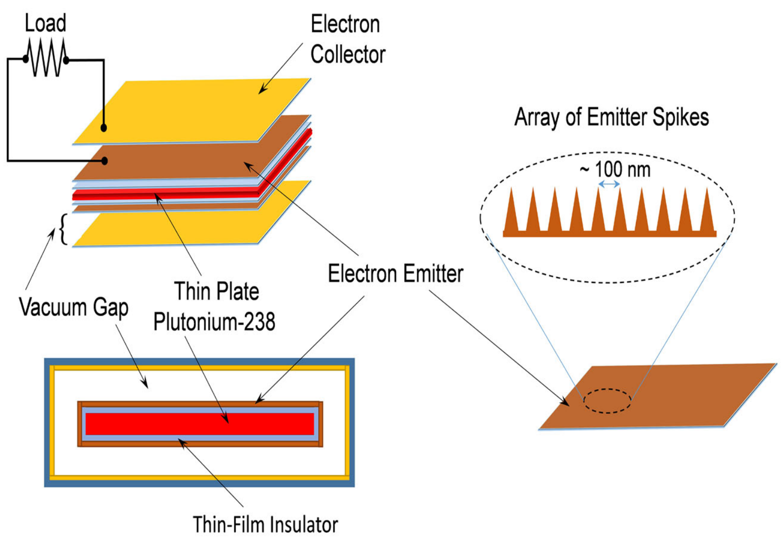


Image Credit: NASA

National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Power Generation and Storage

Portable Compact Thermionic Power Cell

Higher power density than RTGs for long-term remote, isolated or dangerous applications

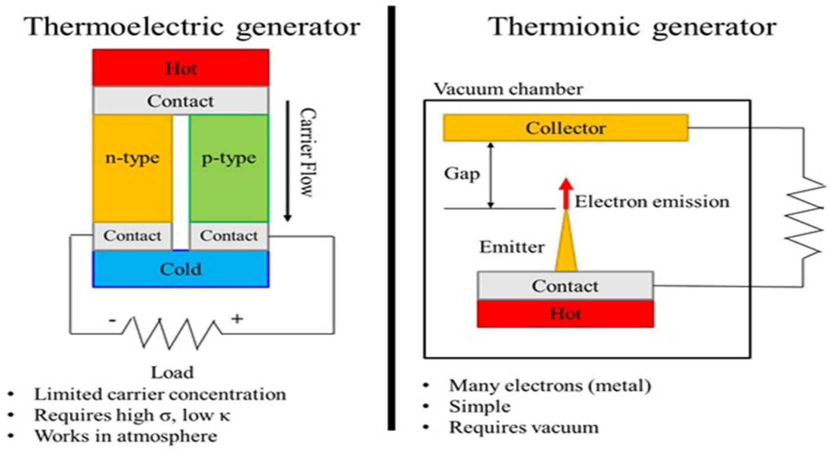
Ideal power sources for portable equipment ideally should be small, compact, lightweight, and provide continuous power with high power density. Batteries meet all but the continuous power requirement. Radioisotope thermoelectric generators (RTG) meet the continuous power condition but none of the others. However, a compact, thermionic-based cell that converts heat to electricity can meet all the above requirements . A tightly spaced array of nanometer-scale emitter points efficiently converts the heat from Plutonium-238 (238 Pu) into usable electricity. The thermionic cell uses metals with low work-function, not semiconductors, and escapes many of the RTG limitations such as lower carrier concentration and mobility, and the difficult requirement of high electrical and low thermal conductivity. It delivers an estimated 10-20% vs. 7% efficiency for an equivalent-sized, 238Pu-based RTG. Such a power cell would be ideal for remote, hazardous or otherwise isolated applications such as remote sensors/transmitters in severe environments.

BENEFITS

- Thermionic emission is simpler and slightly more efficient than thermoelectric materials, with reported efficiencies of 10-20% versus 6-7% for TEG
- Adapts well-established semiconductor manufacturing techniques, lowering the initial investment costs
- Because of thin-film structures, the device can be fabricated as small as a button cell.
- Long lasting since the half-life of 238Pu decay is 87.7 years

THE TECHNOLOGY

This compact thermionic cell (CTI) technology can be manufactured efficiently and economically using existing semiconductor fabrication technology. Its design consists of a top electron collector, separated by a vacuum gap from an electron emitter adjacent to the heat source, a thin plate of 238Pu enclosed by a thin-film insulator to protect the emitter and collector layers from overheating by the 238Pu. For a smart phone battery size, the invented compact thermionic (CTI) cell requires about 5 g maximum of 238Pu. Such small quantities are more readily available and producible, and could be reused for recycling when the CTI cell is dismantled. The emitter surface is topologically modified to have array of spikes, achievable using current semiconductor microfabrication technology. Various other geometries of emitter plates may also be used, such as an array of ridges. The smaller the emitter tips, the higher the voltage concentration.



Thermoelectric vs. thermionic power generation. Image Credit: NASA

APPLICATIONS

The technology has several potential applications:

- Any application requiring a relatively lightweight, compact, long-lived power source, including remote, hazardous (bio, chemical, radiation, environmental), dangerous, and isolated/irretrievable applications. Among them:
- Remote sensors/transmitter
- Beacons
- Small satellites
- Robots
- Drones

PUBLICATIONS

Patent No: 11,094,425; 11,721,451

technology.nasa.gov

More Information

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