Tritium nuclear battery for high-voltage, high impedance loads

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Nuclear batteries have been built utilizing merely a tritium beta source, an electron collector, and vacuum or solid dielectric. Overall conversion efficiencies near 10% are achieved even with 2π source configurations using the vacuum dielectric. Open circuit voltages above 5000V using vacuum dielectric and 1300V can be continuously drained using solid-state dielectrics. An attractive feature of the solid-state tritium device is that the bias voltage under load can be engineered over a very wide range (5-5000V) using dielectric composition, thickness, and source strength. Either negative or positive voltage can be used.

A model describing the behavior of current and voltage on the useful electrical load for both cases of dielectric (solid and vacuum) is presented. The model includes consideration of the tritium beta particle emission from a metal-tritide source and charge accumulation on the metal collector even when the solid dielectric is much thicker than the tritium beta range. Calculations of load characteristics of batteries are in good agreement with experimental results. Based on the model and experimental results with 1 Ci tritium sources and composite polyimide dielectrics the electrical characteristics of a device with 1000 Ci tritium are extrapolated. Open circuit voltage up to and even more 6 kV, short circuit current up to and even more 1 μA, and up to and even more 1 milliwatt of electric power on an optimal load with overall efficiency near 9% is possible. The tritium battery gravimetric energy density of 3700 W·hr/kg is about 20 times more than for lithium-ion batteries, although instantaneous power is less.