BETAVOLTAIC POWER SOURCES FOR LOW-POWER APPLICATIONS IN THE DARK.

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Introduction: One of the desirable technologies for a mission surviving the 354-hour lunar night is the ability to provide a small amount of "keep alive" power, even in conditions of total darkness and low temperatures. Radioisotope sources are a reasonable choice for a power source in such conditions, but for small missions, the cost and the regulatory burden of traditional radioisotope thermoelectric generators using plutonium isotopes can be prohibitive. An alternative power source utilizing betavoltaic conversion may be suitable for such missions. Although these are low power devices (~100 µW power levels), the technology is reasonable for "keep alive" power requirements for electronics across the lunar night.

Betavoltaic Conversion

Betavoltaic power. A betavoltaic cell is a solid-state device that directly produces power from the electrons produced by beta decay of a radioactive isotope [1]. The radioactive decay of a beta-emitting isotope emits high-energy electrons. When these electrons pass through a semiconductor, they produce electrons/hole pairs. The energy of these electron/hole pairs can be converted into electrical power by a p-n junction, in the same way that a solar cell converts electron hole pairs produced from photons. A schematic of such a device is shown in figure 1.

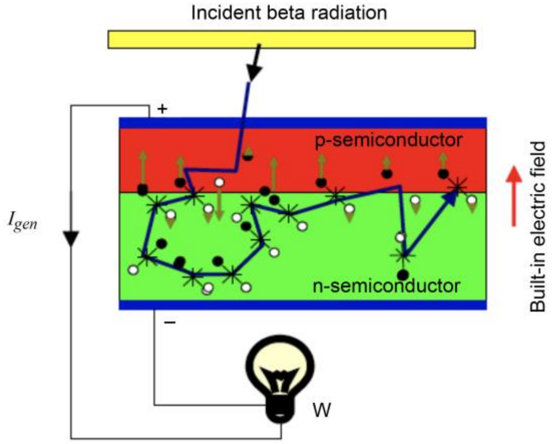

Figure 1*: schematic of betavoltaic power generation.*

Betavoltaic cells have no moving parts, and are capable of operating at low (and even cryogenic) temperatures, and thus are well suited for lunar night applications. Betavoltaic devices scale well to low power levels.

Several beta-emitting isotopes are possible as the source. For the lunar missions, tritium (^{3}T) is a reasonable choice, since the 19-keV emission energy of the electrons is easily shielded, and thus tritium sources are not subject to the stringent radiation standards of other isotope sources used to generate power in space such as ^{238}Pu [6].

A tritium source has the following properties:

- Half-life = 12.3 years
- Maximum beta decay e^- energy 19 keV

Small betavoltaic power sources are in the process of being developed for NASA missions [2,3]. Commercial units are available, *e.g.*, at power levels of 0.1 to 1 µW [7] at a mass of ~8 grams, with power levels up to 100 µW in development [5].

Alphavoltaic power. An alternative radioisotope direct conversion technology could be alphavoltaic power, in which the energy of alpha particles from spontaneous fission are used [2]. A wide range of possible isotopes can be used as the source, including plutonium-238 with a half-life of 87.7 years, or curium 244, with a higher initial power, but a slightly lower half-life of 17.6 years. Alpha emitters produce alpha particles with much higher energy than the electrons produced by beta emitters. While this means that the power levels produced can be significantly higher, it also means that the semiconductors used for alphavoltaic converters are subject to alpha-induced radiation damage, reducing their operating lifetime. While currently existing devices do not have the multi-decade lifetimes desired for deep space missions, they may be usable for keep-alive power for shorter lunar missions.

Acknowledgments: Portions of this work have been supported by the NASA Small Business Innovative Research (SBIR) program.

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