Doping influence on as-grown superconducting Pr$_{2-x}$Ce$_x$CuO$_4$

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Commonly, Nd$_{2-x}$Ce$_x$CuO$_4$ cuprates, which presumably contain impurity oxygen ions at apical sites, show a wide antiferromagnetic region ($x = 0.00-0.12$). However, depth-resolved muon spin rotation measurements by K. M. Kojima et al. on superconducting T'-La$_{1.9}$Y$_{0.1}$CuO$_4$ ($x = 0.00$) thin films have revealed the absence of any long-range antiferromagnetic order [1].

Synthesis conditions as well as electronic correlations have been extensively investigated for both optimally- and under-doped RE$_{2-x}$Ce$_x$CuO$_4$. We have recently demonstrated that superconductivity can be induced to as-grown Pr$_2$CuO$_4$ by a stringent control of growth conditions [2]. In contrast, a process commonly referred to “post-synthesis annealing” is an established route for the induction of superconductivity and elimination of defects in RE$_{2-x}$Ce$_x$CuO$_4$. A much less investigated regime are over-doped RE$_{2-x}$Ce$_x$CuO$_4$. Here, we aim at a detailed investigation of synthesis conditions using molecular beam epitaxy for high quality over doped Pr$_{2-x}$Ce$_x$CuO$_4$ ($x \geq 0.15$). It is worth being mentioned that the Ce substitution in Pr$_{2-x}$Ce$_x$CuO$_4$ reduces thermodynamic constraints for the induction of superconductivity, and hence, even Pr$_{2-x}$Ce$_x$CuO$_4$ films grown in a relaxed mode on SrTiO$_3$ substrates show superconductivity in their as-grown state. This is in contrast to as-grown superconducting Pr$_2$CuO$_4$, where a coherent growth mode on GdScO$_3$ substrates plays a crucial role [2]. Doping enhances the density of states at Fermi level with an increase of defect concentration, and metallic conduction is enhanced, i.e., decrease of resistivity with increase of residual resistivity ratio.


Figure 1. (a) XRD-pattern and (b) temperature dependence of resistivity of as-grown T'-Pr$_{1.85}$Ce$_{0.15}$CuO$_4$ thin films on (001) SrTiO$_3$ substrates.