Thermoelectric Properties of C_{60} Doped $Bi_{0.5}Sb_{1.5}Te_3$

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Abstract

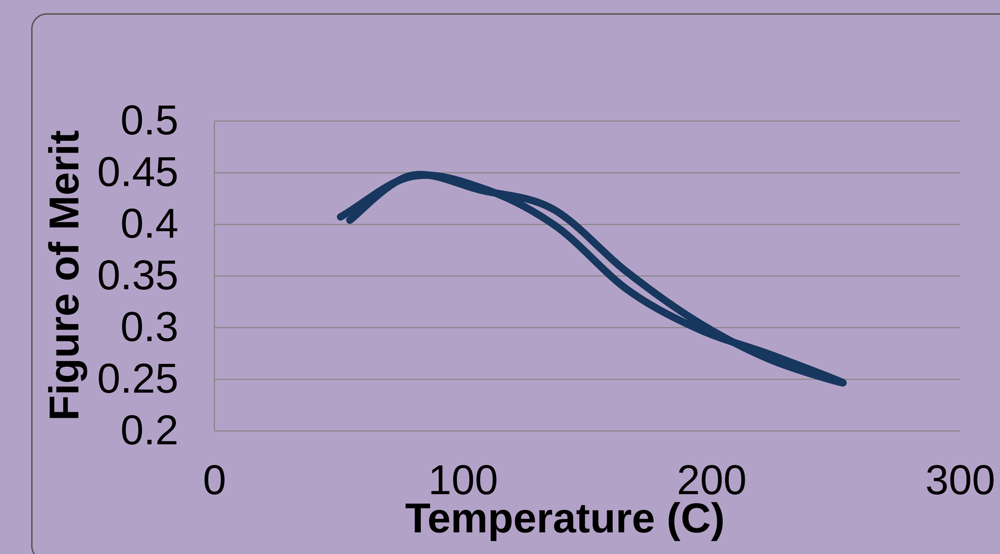
Thermoelectric $Bi_{0.5}Sb_{1.5}Te_3$ compounds doped with C_{60} were fabricated in the laboratory by using ball milling, cold pressing, and several heat treatments. This method ensures the samples to be fabricated with fullerene molecules. Fullerene molecules reduces the lattice thermal conductivity in the sample and is studied for enhancing the dimensionless thermoelectric figure of merit (ZT),

$$ZT = \frac{S^2T}{\rho k}$$

where S is the Seebeck thermoelectric coefficient; *T* is the temperature; *k* is the thermal conductivity; and ρ is the electrical sensitivity, respectively. The samples are optimized with C_{60} in $Bi_{0.5}Sb_{1.5}Te_3$ alloys to improve the figure of merit. Concentrations of C_{60} in 0.35 and 0.5wt% are used to determine the differences between the pure $Bi_{0.5}Sb_{1.5}Te_3$ sample and others doped with C_{60}. The samples are measured in the temperature range of 50˚C to 255˚C.

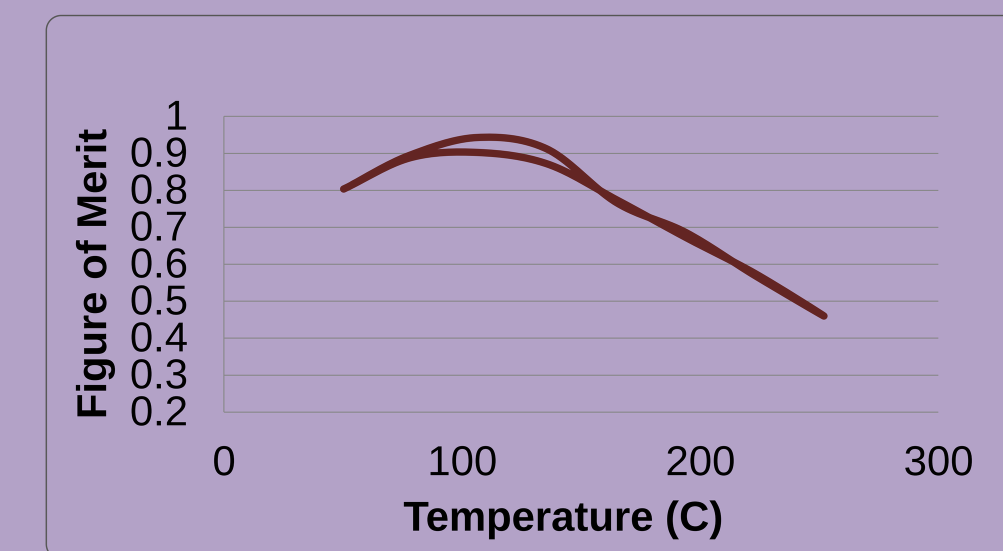
Methods

Syntheses of the samples were possible by ball milling, cold press, and heat treatments. Hydrogen reduction is a priority during heat treatments. Hydrogen reduction allows the sample to remove oxidation. After fabrication, the samples were measured by using a ZEM-3 instrument to determine the thermoelectric figure of merit . The following figures shows the results.



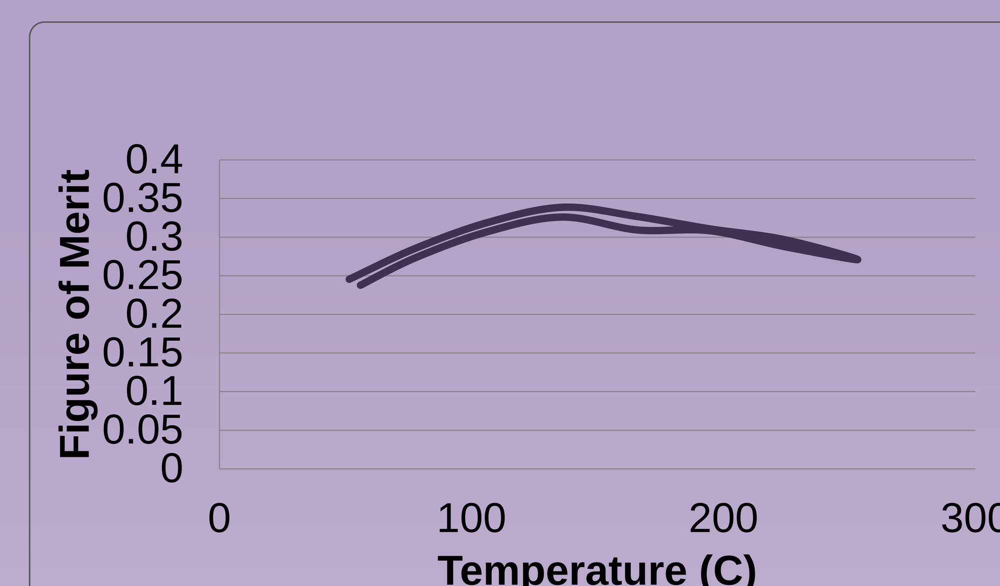
Pure $Bi_{0.5}Sb_{1.5}Te_3$

Figure 1(a)



0.35% C_{60} $Bi_{0.5}Sb_{1.5}Te_3$

Figure 1(b)



0.5% C_{60} $Bi_{0.5}Sb_{1.5}Te_3$

Figure 1(c)

Results

The measured results of the samples show the figure of merit depending on the temperature and C_{60} doping. Figure 1(b) shows the figure of merit to be between 0.8 and 1.0 1 in the temperature range of 75 to 150˚C. This sample show better thermoelectric performance for applications for this temperature range. Whereas, Figures 1(a) and 1(c) share a lower thermoelectric figure of merit, respectively.

Figure 2.
Sample fabricated after cold pressing the materials.

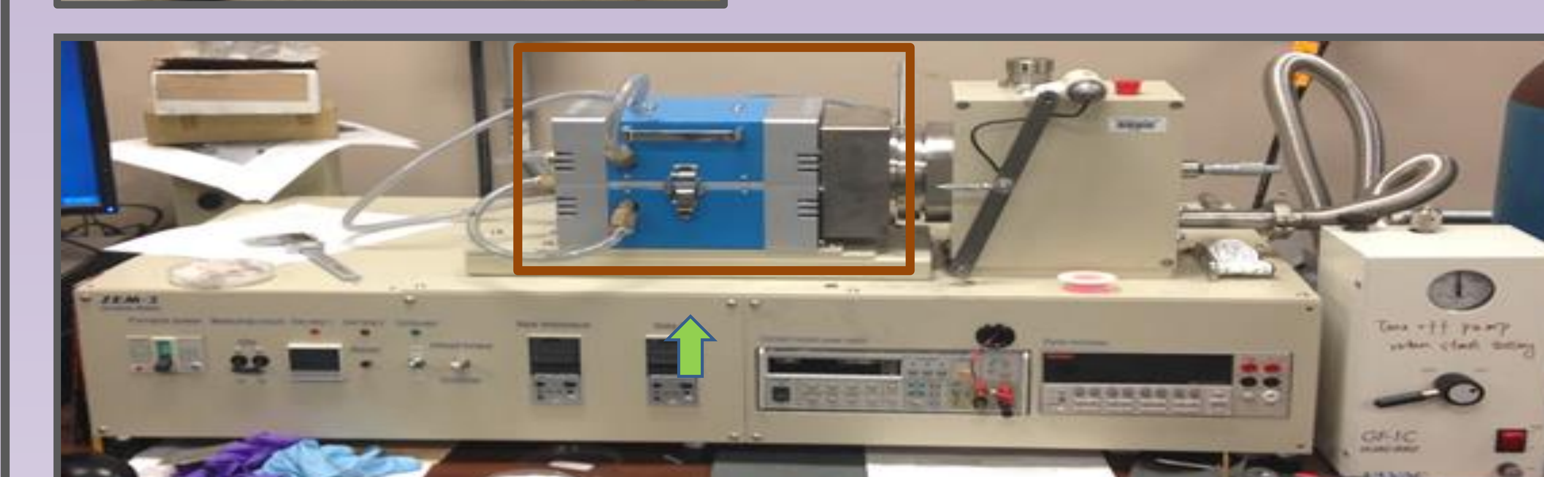


Figure 3. ZEM-3 at LSU Engineering Research and Development Laboratory. Samples were placed in the furnace and current is sent through the sample and T is measured by thermal couplets. Arrow indicates the location of the sample.

Conclusion

Bismuth telluride based alloys are some of the highest thermoelectric performance materials, which are used for waste heat harvest. However, these materials still operate at a relatively low efficiency. With the introduction of C_{60} fullerene molecules to the material structure; the thermoelectric figure of merit of the material is increased significantly. In this work, the syntheses of $Bi_{0.5}Sb_{1.5}Te_3$ doped with C_{60} were achieved. The C_{60} concentration of 0.35wt% warrants promising results for thermoelectric applications. Specifically, in the temperature range of 75˚C to 150˚C, good thermoelectric figure of merit of the sample is between 0.8 and 1.0.

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