Institute of Low Temperature and Structure Research Polish Academy of Sciences

ABSTRACT OF THE DOCTORAL DISSERTATION

Studies of critical currents and pinning properties in $YBa_2Cu_3O_{7-d}$ single crystals substituted with molybdenum

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Copper oxide superconductors form an important family of high temperature superconductors (HTSC) represented by a large number of materials. Yttrium barium copper oxides, often referred to as YBaCuO, are one of them. They are classified as type II superconductors with high critical parameters which make them very perspective for applications. They have a perovskite structure consisting of conductive layers (Y ions between two CuO_2 planes) and quasi-insulating blocks (Ba layers and CuO chains), and therefore have quasi two-dimensional properties. There are several varieties of these compounds, which differ in yttrium, barium and copper ratios, for example $YBa_2Cu_4O_y$ (Y124) and $Y_2Ba_4Cu_7O_y$ (Y247). However, the most promising compound is $YBa_2Cu_3O_{7-d}$ (Y123), which is used in practice for high-energy electric transport. Its critical temperature is slightly above 90 K, when optimally doped with oxygen. In addition, Y123 has an extremely high upper critical field and a critical current density, which at liquid nitrogen temperature are about 40 T and 10^5 A/cm^2, respectively.

After the initial commercialization of HTSC, a challenge arose how to increase their critical parameters, including the critical current density. In the case of Y123 (the only superconductor that can be effectively used in strong magnetic fields at the liquid nitrogen temperature), this is particularly desirable due to the high cost of the superconducting tapes produced from the quasi two-dimensional material requiring texturing and, which further increases the cost, containing rare earth ions. In the long term, increasing the critical current density will reduce the cost of power transmission equipment as well as the size of superconducting electrical devices, which may make these high temperature superconductors competitive in the market.

In the presented work, we investigate the properties and real nature of the critical currents in high-temperature superconductor Y123 in the form of single crystals. This will allow us to determine the intrinsic (without the influence of grain boundaries) characteristics and types of the vortex pinning force present in this material and to determine the anisotropy of the critical currents. The single crystals were doped with Mo and annealed in pure oxygen to increase the pinning force and hence the critical current density which, as we mentioned, increases the attractiveness of Y123 for many applications. Thus, the main aim of the presented work was to investigate the effect of Mo substitution on the critical current density in the Y123 high-temperature superconductors, to determine the types of pinning centers caused by this substitution, and to characterize the temperature-magnetic field regions in which a given type of the pinning center dominates. This is important because it enables the design of the material with the desired parameters at specific temperatures and magnetic fields.

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