Beta Voltaic Power Source Design using an Electron Emitting Radioisotope source for a Pinger Device to be dropped on a Hydrated C-Class Asteroid

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Abstract. The work presented herein was developed with the funding and support of the summer fellowship program at the Center for Space Nuclear Research (CSNR) under Director Dr. Steven Howe. The purpose of this work was to design a beta-voltaic (BV) power source for a pinger (beacon) device. The pinger would be dropped on a hydrated C-Class asteroid for ownership purposes and indication of water availability to a future spacecraft that might be travelling in the asteroid’s direction. This work is part of a preliminary design review of an Asteroid Mapper mission architecture. The primary objective of the asteroid mapper spacecraft will be to map and tag water contained in hydrated C-Class asteroids, in the main asteroid belt. The current chemical batteries have many disadvantages such as short life span and limited temperature & pressure tolerances. However, a BV cell will be an ideal power supply to the pinger. It would generate sufficient low power required to drive the pinger electronics, will be long-lived by lasting for more than 20 years and would be very light weight. The BV cell designs considered in this study consists of a non-conducting plate coated with an electron emitting radioisotope material such as Nickel – 63 ($^{63}$Ni), Cesium – 137 ($^{137}$Cs), Technetium - 99 ($^{99}$Tc) or Strontium – 90 ($^{90}$Sr) on one side that would be separated by a small distance from a p-n diode. The working of the BV cell is analogous to that of a solar cell. In the proposed BV cell design, current will be generated, when a high-energy electron strikes the depletion region of the p-n diode generating electron-hole pairs due to impact ionization. These electron-hole pairs are separated by the built-in electric field and are drifted apart. The separated electron hole pairs make the p-n diode forward biased and are collected at the negative and positive terminals respectively, there by driving the load connected to the BV cell. The design of the BV cell is based upon the Child-Langmuir’s law of space charge limited current in a plane diode. The energy density of $^{90}$Sr, $^{99}$Tc, $^{63}$Ni and $^{137}$Cs were calculated for ten different values of distances between the non-conducting plate and the semiconductor using Monte Carlo N-Particle (MCNP) transport code. The power output required from the beta voltaic battery was limited to 1 mW. Given the power output and fixing the width of the receiving plate the area of the receiving plate was calculated using Child-Langmuir’s law. Out of all the four radioisotopes considered as electron emitting sources, $^{137}$Cs provided the smallest plate area of the non-conducting plate. However, due to the high gamma radiation of $^{137}$Cs, $^{90}$Sr turned out to be the most suitable candidate for this device.

Keywords: Beta Voltaic Battery, MCNP, Cesium-137, Strontium-90, Pinger, Beacon, Asteroid