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M3Or3J-05: [Invited] Flux pinning performance of FeSe0.5Te0.5 thin films modified by low-energy ion irradiation

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Ion irradiation is a well-established technique to create a variety of structural defects, such as points, clusters and tracks in superconducting materials without the problem of sample-to-sample variation. Recently, ion irradiation in a low energy range (< several MeV) has received a renewed interest as a practical method for improving critical current density <i>J</i>_c in magnetic fields, due to compact accelerator, less radioactivation and less expensive to operate¹⁾. Low-energy ion beam can produce displacements of target atoms, which lead to vacancy-interstitial type of defects, including Frenkel pairs and their clusters in superconducting materials. These structural defects could be effective flux pinning centers in superconducting films.
We have grown iron-chalcogenide FeSe_{0.5}Te_{0.5} (FST) thin films on CeO₂ buffer layers using pulsed laser deposition^{2,3)}. These films exhibit enhanced superconducting transition temperature <i>T</i>_c (<i>T</i>_c^{zero} ˜18.0 K), which is about 30% higher than that found in the bulk materials and superior high in-field <i>J</i>_c performance over the low temperature superconductors. We demonstrated a route to simultaneously raise <i>T</i>_c and <i>J</i>_c in FST thin films by using 190 keV proton irradiation^{1,4)}. <i>T</i>_c is enhanced due to the nanoscale compressive strain induced by cascade defects created by the low-energy proton irradiation. <i>J</i>_c is nearly doubled at 4.2 K up to 35 T perpendicular to the film surfaces through strong flux-pinning by the cascade defects and surrounding nanoscale strain. In this talk, we will present systematically the effect of 190 keV proton irradiation on superconducting properties and flux pinning in FST films. Also, we will discuss the relationship between critical current properties and defect structures produced by different irradiation energies and different ion species.

1) T. Ozaki et al., Supercond. Sci. Technol. 33, 094008 (2020).

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3) W. Si, et al., Nat. Commun. 4, 1347 (2013).

4) T. Ozaki et al., Nat. Commun. 7, 13036 (2016).

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