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Modification of critical current density properties in high-Tc superconductors by tuning columnar defect morphologies in different directions

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Columnar defects (CDs) are useful pinning centers (PCs) not only to improve the absolute value of critical current density Jc in a magnetic field (B) but also to modify the anisotropy of Jc of high Tc superconductors: the modification of Jc by installing CDs in a controlled manner can be one of key technologies for superconducting magnet applications using REBa2Cu3Oy coated conductors. Swift-heavy-ion irradiation to high-Tc superconductors can be an effective method to control the CD morphologies by tuning the directions and the energies. In this work, we systematically investigated the morphologies of CDs in different directions in GdBCO coated conductors irradiated with 80 MeV Xe ions by using a transmission electron microscopy. The irradiation with 80 MeV Xe ions produced shortly segmented (discontinuous) CDs along the c-axis. When the irradiation angle were tilted by 20 degrees relative to the c-axis, the morphology of CDs became continuous despite the same irradiation energy. The morphologies of CDs produced by the ion-beams tilted off the c-axis, on the other hand, turned into discontinuous shape from continuous one along the depth direction from the surface. We also investigated the Jc properties of YBCO thin films irradiated with 50 MeV Kr ions and 200 MeV Xe ions respectively, where CDs were installed at various irradiation angles. The values of Jc for the 200 MeV Xe ion irradiated films irradiated were higher than those for the 50 MeV Kr ion irradiated ones regardless of the irradiation directions. When the directions of CDs were dispersed, on the other hand, the Jc was more enhanced both for the 50 MeV Kr and the 200 MeV Xe irradiated samples. These results suggest that the supreme pinning landscape can be provided by further tuning the morphologies of CDs such as discontinuity and direction-dispersion.

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