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FLUX PINNING ENHANCEMENT NEAR T_c IN $YBa_2Cu_3O_7$ CRYSTALS IRRADIATED BY 5.3 GeV Pb IONS§

M. KONCZYKOWSKI[a], F. RULLIER-ALBENQUE[a], Y. YESHURUN[b], E. R. YACOBY[b], A. SHAULOV[b,*] and P. LEJAY[c]

a. CEREM, Laboratoire des Solides Irradiés, Ecole Polytechnique, 91128 Palaiseau, France
b. Department of Physics, Bar-Ilan University, Ramat-Gan, Israel
c. CRTBT-CNRS, 38042 Grenoble, France

We have studied the effect of 5.3 GeV Pb irradiation on irreversible magnetic properties of $YBa_2Cu_3O_7$ crystal, using an ultra-sensitive local Hall-probe technique. In this article we briefly summarize our previous results and present new data at 90 K (=0.97T_c) which demonstrate that this type of irradiation enhances flux pinning in the vicinity of T_c.

In a recent article[1] we reported the first study of irreversible magnetization in $YBa_2Cu_3O_7$ crystal irradiated by high-energy (5.3 GeV) Pb-ions. This kind of irradiation induces continues amorphous latent tracks, with diameter of order 7 nm, along the ion path. At the reported fluence of $7x10^9$ ions/cm^2 the crystal consists of normal amorphous cylinders, approximately 1000 Å apart, embedded in a superconducting matrix. This unique and well defined damage is responsible for a dramatic change in the irreversibility line[1]: The irreversibility temperature increases and the curvature of the irreversibility line changes sign. This is accompanied by a enhancement of critical current density J_c and a decrease in the normalized flux creep rate S=dlnM/dlnt. In this paper we explore the effect of Pb irradiation on J_c and on S in the close vicinity of the transition temperature T_c.

In Ref. 2 we described the application of miniature InSb Hall-probes for measurements of local-magnetization. We make use of the high sensitivity of the technique and improved temperature control (stability below 10mK), in order to explore magnetic properties of Pb irradiated crystals at 90 K = 0.97T_c. Two 23 μm thick $YBa_2Cu_3O_7$ crystals were used in this experiment. One served as a reference for as-grown samples, the other was irradiated by 5.3 GeV Pb ions (For details , see Ref. 1).

Figs. 1a and 1b present the width of the magnetization curves at 90 K, for the as-grown and for the irradiated samples, respectively. The magnetic field was swept up and down with an amplitude H_{max} which was gradualy increased from 100 G up to 400 G in steps of 50 G. The 'width' of the loop is the difference between the measured magnetization for the same field in the ascending and descending branches of the loop. The 'envelope' of all these curves describes width values which are independent of H_{max} and thus represents a true critical state. According to the Bean model[3] this 'envelope' width is proportional to the critical current. The critical current for the irradiated sample is larger by a factor of 4 at low fields and by a factor of 5 at higher fields and it does not show

§ Pb irradiation was done at the Centre Interdisciplinaire de Recherches avec les Ions Lourds, (GANIL), Caen, France
* Work done during a sabbatical leave from Philips Laboratories, North American Philips Corporation, Briarcliff-Manor, NY 10510, USA

the rapid drop at low fields observed for the as-grown sample.

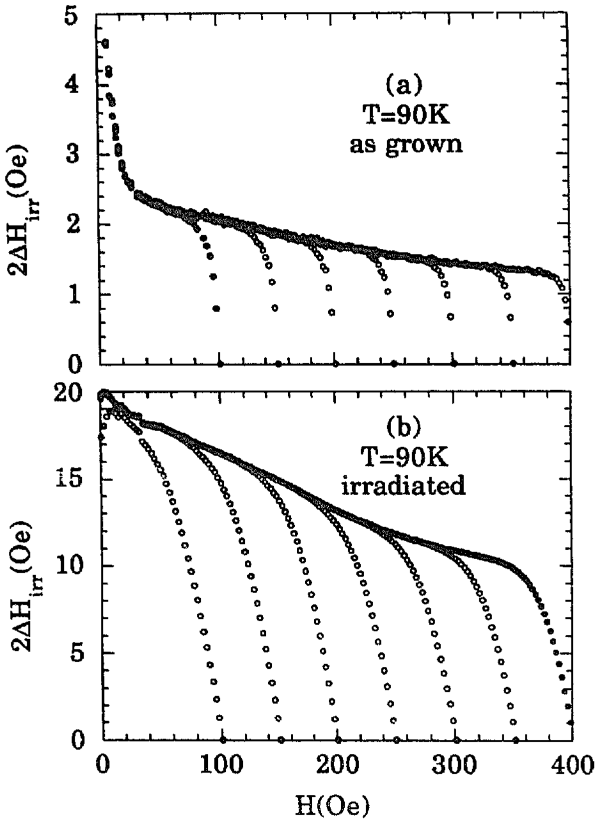

FIGURE 1.
Width of magnetization loops at 90 K (a) for the as-grown sample and (b) for the irradiated sample.

Fig. 2 presents relaxation process at 90 K. Data is accumulated according to the following procedure: a field of 200 Oe is applied and the magnetization is recorded for $2x10^4$ s. The field is increased to its maximum value (400 Oe) and decreased back to 200 Oe where the magnetization is recorded again for $2x10^4$ s. Thus the two sets of magnetization vs. time describe flux penetration (triangles) and flux expulsion (circles). Data for the as-grown and for the irradiated samples are described by full and open symbols, respectively. The **normalized** relaxation rates for the irradiated sample (0.014 and 0.016 for penetration and for expulsion, respectively) are a factor of two smaller than the values found for the as-grown sample (0.024 for both penetration and expulsion).

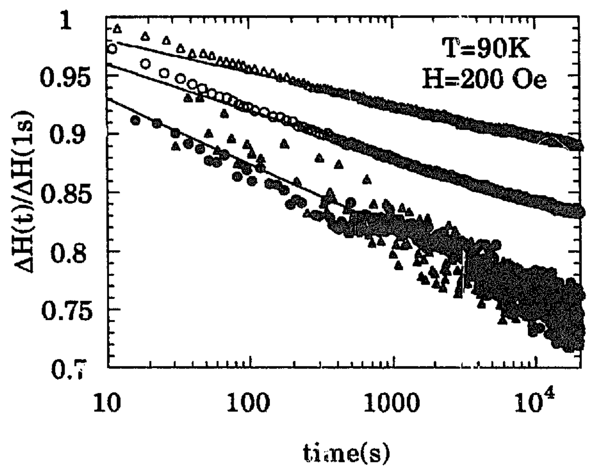

FIGURE 2.
Normalized relaxation rates at 90 K for the as-grown (full symbols) and for the irradiated crystals (open symbols). Δ-flux penetration o - flux expulsion process.

To conclude, we present here the first attempt to explore the effect of irradiation in the close vicinity of T_c. It was not clear a priori whether the effect of irradiation persist close to T_c because of possible changes in pinning mechanism due, for example, to a crossover from individual to collective flux pinning. Our work demonstrates that Pb irradiation enhances J_c and supress normalized relaxation rates up to, at least, $0.97T_c$.

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