THERMOELECTRIC MATERIALS BASED ON THE LAYERED SODIUM COBALTITE

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The nanostructured layered sodium cobaltite (LSC) Na_xCoO_2 is perspective basis for development of materials of sodium ion battery (SIB) electrodes and *p*-branches of high-temperature thermoelectric generators. The physicochemical and functional characteristics of the layered sodium cobaltite can be improved by varying its cationic composition, and therefore research of derivatives of this phase is of considerable interest.

We have prepared by means of the solid-state reactions method a wide range of LSC derivatives with different sodium content and partial substitution of cobalt with transition and heavy metals. Their crystal structure and microstructure, electrical transport (electrical conductivity (σ), thermo-EMF (S)), thermophysical (thermal expansion, thermal diffusivity (η), thermal conductivity (λ)) properties in the range 300 – 1100 K were studied. The values of the power factor (P) and thermoelectric figure of merit (ZT) of LSC were calculated using formulas $P = S^2 \cdot \sigma$ and $ZT = PT/\lambda$. The lattice (λ_{lat}) and electronic (λ_{el}) contributions to the thermal conductivity were found using relationship $\lambda = \lambda_{el} + \lambda_{lat}$, $\lambda_{el} = \sigma LT$, where L is the Lorentz number ($L = 2.45 \cdot 10^{-8}$ $W\Omega K^{-2}$).

Effect of sodium content, nature of substituting cobalt metal and substitution degree on the crystal structure, microstructure, chemical stability in atmosphere containing water vapors and carbon dioxide, physicochemical and functional properties of LSC derivatives was analyzed. It was shown, that variation of cationic composition of LSC allows to obtain thermoelectric ceramics with improved characteristics [1 – 3]. For example, the power factor values of $Na_{0.89}CoO_2$, $Na_{0.55}Co_{0.90}Cr_{0.10}O_2$, $Na_{0.89}Co_{0.90}Ni_{0.10}O_2$ and $Na_{0.55}Co_{0.90}Bi_{0.10}O_2$ cobaltites at 1100 K are respectively 829, 917, 919 and 1018 $\mu W/m \cdot K^2$. The values of the dimensionless thermoelectric quality index for cobaltites $Na_{0.89}Co_{0.90}Bi_{0.10}O_2$, $Na_{0.89}Co_{0.90}Ni_{0.10}O_2$, $Na_{0.55}Co_{0.90}Sc_{0.10}O_2$ and $Na_{0.89}CoO_2$ at 1100 K are 0.83, 1.12, 1.45 and 1.57 respectively. This value exceeds the theoretical criterion ($ZT > 1$) that determines materials of practical interest for thermoelectric conversion, and suggests that LSC is a potentially attractive material for thermoelectric conversion.

References

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