High-Temperature Thermoelectric Figure of Merit of $Ba_{1/3}CoO_2$ Epitaxial Films

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Introduction

Thermoelectric materials, which can convert wasted heat exhausted in our daily life into electricity, have become promising candidates to meet the challenges of global energy issues. Layered cobalt oxides such as $Na_{3/4}CoO_2$ and $Ca_3Co_4O_9$ are attracting increasing attention as potential p-type thermoelectric materials due to their promising thermoelectric properties and environmental compatibility. However, the *ZT* of layered cobalt oxides is lower compared to heavy metal-based chalcogenides like Bi_2Te_3 and PbTe, mainly due to their high thermal conductivity. In this regard, we hypothesized that the thermal conductivity of layered cobalt oxides can be reduced by heavier ion substitution.[1] Recently, we found that $Ba_{1/3}CoO_2$ films exhibit a rather high *ZT* of 0.11 at room temperature[2], which arouse our interest to investigate the high-temperature performance of them. In this study, we investigated the thermal stability and thermoelectric properties of the $Ba_{1/3}CoO_2$ epitaxial films at elevated temperatures.

Experimental

$Na_{3/4}CoO_2$ epitaxial films were prepared by the R-SPE method[3] and then the Na^+ ions were exchanged with Ba^{2+} ions by the ion exchange treatment to obtain $Ba_{1/3}CoO_2$ epitaxial films. Resistivity, thermopower, and thermal conductivity of the $Ba_{1/3}CoO_2$ epitaxial films were measured in air at elevated temperatures.

Results and discussion

The resultant $Ba_{1/3}CoO_2$ films are very stable in air with a limitation temperature of up to ~600 °C, which is higher than the thermal stability temperature of $Na_{3/4}CoO_2$ (~350 °C). The power factor of $Ba_{1/3}CoO_2$ films is similar to $Na_{3/4}CoO_2$ films above room temperature with a value of ~1 mW m^{-1} K^{-2} (**FIG. a**). The thermal conductivity of $Ba_{1/3}CoO_2$ films at room temperature is ~3 W m^{-1} K^{-1}, much lower than $Na_{3/4}CoO_2$ films (~5.5 W m^{-1} K^{-1}), and it greatly decreased to ~1.7 W m^{-1} K^{-1} at 573K (**FIG. b**). As a result, a high *ZT* of ~0.33 at 573K was achieved, which is the highest among oxide thermoelectric materials (among reliable data). The present results indicate that $Ba_{1/3}CoO_2$ films possess excellent high-temperature thermoelectric performance, showing a potential for high-temperature application.

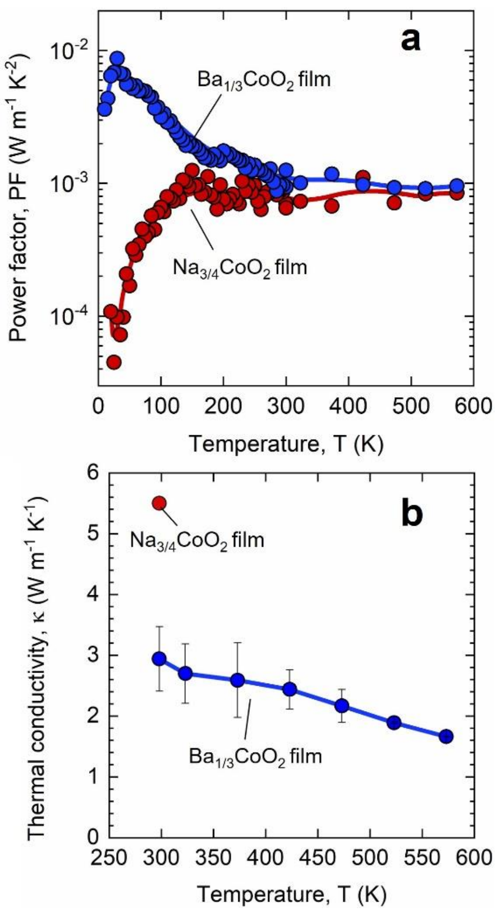

FIG. Temperature dependence of (**a**) power factor and (**b**) thermal conductivity of $Ba_{1/3}CoO_2$ and $Na_{3/4}CoO_2$ epitaxial films.

References

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