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Magnetization Studies and Vortex Phase Diagram of Oxygenated $YBa_2Cu_{3-x}Al_xO_{6+\delta}$ Single Crystal

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Abstract : Cuprate high-temperature superconductors (HTSCs) have been immensely studied during the past few decades because of their structure which is described as a superlattice of superconducting CuO_2 layers. In particular, $YBa_2Cu_3O_{6+\delta}$ (YBCO), with its critical temperature of 93 K, has received the most attention due to its well-defined metal stoichiometry and variable oxygen content that determines the carrier doping level. Substitution of metal ions at the Cu site is known to increase the critical current density without destroying superconductivity in YBCO. The construction of vortex phase diagrams is very important for such doped YBCO materials both from a fundamental perspective as well as from a technological perspective. By measuring field-dependent magnetization on annealed single crystals of Al-doped YBCO, $YBa_2Cu_{3-x}Al_xO_{6+\delta}$ (Al-YBCO), we were able to observe a second magnetization peak anomaly (SMP) in a very large part of the phase diagram. We were also able to observe the SMP anomaly in temperature-dependent magnetization measurements, the first observation to our knowledge. Critical current densities were calculated using Bean's critical state model, flux jumps associated with symmetry reorientation of vortex lattice were studied, the oxygen cluster distribution was also analysed, and by incorporating all observations, we made a vortex phase diagram for oxygenated Al-YBCO single crystal.

Keywords : oxygen deficient clusters, second magnetization peak anomaly, flux jumps, vortex phase diagram
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