First-Order Phase Transition of the Vortex Lattice in $(La_{1-x}Sr_x)_2CuO_4$ single crystals

T. Sasagawa, Y. Togawa, J. Shimoyama, K. Kitazawa, and K. Kishio.

Department of Superconductivity, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

Abstract

The first-order vortex lattice phase transition in $(La_{1-x}Sr_x)_2CuO_4$ (La214) single crystals ($0.046 \leq x \leq 0.077$) was studied by means of magnetization and resistivity measurements for fields parallel to the crystal c-axis. Distinct stepwise changes corresponding to the vortex lattice phase transition were observed in magnetization measurements. Resistive transition took place in both components along the $a(b)$-axis and along the c-axis at the same temperature where the transition was observed in the magnetization measurements. A scaling law, $H_{\rm pt}(T)[{\rm Oe}] = 2.85\gamma^{-2}s^{-1}(T_c/T-1)$, which is based on the *decoupling* theory, was found to universally hold for the phase transition lines not only in the present La214 system but also in Y123 and Bi2212 systems [Sasagawa *et al.*, Phys.Rev.Lett.**80**, 4297 (1998)]. Here $\gamma^2(\equiv m_c^*/m_{ab}^*)$ and s are the anisotropy factor and the superconducting layer spacing. The obtained remarkable scaling feature of the $H_{\rm pt}(T)$ lines provide strong evidence that the first-order phase transition in the high-temperature superconductors manifests itself as the *sublimation* (simultaneous *melting* and *decoupling*) transition of the vortex-lattice rather than simple *melting*. In other words, at fields and temperatures above the phase transition, the vortex lines split up into pancake-vortex gases with no correlation along the c direction.