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Impact of strain on the superconducting properties of underdoped $La_{2-x}Sr_xCuO_4$ thin films

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In the bulk $La_{2-x}Sr_xCuO_4$ (LSCO) compound the decrease of the strontium content doped into La-sites decreases the density of charge carriers in the CuO_2 plane, what suppresses superconducting transition temperature (T_c) and leads to a superconducting-insulator transition (SIT) at x=0.05 [1]. In thin films additional factors may affect the SIT. For example, it is well known that the growth of LSCO films on the $LaSrAlO_4$ (SLAO) substrate produces films with compressive in-plane strain which enhances T_c [2, 3]. Therefore, it may be expected that the SIT will be shifted by the strain. Study of this effect may provide the insight into the nature of the nucleation of superconductivity at the SIT.

Motivated by this idea, we have grown films of LSCO with Sr contents in close vicinity of the SIT, x=0.051 and x=0.048, by pulsed laser deposition on LaSrAlO4 substrates. To study the effects of strain, we prepare several groups of films with different thickness t, in the range from 40 nm to 150 nm. The X-ray diffraction shows that for all t the films grow with variable degree of compressive in-plane strain, which ranges from large to small values, ε_{max} to ε_{min}, respectively. Both ε_{max}, and the range of the strain variability, $\Delta\varepsilon = \varepsilon_{max} - \varepsilon_{min}$, are largest the for the thinnest films, and both decrease with increasing thickness. This suggests that growth-related defects, presumably dislocations, contribute to the strain relaxation. The resistivity measurements show that both the Tc, and the normal-state resistivity, depend very strongly on the built-in strain. In particular, in the thinnest films with the largest ε_{max} the enhancement of the T_c is the strongest, so that for the composition x=0.048, which is insulating in the bulk, we obtain T_c as large as 18K. The change of the resistivity character, from the insulating to metallic with increasing strain, is also observed.

[1] *Structural and superconducting properties of $La_{2-x}Sr_xCuO_4$ as a function of Sr content*, P.G. Radaelli *et al*, Phys, Rev. B **49**, 4163 (1994).

[2] *The effect of strain on the microstructure and superconductivity of the pulsed laser deposited LaSrCuO films*, Marta Z. Cieplak, M. Berkowski, A. Abal'oshev, S. Guha and Q. Wu, Supercond. Sci. Technol. **19**, 564 (2006)

[3] *Doubling the critical temperature of $La_{1.9}Sr_{0.1}CuO_4$ using epitaxial strain*, J.P. Locquet *et al*, Nature **349**, 453 (1998).