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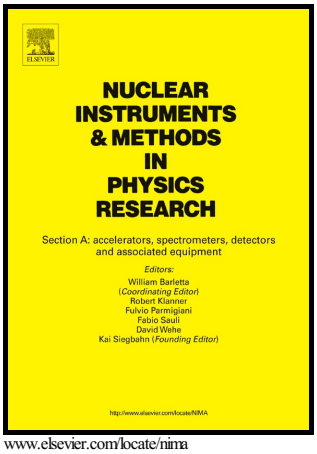

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Toward High Performance Radioisotope Thermophotovoltaic Systems Using Spectral Control

Xiawa Wang[a,b,*], Walker Chan[b], Veronika Stelmakh[a,b], Ivan Celanovic[b], Peter Fisher[b,c]

[a] *Electrical Engineering Department, Massachusetts Institute of Technology, Cambridge, MA, 02139, USA*
[b] *Institute for Soldier Nanotechnologies, Massachusetts Institute of Technology, Cambridge, MA, 02139, USA*
[c] *Physics Department, Massachusetts Institute of Technology, Cambridge, MA, 02139, USA*

Abstract

This work describes RTPV-PhC-1, an initial prototype for a ~~high performance~~ radioisotope thermophotovoltaic (RTPV) system using a two-dimensional photonic crystal emitter and low bandgap thermophotovoltaic (TPV) cell to realize spectral control. We validated a system simulation using the measurements of RTPV-PhC-1 and its comparison setup RTPV-FlatTa-1 with the same configuration except a polished tantalum emitter. ~~with an electric heater providing energy equivalent to one plutonia fuel pellet.~~ The emitter of RTPV-PhC-1 powered by an electric heater providing energy equivalent to one plutonia fuel pellet ~~system~~ reached 950°C with 52 W of thermal input power and produced 208 mW output power from 1 cm^2 TPV cell. We compared the system performance using a photonic crystal emitter to a polished flat tantalum emitter and found that spectral control with the photonic crystal was four times more efficient. Based on the simulation, with more cell areas, better TPV cells, and improved insulation design, the system powered by ~~one~~ a fuel pellet equivalent heat source is expected to reach an efficiency of 7.8%.

Keywords: radioisotope electrical generator, photonic crystal, spectral control, RTPV, thermophotovoltaic

1. Introduction

Radioisotope batteries can power an electrical system when external energy input, such as solar energy or chemical energy, is not possible. The specific energy ~~energy density~~ of a radioactive source is often in the order of 10^6 MJ/kg, which makes radioisotope electrical generators with desired output level and decades of lifetime a possibility. ~~while that of hydrocarbon fuels is only 40 MJ/kg, thus the nuclear batteries have much longer lifetimes than other batteries~~. Thermal-based nuclear power sources use the heat released during radioactive decay. Plutonium-238, which is an alpha emitter with high decay heat, is oxidized,

*Corresponding author
Email address: xiawaw@mit.edu (Xiawa Wang)