Thermoelectric properties of doubly substituted La\(_{0.95}\)Sr\(_{0.05}\)Co\(_{1-x}\)Cr\(_{x}\)O\(_3\) (0 \leq x \leq 0.5) ceramics

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Abstract

Dense La\(_{0.95}\)Sr\(_{0.05}\)Co\(_{1-x}\)Cr\(_{x}\)O\(_3\) (0 \leq x \leq 0.5) ceramics were synthesized by solid-state reaction and conventional sintering. Room-temperature crystal structure and microstructure were investigated and the thermoelectric properties were measured in the temperature range 323 K – 1020 K. All compositions are single phase with rhombohedral structure, and the lattice parameter of La\(_{0.95}\)Sr\(_{0.05}\)Co\(_{1-x}\)Cr\(_{x}\)O\(_3\) increases with increasing Cr content. La\(_{0.95}\)Sr\(_{0.05}\)Co\(_{1-x}\)Cr\(_{x}\)O\(_3\) is a p-type small polaron conductor. The charge carrier concentration is determined by both substitution of La\(_3^+\) with Sr\(_2^+\) and thermally-activated charge disproportionation of Co\(_3^+\) and / or Cr\(_3^+\). Above 550 K, the substitution of Co with Cr increases the Seebeck coefficient and reduces the electrical conductivity. Below 550 K, the trend of Seebeck coefficient with Cr content is not clear due to the thermally activated charge disproportionation. At low temperature, the electrical conductivity shows a minimum with Cr content of x = 0.4, as a result of trapped polarons in the Cr sites. By substituting Co with Cr, the power factor below 800 K is reduced and that above 800 K is improved. The thermal conductivity is effectively reduced by doping Cr. The highest ZT value of 0.053 at 373 K is achieved for x = 0, but it decreases rapidly with increasing temperature. Substitution of Co with Cr can effectively improve the ZT values at high temperatures. In the temperature range 700 K – 1000 K, ZT increases with increasing Cr content, the highest being 0.04 at 1000 K for the composition with x = 0.5, more than 4 times the value of the La\(_{0.95}\)Sr\(_{0.05}\)CoO\(_3\) compound.

Keywords: thermoelectrics, p-type, perovskite, double substitution

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