CRIMSON PUBLISHERS
Wings to the Research

Research & Development in Material Science

ISSN: 2576-8840

Mini Review

Application Prospects of Thermoelectric Technique

Lijuan Zhang[1], Xinqi Chen[2,3] and Chao Han[1]*

[1]*Institute for Superconducting and Electronic Materials, Australia*

[2]*School of Physics and Mechanical & Electrical Engineering, China*

[3]*State Key Laboratory for Modification of Chemical Fibres and Polymer Materials, China*

***Corresponding author:** Chao Han, Institute for Superconducting and Electronic Materials, Australia

Submission: February 13, 2018; **Published:** February 22, 2018

Abstract

Thermoelectric devices (TE), which could convert heat into electricity directly or vice versa, as presented in Figure 1a [1], may serve as solid state power generation or refrigeration with advantages of good reliability and scalability without any moving parts or emissions. Thereby although the energy conversion efficiency of TE devices is low; it has shown bright future in many fields.

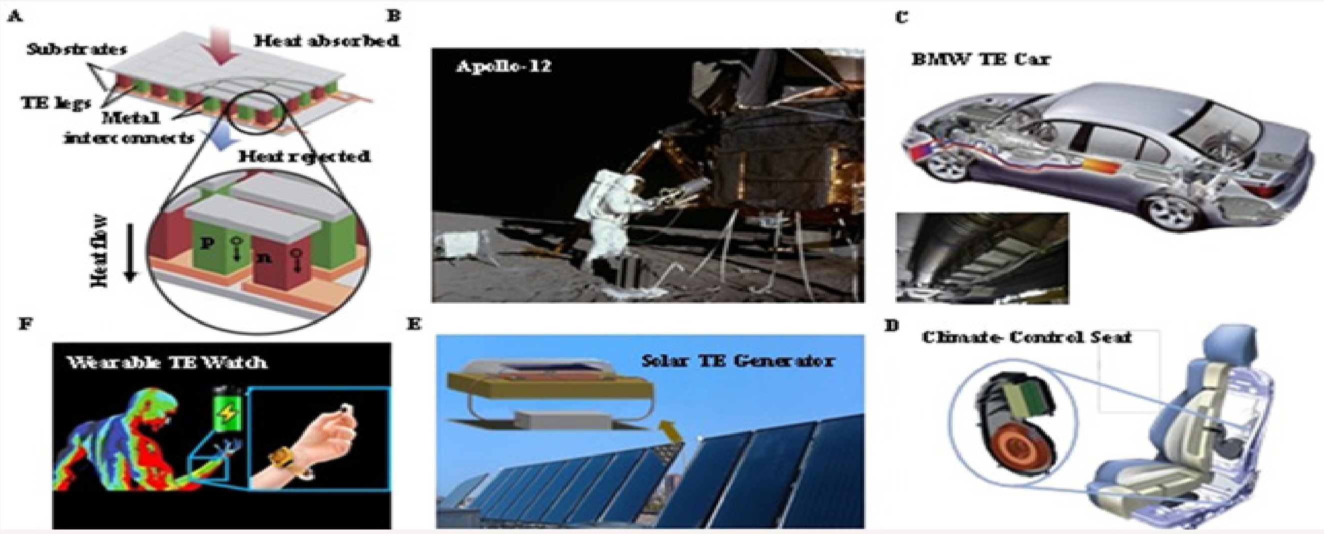

Figure 1:
1a: Schematic of thermoelectric module [5]
1b: An example of RTG deep space exploration on Moon [6]
1c: Schematics of BMW 530i concept car with a thermoelectric generator [7]
1d: Automotive climate control seat in cars [8]
1e: Schematics of solar TE generators [9]
1f: An example of TEG-powered wearable device [10].

Mini Review

Deep space exploration

Since the silicon germanium based high-temperature thermoelectric materials have been developed (around 1960s), TE generators have been used to power deep space exploration missions. A uniquely capable source of power is the radioisotope thermoelectric generator (RTG), which direct converts heat from the natural decay of radioisotope materials, often plutonium-238, into electricity. Up to now, series spacecrafts including the Apollo missions (to the Moon, Figure 1b), the Curiosity missions (to the Mars), and Voyager missions (outer Solar System) are all powered by RTGs because of their reliability and universal [2-4].

Automotive exhaust TE generators (TEGs)

It is estimated that more than 60% of the energy are lost in the form of heat in a common hot engine, with half of which going to exhaust heat and the other to the cooling system. Exhaust TEGs can capture exhaust waste heat and turn it into electrical energy, which was first attracted to the BMW engine with development more than 10 years (Figure 1c) [7]. Thus far, this technology has successfully converted 4%-5% of the escaping heat to 500-750 watts of electricity. This increases fuel economy by 1%-5%, and in turn, reduces the fuel combustion and emissions.

Climate-control seat (CCS)

CCS system has thermoelectric heat pumps in the back and bottom cushions (Figure 1d) [8]. Conditioned air passes from the thermoelectric system through channels to the occupant, providing on-demand cooling or heating. This CCS system is being installed in more than 500,000 vehicles one year. Although their thermodynamic energy conversion efficiency is lower than that of traditional automotive air-conditioning systems, their overall system efficiency at delivering thermal comfort is noteworthy enhanced.

Solar TE generators (STEGs)

The conversion of sunlight into electricity has been dominated by photovoltaic and solar thermal power generation. A typical STEG is shown in Figure 1e. At present, STEGs have achieved efficiencies as high as 5% [9]. The ability to generate electricity by improving existing technology at minimal cost makes this type of power generation self-sustaining from a cost standpoint. Besides solely worked as STEGs, the TE devices could also be integrated onto a traditional solar photovoltaic decvices to further increase efficiency of solar to electricity because extra electricity would be produced by surface heating of the solar panel.

Wearable and importable electronics

Recently, to avoid the limitations of traditional solid-state thermoelectric materials, such as frangibility and lack-of-fit between the TEGs and the surface of heat source, flexible TE devices are proposed and designed for wearable and importable electronics. Implantable TEGs capture the heat temperature gradient from the body core to the skin surface, while wearable TEGs utilize the temperature difference between the skin surface and the ambient (Figure 1f) [10,11]. The MATRIX PowerWatch, which is first released in 2016, is the world's first smartwatch that you never have to charge. Powered by your body heat, it measures calories burned, activity level, and sleep using our advanced thermoelectric technology.

Conclusion

With the development of society and other relevant techniques, thermoelectric techniques should have much brighter future in micro-electronics; coupling with other techniques to enhance efficiency; and places requiring maintenance-free, low consumption power sources/coolers.

Acknowledgement

L. J. Z. and X. Q. C. contributed equally to this work. This project was funded by National Natural Science Foundation of China (No.51702091), the Natural Science Foundation of Hubei Province, China (No. 2017CFB192), the China Postdoctoral Science Foundation (No.2017M621320), and the Fundamental Research Funds for the Central Universities.

References

1. Han C, Sun Q, Li Z, Dou SX (2016) Thermoelectric enhancement of different kinds of metal chalcogenides. Advanced Energy Materials 6(15): 1600498.
2. Grotzinger JP (2013) Analysis of surface materials by the curiosity mars rover. Science 341(6153): 1475-1475.
3. Champier D (2017) Thermoelectric generators: A review of applications. Energy Conversion and Management 140: 167-181.
4. Zhang L, Wang J, Sun Q, Qin P, Cheng Z, et al. (2017) Three-stage inter-orthorhombic evolution and high thermoelectric performance in Ag-doped nanolaminar snse polycrystals. Advanced Energy Materials 7(19): 1700573.
5. Snyder GJ, Toberer ES (2008) Complex thermoelectric materials. Nature materials 7(2): 105-114.
6. Pei Y, LaLonde A, Iwanaga S, Snyder GJ (2011) High thermoelectric figure of merit in heavy hole dominated PbTe. Energy & Environmental Science 4(6): 2085-2089.
7. Vining CB (2009) An inconvenient truth about thermoelectrics. Nature materials 8(2): 83-85.
8. Heremans JP, Dresselhaus MS, Bell LE, Morelli DT (2013) When thermoelectrics reached the nanoscale. Nature nanotechnology 8(7): 471-473.
9. Kraemer D, Poudel B, Feng H-P, Caylor JC, Yu B, et al. (2011) High-performance flat-panel solar thermoelectric generators with high thermal concentration. Nat Mater 10(7): 532-538.
10. Leonov V, Vullers RJ (2009) Wearable electronics self-powered by using human body heat: The state of the art and the perspective. Journal of Renewable and Sustainable Energy 1(6): 062701.
11. Yang Y, Wei X-J, Liu J (2007) Suitability of a thermoelectric power generator for implantable medical electronic devices. Journal of Physics D: Applied Physics 40(18): 5790-5800.

How to cite this article: Lijuan Z, Xinqi C, Chao H. Application Prospects of Thermoelectric Technique . Res Dev Material Sci. 3(5). RDMS.000571.2018.
DOI: 10.31031/RDMS.2018.03.000571