Superoxygenation Study of Cuprate and Iridate Thin Films

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The technique of superoxygenation has been used to hole-dope cuprate superconductors and to synthesize higher-oxidation phases of Y-Ba-Cu-O in powder form. We extend this technique to thin-film samples, which have wider thermodynamic range due to their large surface-to-volume ratio, and to the layered iridate Sr_2IrO_4, which is difficult to hole-dope by cation substitution. First, $YBa_2Cu_3O_{7\text{-}\delta}$ thin films grown by pulsed laser deposition are annealed in up to 700 atm O_2 at 900°C, and then characterized by transmission electron microscopy, x-ray diffraction and x-ray absorption spectroscopy [1]. The high-pressure annealed films show phase conversion to $Y_2Ba_4Cu_7O_{15\text{-}\delta}$ and $Y_2Ba_4Cu_8O_{16}$, which contain double CuO chains, as well as regions of $YBa_2Cu_5O_{9\text{-}\delta}$ and $YBa_2Cu_6O_{10\text{-Î}\text{t}'\delta}$, which contain triple and quadruple CuO chains respectively. Second, epitaxial thin films of Sr_2IrO_4 are subjected to extended high-pressure annealing at lower temperatures, and then similarly characterized. Whereas the as-grown films are insulating, the post-annealed films show evolution towards semi-metallic behavior with up to 3 order-of-magnitude drop in room temperature resistivity. Furthermore, as film thickness is reduced, the high-pressure annealed films show structural transformation towards a quasi-cubic $SrIrO_3$ phase. Our results demonstrate the potential of using superoxygenation to stabilize exotic phases of transition metal oxides not achievable in bulk form.

[1] H. Zhang *et. al.*, Phys. Rev. Materials **2**, 033803 (2018), and references therein.