Synthesis and Bulk Properties of Oxychloride Superconductor $Ca_{2-x}Na_xCuO_2Cl_2$

N. D. Zhigadlo[(1)], J. Karpinski[(1)], S. Weyeneth[(2)], R. Khasanov[(2)], S. Katrych[(1)], P. Wägli[(1)] and H. Keller[(2)]

(1) Laboratory for Solid State Physics, ETH Zürich, 8093 Zurich, Switzerland
e-mail: zhigadlo@phys.ethz.ch
(2) Physik-Institut der Universität Zürich, 8057 Zürich, Switzerland

Abstract - A series of polycrystalline samples and submillimeter size single crystals of a cuprate oxychloride $Ca_{2-x}Na_xCuO_2Cl_2$ (Na-CCOC) with values of Na content ranging from underdoped to optimally doped regions were synthesized at pressure of 30-55 kbar and temperature of 1250-1700 ºC. A systematic variation of the transition temperature T_c with a maximum value of 29 K for $x \approx 0.20$ has been found as a function of Na content. In order to check the role of the apical oxygen for high-temperature superconductivity, we performed muon-spin rotation and magnetization studies of the in-plane magnetic penetration depth λ_{ab} for $Ca_{2-x}Na_xCuO_2Cl_2$ samples with $x \approx 0.11$, 0.12, 0.15, 0.18, and 0.19. The absolute value of the in-plane magnetic penetration depth at $T=0$ was found to increase with decreasing doping from $\lambda_{ab}(0)=316(19)$ nm for the $x \approx 0.19$ sample to $l_{ab}(0)=430(26)$ nm for the $x \approx 0.11$ one. Based on a comparison of the present Na-CCOC data with the data of $La_{2-x}Sr_xCuO_4$ cuprate superconductors, it is concluded that replacing of apical oxygen by chlorine decreases the coupling between the superconducting CuO_2 planes, leading to an enhancement of the two-dimensional properties of Na-CCOC. The torque studies implies that the anisotropy coefficient $\gamma=84$ of $Ca_{1.82}Na_{0.18}CuO_2Cl_2$ single crystals is much more enhanced compared to the structurally related $La_{1.82}Sr_{0.18}CuO_4\gamma$ is much lower, i.e., $\gamma \approx 11$.

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