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An efficient Nuclear battery design using Americium-241 and Carbon-14

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Abstract— Nuclear batteries are the batteries which work with nuclear fuel. They generally lasts longer because the half life of a radio active metal is more. So, they continuously emit radiation and this radiation is converted into electrical energy. The conversion of radiated energy to electrical energy is done using p-type and n-type semiconductors. The average estimated life of these nuclear batteries is about 500 years as the half-life of both radio active isotopes is more than 500 years.Here the americium-241 emits alpha rays which ionizes atoms in p-type semiconductor and carbon-14 emits beta rays which ionizes n-type semiconductor and hence potential is produced in between those two semiconductors gives us electrical energy.

Index Terms— Carbon-14, Americium-241, α radiation, β radiation, p – type semiconductor , n- type semiconductor.

1 Introduction

Nuclear energy is one of the most powerful energy in the world. The potential scope of a nuclear battery for its amazing extended shelf-life and excellent energy density as compared with other modes of energy storage devices makes them an excellent alternative to research. The performance of nuclear batteries can be defined as a function of the radioisotope and radiation transport properties. The energy conversion mechanisms vary significantly between different nuclear battery types, where the radioisotope thermometric generator is often considered a performance standard for all nuclear battery types.

Nuclear batteries can be classified by energy conversation technology into two main groups: thermal converters and non-thermal converters.

The thermal types convert some of the heat generated by the nuclear decay into electricity. The most notable example is the radioisotope thermoelectric generator (RTG), often used in spacecraft.

The non-thermal converters extract energy directly from the emitted radiation, before it is degraded into heat. They are easier to minutarize and do not require a thermal gradient to operate, so they are suitable for use in small-scale applications. The most notable example is the betavoltaic. The betavoltaic effect is one of the promising technique to convert radioactive energy into electrical power. Efficiency and output power of betavoltaic cell has constantly increased and discovery of new practical applications.

Atomic batteries usually have an efficiency of 0.1–5%. High-efficiency betavoltaic devices can reach 6–8% efficiency.

I have proposed a method of non-thermal conversion of nuclear energy and it's safe packing technique in this paper. Using this technology the life of people would be further simplified, physical efforts would be considerably reduced and it would also prove as one of the best technology to use.

2 HARDWARE DESIGN

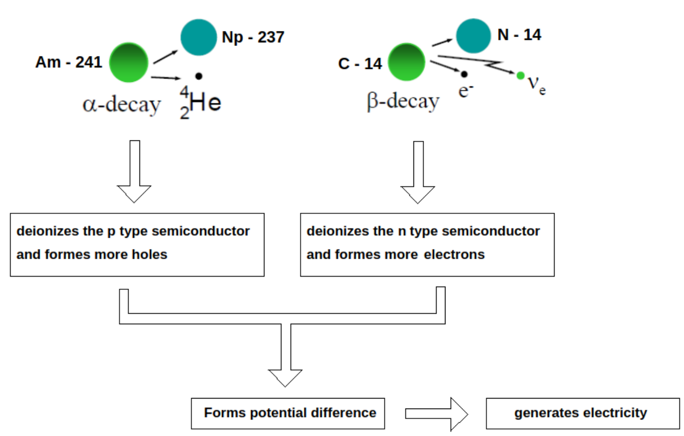

Fig -1: System Block diagram

The hardware consists of six main parts that are useful to process the signal from our brain.

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2.1 C – 14
A thin sheet of Carbon 14 is used in the design. It has a half-life of 5,730 years. It is used to conduct various research of beta decays. Even it is used to find the age of ancient items with carbon dating as it has huge half-life. The C -14 emits a beta particle and converts into nitrogen – 14 which is stable and acts as inert condition in this experiment.

2.2 Am – 241
A thin sheet of Americium 241 is used in the design. It has a half-life of 432 years. It is used in smoke detectors. The Am -241 emits alpha particle and converts into Neptunium - 237 it further emits alpha particles which can be benficial in experiment.

2.3 n - type Semiconductor
The pure silicon sheet is doped with 15th group elements, here arsenic is used for doping. As the arsenic fills the gaps in silicon, each arsenic is coordinated with four silicon atoms. So, you can have a free electron for each arsenic atom and here arsenic is heavily doped. And during potential difference between n-type and p-type semiconductor these electrons move to p type semiconductor which leaves As+ and exposed with C 14 which contains beta rays. The beta rays which contains electron makes As+ to As as it recharges As atom to participate in electron transfer.

2.4 p - type Semiconductor
The pure silicon sheet is doped with 13th group elements, here boron is used for doping. As the boron fills the gaps in silicon, each boron is coordinated with four silicon atoms. So, you can have a deficient electron for each boron atom which are called holes and here boron is heavily doped. And during potential difference between n-type and p-type semiconductor these holes takes electrons from n type semiconductor which leaves B- and exposed with Am 241 which contains alpha rays. The alpha rays which contains positive charge takes these electron makes B- to B as it recharges B atom to participate in electron transfer.

2.5 Seperator
The p type and n type semiconductors are seperated with a seperator of one side and reflector on other side. This seperator is used to seperate the two semiconductors and also it acts as a shield for the radiation it does not allow any radiation to go through it. The seperator is made up of lead as it is a dense particle so even gaama radiation won’t penetrate through it.

2.6 Reflector
The once side of the radio active material is exposed with it’s corresponding semiconductor and the remaining sides are covered with reflectors. The reflectors used to reflect the radiation from it. Here aluminium foil is used as a reflector.

3 Materials Design

Silicon was selected as a semiconductor material for nuclear cells because it is both cheap and available. We used silicon wafers (P {100} 20 Ω·cm) with a thickness of about 470 μm to fabricate betavoltaic cells. The wafers were placed in a tube furnace at 950 °C for 60 min to create a heavily doped n^+ layer for the ohmic contact and n^+ ring by diffusing arsenic. The heavily doped p^+ layer was manufactured with Boron implantation and was used to create the second ohmic contact. The implantation energy and the implantation dose were 60 keV and 500 μC/cm^2, respectively. After implantation, getter thermal annealing at 900 °C was performed with slow cooling of 1 °C/min for 300 min.

4 Battery Design

The n type semiconductor and p type semiconductor is heavily doped with arsenic and boron and lead is placed between them and on other side the the n type semiconductor is exposed to the C 14 sheet. So, when ever the arsenic atom losses electron for stablity the beta exposure again helps it to gain it’s neutral state.Similarly, the other side of p type semiconductor is exposed with the Am 241. So, whenever the boron atoms gain the electrons for stability the alpha particles takes that electron and makes it neutral again. So, when the potential is connected internally the electrons will move from n type to p type through lead and externally they moves through the conductor while electron and holes combine the alpha radiation again takes that electron from hole and bets radiation gives an electron in other side(n type) so again the path is followed continuously. Hence constant electric field is formed and drives the electrons to holes continuously.

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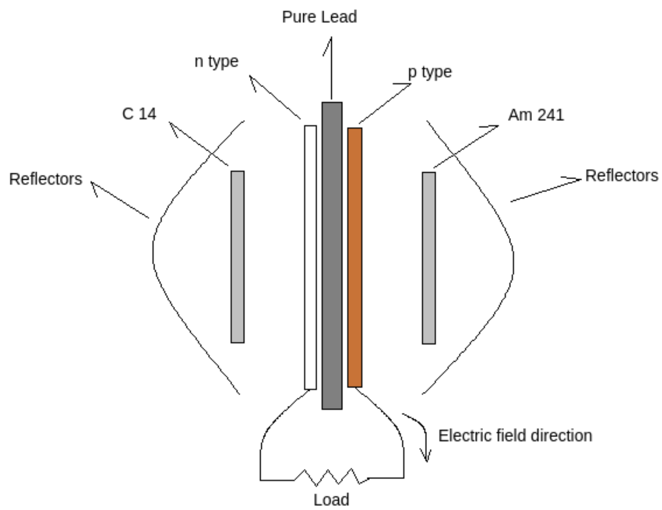

Fig -2: Battery Design

5 Merits of using Nuclear Batteries over other batteries

Depending upon the structure and the quantity the above nuclear battery can deliver sufficient amount of output power. Nowadays, the most widely used batteries are lithium ion batteries. Nearly every electronic devices today are running with lithium ion batteries. And the main problem with these batteries is that they need to charge again and again. But this nuclear battery design work continuously for years without charging and deliver better results.

6 APPLICATIONS

Space exploration poses unique challenges that are not faced when working with electronics on Earth. It is impossible or extremely costly to access a device once it has been launched into the space. Because only a small percentage of sunlight reaches the outer perimeter of the solar system compared to the orbit of Earth, solar energy is not a practical solution to powering electronic equipments when exploring the outer planets. So, we can use this type of nuclear battey (enhance the structure of battery) to overcome this problem.

Implantable medical devices (IMDs) can also utilize this nuclear batteries. Just like in spacecrafts, batteries used to power IMDs must function reliably over a long period of time without being accessed for recharge or maintenance. Unlike in spacecrafts, however, batteries used in IMDs must be limited in size and radioactivity. Hence, This nuclear battery technology is used in IMDs. Although the technology was invented and widely used for patients in the 1970s with beta voltaic cells, the potential risk of radiation convinced the medical industry to shift to lithium ion batteries in the 1980s. Only with the advancement in safety in this nuclear battery, the option with a considerable advantage in battery life is being reconsidered.

The United States Department of Defense requires that every missile and aircraft be equipped with an anti-tamper protection such that the technology cannot be reverse-engineered by others. Because a single instance of battery malfunction can wipe the memory circuit's configuration, batteries used in anti-tamper system must withstand temperatures between -65 and +150 degrees Celsius, high-frequency vibrations, and high humidity. Lockheed Martin Missiles and Fire Control, can use this nuclear batteries to power the anti-tamper system under harsh conditions and prolonged usage.

7 CONCLUSION

Hence i conclude that using this kind of technology, our lives become more easier and secure and helps us to get enough power throughout years. This design can further be enhanced and we can even use this to replace thermal and nuclear plants(which generates energy though nuclear fission) so that the nuclear waste is reduced and we can save our conventional energy sources.The scope of the project was primarily to develop an effcient design of nuclear battery and it has been successful in doing so but it has also laid a foundation for many applications which would greatly improve the standard of life for all.

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