Growth and characterization of Pr-doped Ca_2RuO_4 single crystals

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Mott insulators are widely studied systems which exhibit relevant quantum phenomena when subjected to external stimuli such as pressure, electrical field, or chemical doping. Among them, Ca_2RuO_4 has been largely investigated in the last years, since, in its ground state, it has proved to be particularly sensitive to perturbations. Regarding in particular the effects of elemental substitutions, previous studies have shown that praseodymium doping of Ca_2RuO_4 makes the metal-insulator transition (MIT) occur at lower temperatures compared to the undoped case; the critical temperature T_{MI}, approximately equal to 360 K in the pure system, is indeed reduced to around 85 K in $Ca_{(2-x)}Pr_xRuO_4$ with x=0.07 [1].

In this work, we present the results of a study aimed at tuning T_{MI} near room temperature by suitably doping Ca_2RuO_4 crystals with praseodymium. To this purpose, $Ca_{(2-x)}Pr_xRuO_4$ single crystals with x=0.04 were prepared by the floating zone technique. A comprehensive characterization of the obtained bulk crystals was performed by X-ray diffraction, optical and scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), and electron backscattered diffraction (EBSD). The crystals were successfully grown using an excess of Ru from 23% to 30% in the starting mixture; the Ru excess was necessary to balance the high volatility and the consequent loss of RuO_2 during the growth process. Ru metal inclusions were found in many samples, especially in the cases where higher Ru content was used; a pattern of lamellae aligned along a certain direction was observed. As demonstrated also in other studies on single crystal ruthenates [2,3], the presence of Ru metal inclusions, far from being detrimental, deserves attention because it can further improve the properties and performance of such materials.

References

[1] Riccò S et al. In situ strain tuning of the metal-insulator-transition of Ca_2RuO_4 in angle-resolved photoemission experiments. Nat Commun. 2010; 9:4535.
[2] Maeno Y et al. Enhancement of superconductivity of Sr_2RuO_4 to 3 K by embedded metallic microdomains. Phys Rev Lett. 1998;81(17):3765–3768.
[3] Granata V et al. Crystal growth of the Ca_2RuO_4–Ru metal system by the floating-zone technique. J Alloys Compd. 2020;832:154890.