Highlights

Novel superconducting and functional materials for energy and environment - 2018

Effects of high-energy proton irradiation on the superconducting properties of Fe(Se,Te) thin films

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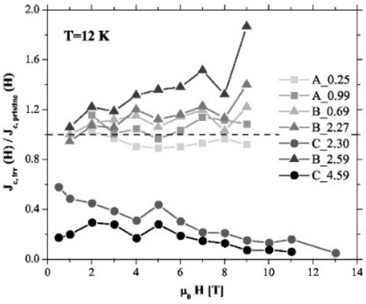
SUPERCONDUCTORS SCIENCE AND TECHNOLOGY 31 (2018) 054001

The effects of 3.5 MeV proton irradiation – performed at the CN Van de Graaf accelerator of INFN — Laboratori Nazionali di Legnaro - on Fe(Se,Te) thin films grown on CaF_2 were investigated with different irradiation fluences up to $7.30 \cdot 10^{16}$ cm^{-2} and different proton implantation depths, in order to clarify whether and to what extent the critical current is enhanced or suppressed, what are the effects of irradiation on the critical temperature, resistivity, and critical magnetic fields, and finally what is the role played by the substrate in this context. The effect of irradiation on superconducting properties is generally small compared to the case of other iron-based superconductors. The irradiation effect is more evident on the critical current density J_c, while it is minor on the transition temperature T_c, normal state resistivity ρ, and on the upper critical field H_{c2} up to the highest fluences explored in this work. The analysis shows that when protons implant in the substrate far from the superconducting film (patterns A and B in figures), the critical current can be enhanced up to 50% of the pristine value at 7 T and 12 K; meanwhile, there is no appreciable effect on critical temperature and critical fields together with a slight decrease in resistivity. On the contrary, when the implantation layer is closer to the film–substrate interface (pattern C in figures), both critical current and temperature show a decrease accompanied by an enhancement of the resistivity and lattice strain. This result evidences that possible modifications induced by irradiation in the substrate may affect the superconducting properties of the film via lattice strain. The robustness of the Fe(Se,Te) system to irradiation-induced damage makes it a promising compound for the fabrication of magnets in high-energy accelerators.

A)



B)

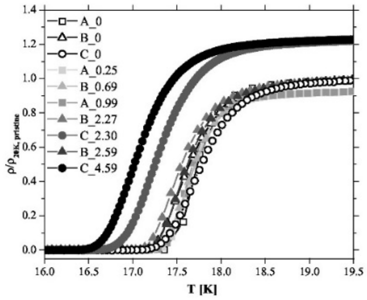


Fig. 1: A) J_c versus magnetic field at 12 K for the different irradiated patterns normalised to the values of the relative pristine samples at the same fields. B) Resistive transitions for all the irradiated bars of samples A, B, and C, where the resistivity at 20 K for each bar is normalised to the resistivity of the relative pristine sample at 20 K.