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# Betavoltaic Prediction using Ni-63 beta radioisotope and Semiconductor

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## 1. Introduction

Micro-electromechanical Systems (MEMS) comprise a rapidly expanding research field with potential applications varying from sensors to more recent optical applications. Depending on the application, these devices often require an on-board power source for remote operation, especially in medical cases requiring operation for an extended period of time. Suggested power sources include fuel cells and solar energy, but nuclear power sources may provide significant advantages for certain applications. [1] Hence, the objective of this study is to establish the feasibility of nuclear sources (beta and alpha particles) for supplying a power to realistic MEMS devices.

The betavoltaic effect shown in Fig. 1 is the generation of potential due to net positive charge flow of the electron-induced electron-hole production (EHP). When EHPs diffuse into the depletion region of the semiconductor pn-junction, the electrical field of the depletion region sweeps them across the depletion region. Because the resulting current is from n-type to p-type semiconductor, net power can be extracted.

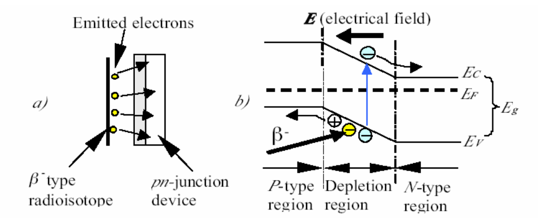


Figure 1 Betavoltaic effect a) Schematic diagram of betavoltaic battery b) Potential diagram for a betavoltaic effect

## 2. Prediction of betavoltaic performance

### 2.1 Calculation of Ni-63 energy spectrum

Selection of radioisotope is a critical aspect in betavoltaic conversion. In this study, Ni-63 is selected considering safety, lifetime, activity, and convenience of handling. The kinetic energies of beta particles emitted from Ni-63 ranging from 0 to 66.7 keV, with an average of 17.6 keV. This energy makes it appropriate from damage concerns to silicon and accidental exposure to skin.

A. Lal et al at Cornell university [2] used the theory of continuous slowing down approximation ranges (CSDA) but we calculated the energy spectrum with BTSPEC and BTPLOT programmed by NEA. The spectrum result of Ni-63 radioisotope is shown in Fig. 2.

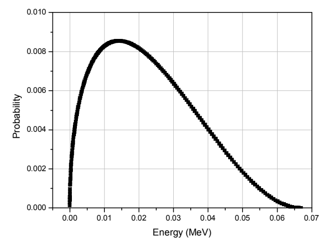


Figure 2 Calculated energy spectrum of Ni-63 radioisotope

### 2.2 Simulated Betavoltaic of PN junction in Silicon

To evaluate the betavoltaic effect of PN junction in silicon, PC1D program developed by University of New South Wales in Australia [3] was used to simulate the performance. The I-V curve from the 10 mCi/cm$^2$ of Ni-63 deposited on the surface of planar PN-diode was shown in Figure 3.

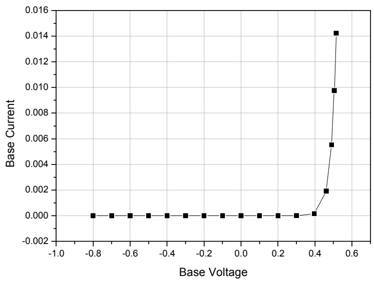


Figure 3 I-V curve using the Silicon PN diode and Ni-63 radioisotope.

This device showed short circuit current of -3 nA and open circuit voltage of 6.3 mV, and the maximum output power is about 0.2 nW. Thus nano power betavoltaic microbattery can be obtained.

## 3. CONCLUSIONS

Ni-63 radioisotope was selected due to mean energy of radioactivity and easy sealing of beta-radiation. PC1D program can be used with respect to optimal design of silicon diode and maximal electron energy usage.

Betavoltaic microbattery could be expected to be applicable in the medical and military fields as the power source.

**Acknowledgements**

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**References**

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