Project Summary

Purpose of Phase I

RMD has carried out Phase I of a program to develop a novel style of betabattery which will efficiently harness the energy of radioisotopes in a small, compact device, with efficiencies that may be as much as twice that of radiothermal generators (RTG's), the current state of the art technology. Our device is based on incorporating the radioisotope within high luminescent scintillators, which can then be coupled to solar cells to harvest the energy. This approach has several advantages over traditional beta batteries, which rely on direct conversion of the radioactive emissions to electron hole pairs in a photodiode. First, scintillators are far less susceptible to radiation damage than photodiodes. Second, in direct conversion devices, the optimal depth of the junction may not match the stopping depth of the material to the radioactive emissions. Third, the scintillator allows large amount of radioisotope to be used without losses due to self-absorption. The goals of Phase I of this program was to demonstrate the feasibility of the proposed device by: (1) verifying the choice of scintillator, radioisotope, and solar cells to be used (2) demonstrating adequate radiation hardness of the scintillator and (3) demonstrating a scintillator fabrication process that would be compatible with the commercially available form of the radioisotopes.

Phase I Research and Results

During Phase I we created two computer models of the system – a Monte Carlo transport and interaction model and a COMSOL finite element thermal model. These models will allow us to optimize the device geometry. In addition, the model was used to design the radiation hardness experiments and to interpret the experimental results. We also made a more detailed survey of the system component option, and verified our choice of $SrI_2/^{90}Sr$ as the optimum scintillator/radioisotope pair.

The radiation hardness of the scintillator is a critical aspect of the feasibility of the betabattery concept. We evaluated the radiation hardness of high quality SrI_2 crystals by exposing them to 1MeV electrons in a commercial irradiation facility. While we did observe degradation, we also found that room temperature annealing reversed the damage.

The other critical aspect of feasibility is the development of a fabrication process for the scintillator that is compatible with the commercially available form of the radioisotope, since the radioisotopes are sold in aqueous solution and the scintillators are extremely hygroscopic. We developed the process using small scale equipment suitable for use in a hood. We demonstrated the suitability of the process by fabricating SrI_2 doped with ^{131}I, which luminesced under its own power.

Phase I Conclusions and Justification for Phase II

We have successfully completed all the Phase I tasks and met the Phase I goals. We have identified SrI_2 with ^{90}Sr as the most promising system for scintillator based betabatteries. We have demonstrated the feasibility of the approach by confirming that SrI_2 can be made with the addition of a radioisotope and that it then scintillates under its own power. We have also demonstrated that radiation damage should not limit the performance of the device. While the scintillator does show damage under high radiation dose rates, the damage heals through room temperature annealing. For an operating betabattery the irradiation rate is much slower, and the healing may occur as quickly as the damage forms. Thus, our Phase I research has addressed the most major fundamental questions about feasibility and established the path to successful device development in Phase II.