Introduction

The doping dependence of the critical current density, $J_c$, and the transition temperature, $T_c$, are qualitatively different from each other in Ba-122 single crystals. A sharp peak was observed in the doping dependence of $J_c$ for all dopants (K, P and Co), while $T_c$ varies much smoother around its maximum [1]. We investigated the change of this behavior in the K-doped system after fast neutron irradiation. This technique is known to introduce defects up to a size of a few nanometers, which have proven to be more efficient for flux pinning than the crystallographic defects in the pristine crystal. Therefore, the doping dependence of $J_c$ after irradiation can be understood by the pinning behavior in Ba-122. The K-doped system was chosen since it was shown that the achievable $J_c$ after fast neutron irradiation are the highest [2]. This is of particular interest, because understanding the pinning behavior may enable an optimization of the defect structure for achieving even higher $J_c$ values by introducing artificial pinning centers during the crystal growth. The irradiation shifts the peak in $J_c$ to higher doping levels than in the pristine crystal. Furthermore, the peak broadens, but is still sharper than the variation of $T_c$ around its maximum.

Samples

- Iron based superconductors, K doped Ba$_{12-x}$Fe$_x$As$_2$ single crystals (Ba-122): Ba$_{12}$K$_x$Fe$_{12-x}$As$_2$.
- Crystals were grown by the self flux method [3].
- Typical size: 1 mm x 1 mm, 30 µm thick

Experiments

- $T_c$ was obtained by AC susceptibility measurements in a SQUID magnetometer. For the definition of $T_c$, the 30% criterion was used.
- $J_c$ was calculated from magnetisation measurement performed in a vector VSM. A self field correction was performed for the calculation of $J_c(B)$.
- The samples were irradiated with fast neutrons to introduce more efficient flux pinning centers. This was performed in a TRIGA Mark-II research reactor.
- The measurements before and after irradiation were done on the same crystals to avoid sample variations.

Results

- Pristine single crystals → sharp transitions due to high sample quality:
- $T_c$ as a function of the K concentration: 1) smooth variation over the whole doping range, 2) broad maximum
- Fast neutron irradiation with a fluence of $1.7 \times 10^{13}$ m$^{-2}$ $\Rightarrow$ $T_c$ decreases for all doping levels.
- Transition after irradiation widens, but is still sharp $\Rightarrow$ no sample damage due to the irradiation.
- The crystal with K concentration $x = 0.3$ before and after irradiation:
- Similar relative change of $T_c$ for all K concentrations:

Summary and Outlook

- Pristine crystals: smooth variation of $T_c$ → irradiated crystals: decrease of $T_c$ → relative change similar for all doping levels
- Distinct peak in $J_c$ → irradiated crystals: shift of the peak and smoother curve
- Next steps: 1) Further irradiation of the crystals. 2) Investigation of Ba122 with other doping atoms.

References


Department of Physics, Osaka University, Toyonaka, Osaka 560-0043, Japan


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