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A route for simultaneous increase of Tc and Jc in FeSe0.5Te0.5 superconducting films by low-energy proton irradiation

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Iron-based superconductors have attracted a great deal of interests in both fundamental physics and potential applications. We have grown iron-chalcogenide FeSe_{0.5}Te_{0.5} (FST) superconducting films on various single crystal substrates and metal substrates in coated conductors by pulsed laser deposition.^[1] The FST films on CeO₂ buffer layer exhibit enhanced transition temperature T_c (onset T_c = 20 K, zero resistance T_c = 18 K), which is about 30% higher than that found in the bulk materials, and carry high critical current density J_c more than 1 MA/cm² in self-field and 0.1 MA/cm² under 35 T at 4.2 K.^[2] In this talk, we present a route for simultaneous increase of T_c and J_c in FST films by low-energy proton irradiation.^[3]
A robust enhancement of T_c and J_c has been realized simultaneously in the FST film irradiated with 190 keV proton, resulting in an increase of zero resistance T_c from 18.0 K to 18.5 K and an increase of J_c at 12 K by one order of magnitude after the irradiation at applied magnetic field over 15 T for H//ab and over 6 T for H//c. Extensive transmission electron microscopy analysis provides direct atomic-scale imaging of cascade defects and the surrounding nanoscale strain field produced by low-energy proton irradiation. Our studies opened up the possibility to achieve significant enhancement of J_c without T_c reduction through the design of vortex pinning landscape by low-energy ion irradiation for superconducting films.

1) Q. Li et al., Rep. Prog. Phys. 74, 124510 (2011).
2) W. Si et al., Nat. Commun. 4, 1347 (2013).
3) T. Ozaki et al., Nat. Commun. 7, 13036 (2016).

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