

Development of Nanocomposite Thermoelectric Generators for Body Heat Harvesting

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This work evaluates wearable thermoelectric (TE) devices consisting of nanocomposite thermoelectric materials, aluminum nitride ceramic headers, and a flexible and stretchable circuit board. These types of wearable systems are part of a broader effort to harvest thermal energy from the body and convert it into electrical energy to power wearable electronics. Thermoelectric generators are made of p-type $(\text{Bi,Sb})_2\text{Te}_3$ and n-type $\text{Bi}_2(\text{Te,Se})_3$. The nanocomposite thermoelectric materials investigated in this research address the two fundamental challenges for body heat harvesting. The first challenge is related to the unavailability of high zT n-type materials near the body temperature. The second challenge is related to the thermoelectric power factor. To improve the zT , one has to increase the power factor simultaneously while reducing the thermal conductivity. Our nanocomposites result in enhancement of the TE power factor along with the reduction of the thermal conductivity. The fundamental reason is a nanoscale effect that happens only when the energy distribution function of the carriers does not relax to that of the bulk material in the crystallites. Ten p-type and ten n-type nanocomposite ingots were synthesized and characterized in this research. All ingots were characterized versus their thermoelectric properties and they all showed similarly enhanced properties. Our nanocomposites, compared to commercial materials, have better zT and thermal resistivity by 40% and 75% for p-type, respectively, and 15% and 140% for n-type. Compared to the state-of-the-art materials, our nanocomposites produce significantly higher power due to their optimized properties for the body temperature.