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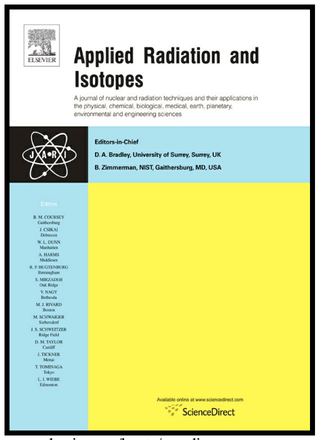

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High Power Beta Electron Device - Beyond Betavoltaics

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Abstract

Developing watt level power sources with beta emitting radioisotopes has been limited by the inability to utilize high energy (> 100 KeV) beta emitters at high radioisotope loadings without damaging the energy conversion materials. A new type of beta electron power source is described that removes those restrictions. The approach contains the radioisotope in a beta transparent titanium tube and confines beta electrons emitted through the tube wall to spiral trajectories around the tube with an axial magnetic field. The confined beta electrons dissipate energy though multiple interactions with surrounding excimer precursor gas atoms to efficiently generate photons. Photovoltaic cells convert the photons to electrical power. Since the beta electrons dissipate energy in the excimer precursor gas, the device can be loaded with more than 10^{13} Bq of radioisotope to generate 100 milliwatt to watt levels of electrical power without damaging the device materials or degrading its performance. The power source can use a variety of beta radioisotopes and scales by stacking the devices.

1. Introduction

Unattended, long-life power sources are needed for devices in isolated environments. These sources can power communications and sensor applications on undersea platforms, deep space vehicles, and other remote, dark locations. Powering such devices with beta electron emitting radioisotope sources rather than rechargeable batteries can decrease system weight, provide extremely low temperature operation, and increase system longevity.

Attempts to efficiently convert beta electron charge and kinetic energy into electrical power have been pursued for decades. However, these approaches capture only a very small fraction of the beta electron energy. A recent review describes one type of beta radioisotope power device, the betavoltaic cell [1]. In these devices, beta electrons are absorbed in a doped semiconductor material to produce electron-hole pairs. The electron-hole pairs are separated by a Schottky or PIN junction to produce electrical power. The devices have nanowatt to microwatt power output and very low conversion efficiencies. A major problem with betavoltaic cells is destruction of the semiconductor material from beta electron bombardment. This limits such cells to low energy beta emitters, such as tritium, and small quantities of radioisotope[2]. The low radioisotope loading limits the power output.

Another energy conversion approach relies on generating excimer light from noble gas atoms with alpha and beta particles emitted from fission by-products. Prelas and co-workers have investigated this approach [3,4]. The alpha and beta emitting materials in the form of aerosol powders or encapsulated particles are mixed with the noble gas. The excimer light emission is captured by a photovoltaic cell to generate power. Problems with this approach include the need for significant radiation shielding,