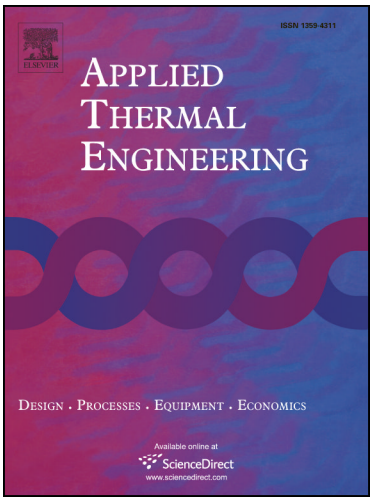

Research Paper

Experimental prototype and simulation optimization of micro-radial milliwatt-power radioisotope thermoelectric generator

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Experimental prototype and simulation optimization of micro-radial milliwatt-power radioisotope thermoelectric generator

Kai Liu [a], Yunpeng Liu [a,b], Zhiheng Xu [a], Zhengrong Zhang [a], Zicheng Yuan [a], Xiao Guo [a], Zhangang Jin [a] and Xiaobin Tang [a,b,*]

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Highlights

- A micro-radial radioisotope thermoelectric generator is manufactured and tested.
- The simulated performance of the RTG are compared with the experimental value.
- Performance characteristics were determined in different sizes and numbers.
- The designed RTG is expected to be a reliable space power supply for MEMS.

Abstract

To satisfy the flexible power demand of the low power dissipation devices in the independent space electric system, a micro-radial milliwatt-power radioisotope thermoelectric generator (RTG) was prepared and optimized in this research. The overall geometrical dimension of the RTG in the experiment was 65 mm (diameter) × 40 mm (height). The RTG, which was built and tested using simulated radioisotope source, eventually obtained an open-circuit voltage of 92.72 mV, an electric power of 149.0 μW, and an energy conversion efficiency of 0.015% at the ambient temperature of 293.15 K and heat source power from 0.1W to 1 W. On the basis of the structure used in the experiment, the length and cross-sectional area of the thermoelectric leg and the number of thermoelectric modules were effectively optimized through the COMSOL Multiphysics. With the optimized length of 35 mm and cross-sectional area of 1.2 mm^2, the RTG with four thermoelectric modules achieved a 15.8 mW output power under 1 W heat source power. The maximum conversion efficiency calculated using COMSOL code increased to 1.58%. According to the optimized electrical output, the micro-radial RTG is expected to be a reliable space power supply for micro components and could satisfy the low power requirements of space missions.

Keywords : Bismuth telluride; Energy conversion; COMSOL; MEMS; Radioisotope thermoelectric generator

Nomenclature

A_1 the heat-receiving area, mm^2

C the Stefan－Boltzmann constant

F_{12} the view factor

h the convective heat transfer coefficient, $W/(m^2 \cdot K)$