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Large Jc enhancement and matching effects by Ba2Y(Nb/Ta)O6 nanocolumns in YBa2Cu3O7-x thin films

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YBa2Cu3O7-x based coated conductors have large potential in such diverse applications as wires/cables, motors/generators, high-field coils, and superconducting permanent magnets, each of them with a certain range of temperature and magnetic field and a certain need in magnitude and isotropicity in critical current density Jc. In order to use the full potential of YBa2Cu3O7-x, it is mandatory to tailor its transport properties for the envisaged application. This is done by inserting artificial pinning centers, such as perovskites (e.g. BaZrO3) or (mixed) double-perovskites, which precipitate as nanoparticles and/or nanorods.
We report on a study on the addition of the mixed double perovskite Ba2Y(Nb/Ta)O6 to YBa2Cu3O7-x thin films on SrTiO3 single crystals prepared by pulsed laser deposition. Size, shape, density and orientation distribution of these pinning centers are analysed by X-ray diffraction and TEM. The electrical transport properties are determined in 4-point geometry in maximum-Lorentz force configuration in fields up to 9 T on bridges prepared by laser cutting.
For small deposition rates, Ba2Y(Nb/Ta)O6 grows as well oriented, densely distributed nano-columns (d ˜ 10 nm). We achieved a pinning force density of 25 GN/m³ at 77 K at the matching field of 2.3 T, which is among the highest values reported for YBa2Cu3O7-x. The field dependence of the pinning force density and the anisotropy of the critical current density show a complex behavior which is explained by a matching effect of the magnetic field's c-axis component and the superposition of up to three pinning components. The exponent N of the current-voltage characteristics (inversely proportional to the creep rate S) elucidates the depinning mechanism, changing from double-kink excitation below the matching field to pinning-potential-determined creep above.

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