Oxide thermoelectric power generation

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ABSTRACT

Oxide thermoelectric materials are considered to be promising ones because of their durability against high temperature, cost, no content of toxic elements, and so on. It is partly correct. For example, since n-type oxides of ZnO or $SrTiO_3$ systems need oxygen deficiency for electrical conduction, their electrical resistivity increases by oxidization at high temperature in air. However, the durability and cost of modules, which is composed of many p and n-type devices connected by electrodes, are more important for power application. In this paper, after discussion of thermoelectric properties of p-type $Ca_3Co_4O_9$ (Co-349) and n-type $CaMnO_3$ (Mn-113) devices power generation properties of modules composed of these oxides, a new concept of creating oxides possessing high *ZT* values will be shown from a standpoint of power application.

Thermoelectric modules composed of 108 pairs of p-type $Ca_{2.7}Bi_{0.3}Co_4O_9$ and n-type $Ca_{0.9}Yb_{0.1}MnO_3$ legs were constructed using Ag electrodes and Ag paste including the p-type powder. Dimensions of both oxide legs were 7 mm wide and 3.5 mm thick and 5 mm high. There was no substrate on the both sides of the module, namely a skeleton type module. The module can generate up to 10 V and 12 W of open circuit voltage and maximum power, respectively, at a hot-side temperature of 873 K and a temperature differential of 400 K in air. The maximum density of power generation reaches 4.2 kW/m^2 by decrease in space between oxide devices so far.

Spontaneous phase separation in nano scale by spinodal decomposition is observed in slowly cooled $Zn(Mn, Ga)_2O_4$. Thermal conductivity of an intra-granular phase separated bulk, in which two distinct types of rectangular nano-rods with different compositions interlace to form a cross-sectional checkerboard pattern, and of a bulk of inter-granular mixture of the same composition with two types of the nano-rods was compared. Thermal conductivity of the intra-granular phase separated bulk is lower than that of the inter-granular mixture and locates below the theoretical minimum limit of the mixture.