Thermoelectric Properties of $Ca_{2.9}M_{0.1}Co_4O_9$ (M = Li, Na, and K) and $Ca_3Co_{3.9}N_{0.1}O_9$ (N = Li, Na, and K) Fabricated by Spark Plasma Sintering Process

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Abstract (Arial 10)

Thermoelectric modules are solid-state devices that directly convert thermal energy into electrical energy, based on the Seebeck effect. The key issue in thermoelectric modules is to develop materials whose thermoelectric properties are highly stable at high temperatures. Oxide based materials have attracted a significant attention for high-temperature thermoelectric applications, due to their high thermal and chemical stability [1]. In particular, $Ca_3Co_4O_9$ has been recognized as a good candidate for high-temperature thermoelectric applications. The $Ca_3Co_4O_9$ has a layered structure consisting of two monoclinic subsystems, CaO–CoO–CaO rock salt-type layer and CdI_2-type CoO_2 layer, stacked along the *c*-axis direction [2]. In this study, polycrystalline $Ca_{2.9}M_{0.1}Co_4O_9$ (M = Li, Na, and K) and $Ca_3Co_{3.9}N_{0.1}O_9$ (N = Li, Na, and K) samples were fabricated by spark plasma sintering process using the $Ca_{2.9}M_{0.1}Co_4O_9$ and $Ca_3Co_{3.9}N_{0.1}O_9$ powders prepared by sol–gel method. XRD patterns were in good accordance with $Ca_3Co_4O_9$ (JCPDS card No. 21-0139), indicating that the prepared samples are in $Ca_3Co_4O_9$ type symmetry. The electrical conductivity increased with increasing temperature in the whole temperature range, indicating the semiconducting behavior. The sign of the Seebeck coefficient was positive for the entire measured temperature range, indicating that the major conductivity carriers are holes. The Seebeck coefficient increased with an increase in temperature. The power factor and figure-of-merit of the $Ca_{2.9}M_{0.1}Co_4O_9$ and $Ca_3Co_{3.9}N_{0.1}O_9$ increased with an increase in temperature, implying high thermal stability at high temperatures. The effects of substitution of alkali metal elements (Li, Na, and K) for Ca and Co on the thermoelectric properties were systematically investigated in an attempt to achieve a further improvement in the thermoelectric performance of the material.

References

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