Modelling the Anomalous Low Field Peak Position in Bi-2223 Tapes

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Magnetization measurements on $(Pb,Bi)_2Sr_2Ca_2Cu_3O_{10+\delta}$ (Bi-2223) tapes revealed an anomalous position of the low field peak, B_{pc}, at positive fields in decreasing external field [1]. On the basis of the critical state model, such a peak position cannot be explained [2]. In Ref. [3], we proposed a model for this situation, taking into account effects of a remaining granularity. We regard a layer of Bi-2223 grains in a tape as a close-packed lattice of thin superconducting disks, which touch each other at the circumferences in order to enable the flow of both intra- and intergranular currents (Fig. 1). In decreasing external field B_e, the local field, B_i, at the circumferences becomes negative in still positive fields. The intergranular currents will then experience this negative field at the contacts. This should lead to the situation that B_i is apparently ahead of B_e as observed experimentally on tapes, and consequently, $B_{\rm pc} > 0$. In this Note we report on our preliminary results on a model sample which realizes the proposed structure. For this sample we have chosen a 150 nm thick $YBa_2Cu_3O_{7-\delta}$ (YBCO) thin film prepared by laser ablation on a $LaAlO_3$ substrate. After patterning by electron beam lithography, the sample has a T_c of ≈83 K. The polarization image in Fig. 1 (b) shows the excellent etching which ensures a uniform current flow through the contacts between the disks (diameter 50 μm, contact width 3.5 μm).

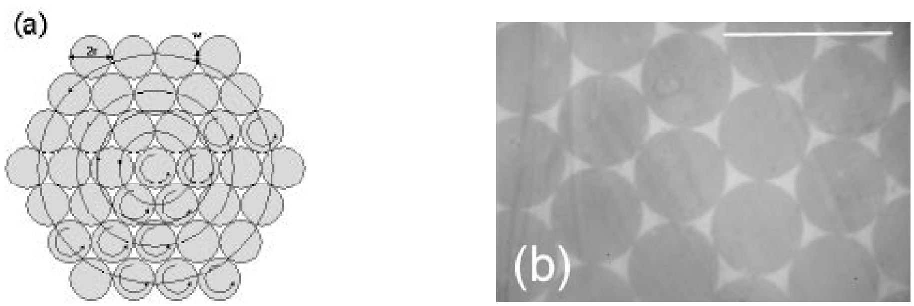

Figure 1: (a): Schematical drawing of the model structure, (b): polarization image of the sample. The marker is 100 μm long.

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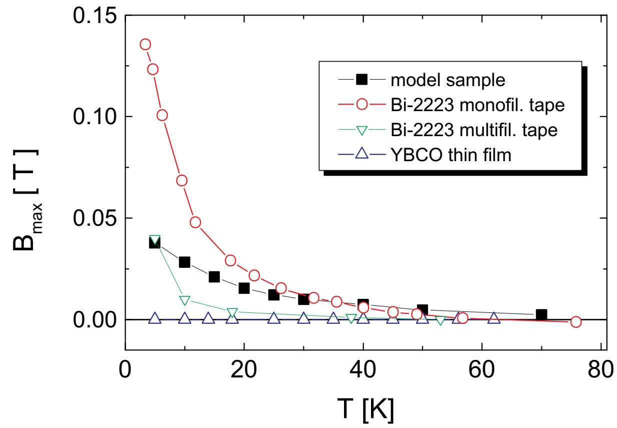

Figure 2: Peak field $B_{\rm pc}$ as a function of temperature for our model sample, a monofilamentary Bi-2223 tape, a Bi-2223 tape with 19 filaments and a homogeneous YBCO thin film.

Figure 2 presents $B_{\rm pc}$ extracted from the magnetization loops measured by a vibrating sample magnetometer in the temperature range 5 K $\leq T \leq$ 70 K together with data of a Bi-2223 monofilamentary tape [3], a Bi-2223 tape with 19 filaments [4] and a homogeneous YBCO thin film without any defects [5]. It is clearly visible that our model sample is capable to reproduce non-trivial features in the behaviour of layered granular structures. $B_{\rm pc}$ of the monofilamentary tape is extremely large at low T (+170 mT, 3 K) which is attributed to a steep increase of the intragranular current density at $T < 20$ K thus leading to a truely granular behaviour. In the multifilamentary tape, a better grain growth and orientation along the Ag sheath is achieved [4], so still $B_{\rm pc} > 0$ but considerably reduced. The YBCO film behaves as expected from the critical state model, $B_{\rm pc} = 0$ T. The properties of the model sample will be further investigated using magneto-optic imaging in order to study the local field distributions [6]. Future experiments with varying sample parameters should enable the modelling of various properties of granular high-T_c superconductors.

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References

[1] K.-H. Müller, C. Andrikis, and Y. C. Guo, Phys. Rev. B **55**, 630 (1997).
[2] H. Ullmaier, Irreversible Properties of Type-II Superconductors, Springer-Verlag, Berlin, 1975.
[3] M. R. Koblischka, L. Půst, A. Galkin, and P. Nálevka, Appl. Phys. Lett. **70**, 514 (1997).
[4] M. R. Koblischka, T. H. Johansen, H. Bratsberg, L. Půst, A. Galkin, P. Nálevka, M. Maryško, M. Jirsa, M. D. Bentzon, P. Bodin, P. Vase, and T. Freltoft, J. Appl. Phys., in press.
[5] M. R. Koblischka, T. H. Johansen, H. Bratsberg, L. Půst, Y. Shen, and P. Vase, J. Phys. C **9**, 10909 (1997).
[6] M. R. Koblischka, L. Půst, A. Galkin, P. Nálevka, M. Jirsa, T. H. Johansen, H. Bratsberg, B. Nilsson, and T. Claeson, submitted to Phys. Rev. B.