material of 1–2 nm thickness. The average spacing of 30 nm between the tracks is consistent with the applied dose. The inductively measured transition temperatures decreased by only 2–3 K which indicates good superconduction properties of the undamaged material. These rather sharp and well oriented surfaces within the superconducting YBCO have been used in the following measurements to determine the penetration depth as a function of the track orientation. Surfaces of a superconductor with anisotropic pairing are expected to be covered by a layer of thickness of a few coherence length of strongly distorted superconductivity with anomalous behavior. Typical anomalies would be "anomalous Meissner currents" flowing in the "wrong" direction and hence canceling out part of the normal Meissner currents. In measurements of the penetration depth a new low–temperature anomaly has been found which indicates first evidence for surface–induced Andreev bound states [3].

References

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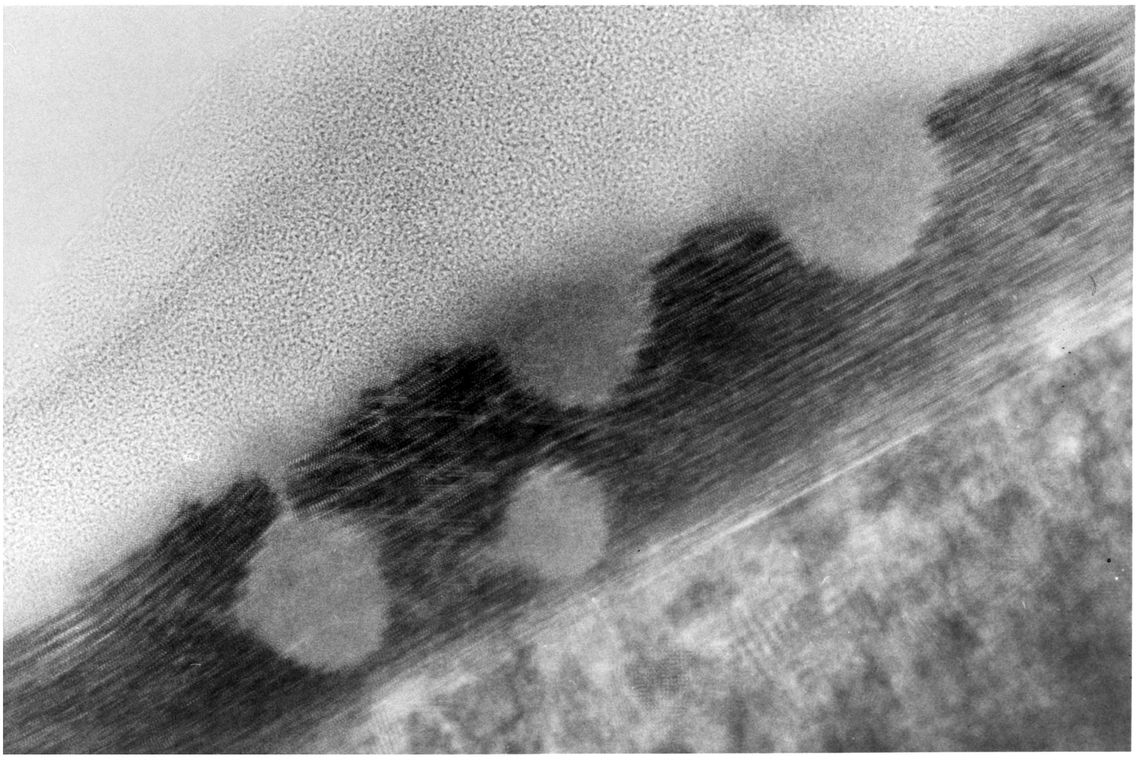

Fig. 1: HTEM cross section picture of a 40 nm thick YBCO film on YSZ substrate with amorphized cross sections of heavy ion tracks.