Conceptual design of nuclear battery using semiconductor

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1. Introduction

Until now, the development of the useful micro-electro mechanical systems (MEMS) has the problems because previous batteries (solar, chemical, etc) did not satisfy the requirements related to power supply. At this point of time, nuclear battery using isotope sources is rising as the solution of this problem. Nuclear battery can provide superior output power and lifetime. So a new type of micro power source (nuclear battery) for MEMS was designed and analyzed

2. Three parts of battery

The nuclear battery is composed of the three parts, isotope source, conversion device, and shielding.

2.1 Isotope source

The selection of isotope source is very important for the design of nuclear battery.
In this study, Ni^{63} was selected. The maximum kinetic energy of the electrons emitted to 66.7 keV, is less than 200~250 keV, the threshold energy is necessary to cause substantial permanent damage to the silicon crystalline matrix.[1] If we want to get 1mA using the isotope source, we need several curies. Theoretically we need about 30Ci in case of nickel. And nickel can be manufactured by various forms, so nickel is flexibile to design device.[2]

2.2 Conversion device

Electric power is generated by radiation excited electrons in the semiconductor depletion region. The efficiency of the nuclear battery depends upon the pn-junction.[3]
Below Fig. 1. show the configuration of semi-conductor. The state-of-the-art technology of sem-iconductor can dig down to 500μm. So semiconductor can have 30μm pins for the absorption of radiation using theory of continuous slowing-down approximation ranges.[4]

2.3 Shielding

For the safety of human and environment, shielding was also considered. Radiation is protected by reducing the kinetic energy of beta particles. TiB_2, TiC and TiN were selected as shielding materials. Because they have good reflection rate, so they are effective to achieve sufficient performance as shielding.

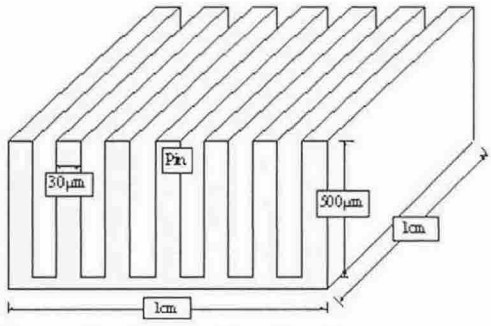

Fig. 1. Conversion device of semiconductor.

3. Conclusion

In this study, nuclear battery that is useful to overcome the limitations of the past power sources to MEMS was designed. The isotope source as the fuel is used. The Semiconductor is used for pn-junction type battery. And the shielding is figured. Battery using Ni^{63} has benefit for safety assessment, but low radiation flux causes bigger volume than other isotope sources. So total volume of the MEMS including this battery may not satisfy a critical requirement. But in case of the battery using promethium, the isotope source can be relatively smaller than that of Ni^{63} even though shielding problems is difficult. But at this point, we have some difficult problems such as treatment of isotope sources and manufacturing process of semiconductor. If we want to use isotope sources, we must solve the technical and legalistic hardship.

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