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Abstract Submission

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Nanostripes in (Nd,Eu,Gd)$Ba_2Cu_3O_x$ (NEG) Single Crystals

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Surfaces of most light rare earth (LRE)-based high-T_c superconductors were found to exhibit a pronounced nanostripe structure with a periodicity between 10 and 60 nm by means of atomic force microscopy (AFM) and scanning tunnelling microscopy (STM) investigations in ambient conditions [1-4]. The most pronounced nanostripe patterns were observed in (Nd,Eu,Gd)$Ba_2Cu_3O_x$ (NEG) melt-textured superconductors, which also exhibit the largest critical current densities for bulk superconductors [5]. The nanostripes represent regions where the LRE atoms have substituted for Ba within an unit cell, thus leading to a spatial variation of the superconducting properties within the sample. In turn, this spatial variation may be responsible for the extraordinary performance of the (LRE)$Ba_2Cu_3O_x$ superconductors concerning the increased values of the critical current density especially at elevated applied magnetic fields. The stoichiometric variation within such nanoclusters was already demonstrated by EDX analysis [6] using high-resolution TEM measurements.

Recently, also single crystals of this material became available, which enable the study of the nanostripe patterns in a homogeneous material, not disturbed by non-superconducting inclusions. In these single crystals, the dimensions of the nanostripes were found to be much bigger as the periodicity of the stripes is found to be in the 500 nm range. Furthermore, the single crystals enable further measurements like electron backscatter diffraction (EBSD) and low-temperature STM/STS to be performed. With the recent developments of the EBSD technique concerning the detection system, a resolution of about 40 nm is possible even on ceramic samples [7]; the EBSD setup (TSL Co.) is based in a FEI dual-beam workstation. The EBSD measurements allow the determination of the direction of the nanostripe pattern with respect to the twins running in [1 1 0] and [1-1 0] direction. The figure presents an EBSD image quality (IQ) map, resembling a backscattered electron image. Here, the twin directions are clearly visible. A magnification of this map reveals the nanostripes, which are resolved to be chains of clusters being represented bright. The yellow line indicates the direction of the nanostripes, along which the profile shown was taken. As the IQ map contains the information about the image quality of the recorded Kikuchi patterns, which expresses the crystallographic quality of the investigated region, this demonstrates that the nanostripes consist indeed of nanoclusters. Furthermore, the EBSD IQ maps enable a determination of the direction of the nanostripes, which form an angle of about 30° to one of the twin directions. Remarkably, the EBSD orientation (IPF) map does not reveal any influence of the nanostripes on the crystallographic orientation; the colour code used for the IPF map is given in the stereographic triangle. At the right side of the figure, a STM image (ambient conditions) of the nanostripe structure is presented, revealing the much larger periodicity of the nanostripes in the NEG single crystals. The low-temperature STM/scanning tunnelling spectroscopy measurements also confirm the chain-like arrangement of the nanoclusters. The nanoclusters are located in the centre of the nanostripes,

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having dimensions of 450 nm in length and a width of 50 – 70 nm [8].

[1] A. Hu, M. Murakami, Appl. Phys. Lett. 83 (2003) 1788
[2] M. R. Koblischka, M. Winter, A. Hu, M. Muralidhar, U. Hartmann, M. Murakami, Phys. stat. sol. (c) 2 (2005) 1720
[3] M. R. Koblischka, M. Winter, A. Hu, M. Murakami, U. Hartmann, Jpn. J. Appl. Phys. 45 (2006) 2259
[4] A. Hu, I. Hirabayashi, M. Winter, M. R. Koblischka, U. Hartmann, H. Zhou, Appl. Phys. Lett. 86 (2005) 092505
[5] M. Muralidhar, M.R. Koblischka, M. Murakami, Supercond. Sci. Technol. 13 (2000) 693
[6] M. Muralidhar, N. Sakai, N. Chikumoto, M. Jirsa, T. Machi, M. Nishiyama, Y. Wu, M. Murakami, Phys. Rev. Lett. 89 (2002) 237001
[7] A. Koblischka-Veneva, M. R. Koblischka, N. Hari Babu, D.A. Cardwell, L. Shlyk, G. Krabbes, Supercond. Sci. Technol. 19 (2006) S562
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