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Utilization of Nuclear Diamond Batteries

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1.Abstract

The proper way of disposal of both Nuclear Fuels and Spent Nuclear Fuel is the down standing problem these days. The SNF is safely stores until its permanent disposal takes place. There may be low level waste and high-level wastes; problem arises in disposing of high-level wastes itself. Hence, proper energy recycling techniques are in much need to dispose radioactive wastes. A new technology is developed that uses the SNF to generate electricity through a Nuclear-powered battery. The main emerging challenges in using a convectional battery are that they cannot be used for long time for long lifespan and drawbacks in situations where it is not feasible to charge and replace. The battery is proposed to run on the radioactivity of waste graphite blocks and would generate small amounts of electricity for thousands of years. Commonly used semiconductors and b-rays absorbers are ^{63}Ni. Advancements are made to use ^{14}C as a prototype. In the field of micro electromechanical systems (MEMS) the possibilities are explored in producing miniscale batteries that can be applicable in various convectional fields. The structural arrangement of these diamond cells can now replace the domestic batteries where a 10MW Output can produce electricity for 8000 homes.

Keywords:SNF,NDB,Prototype.

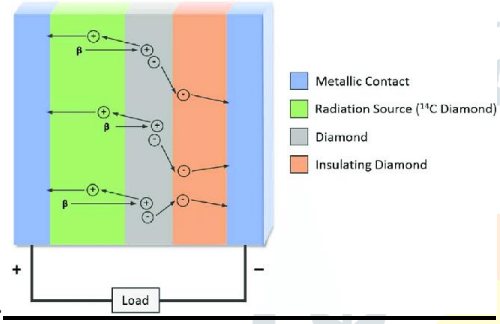
2.Introduction

A “high powered Diamond based alpha, beta, and neutron voltaic battery” for its ability to give driven “life-long and green energy”. NDB uses layers of impossibly tiny panneled nano diamonds (for context, one nanometer is one billion of a meter). Diamond have exceptional heat conductance which makes them ideal for electronic devices. Scientists cultivate these miniature diamonds using chemical vapour deposition, a process in which gases at extremely high temperature forces carbon to crystalline on a substrate material. These are artificially boron-doped diamonds that produces diamonds with blue color and higher conductivity than any average diamond. Once NDB has sourced the nano diamonds, the company combines then with radioactive isotopes from nuclear waste specifically they use radioactive isotopes of Uranium and Plutonium , which probably comes from radioactive waste. Single crystal diamonds are often a few square millimeters in size. Due to more heat evolved from the radioactive decaying of isotopes so quickly that transaction generates electricity. The decaying sources deposit their energy onto the NDB transducers, which converts the kinetic energy of the incident radiation to electrical energy. Each battery cell will provide only a small amount of energy, for on ething, so scientists must combine the cells in huge numbers in order to regularly power large devices. But still there is an issue of wear and tear.

3.Materials and methods

WORKING OF A NDB:

Firstly, a group of researchers and scientists were working on a device called a Beta Voltiac Device(BVD). BVD used because the beta decay of a nuclear waste powered it. However, after development it is observed to be radioactive and then it is said to be Diamond Battery. Beta decay happens when an atom's nucleus has an excess of particles and release some of them to obtain a more stable ratio of protons to neutrons. Thios produces a kind of ionizing radiation called Beta Radiation. Generally, this BVC contains of a thin layer of a radioactive material placed between semiconductors as the nuclear material decays it and emits beta particles that knock electrons lose in the semiconductor creating an electric current.However, the power received from a BVC is very less and it is about 100(mu)Wwhich is not efficient.



So, lets fix it.The efficiency can be increased by polycrystalline diamond (PCD) radioactive batteries. These are made through process called Chemical Vapour Deposition .It is a general process used for making artificial diamonds. A modification on CVD can be made to modify aradioactive diamond by using methane containing a radioactive isotope 14-C which can be harvested using a radiated reactor graphite blocks.These diamonds can act as radioactive source and semiconductor.These diamonds move heat away from the radioactively decaying isotopes so quickly that the transaction actually generates electricity. The decay source4s deposit their energy onto the NDB transducers which converts the kinetic energy of the incident radiation to electrical energy.

DIAMOND NUCLEAR VOLTAIC TECHNOLOGY(DNVT)

As a device DNV is a combination of semiconductor, metal and ceramic that has two contact surfaces to facilitate charge collection .

PROTOTYPES USED (CARBON COMPONENTS)

The actual amount Carbon-14 in each battery has yet to be decided but one battery containing 1g of Carbon-14 would deliver 15v joules per day .Using C-14 as a prototype the battery would take 5730 years to react 50% of the power.

$^{14}C_6 \rightarrow {}^{114}N_7 + {}^{0}P_{-1}$

These beta particles, having an average energy of 50 keV, undergo inelastic collissions with other Carbon Atoms , thus creating electron-hole pairs which then contribute electric current.This can be restated according to band theory .

In graphite-moderated reactors, fissile Uranium rods are placed inside graphite blocks. These blocks acts as Neutron moderators whose purpose is to slow down fast-moving neutrons so that, nuclear chain reaction can occur with thermal neutrons. During their use, some of the non radioactive C-12 and C-13 isotopes in graphite yet gets converted into radioactive C-14 by capturing neutrons. When the graphite rods are removed during station decommissioning, their induced radioactivity qualifies them as a low level waste requiring safe disposal.

3.Applications

The main applications of NDB in the present day are in two sectors:

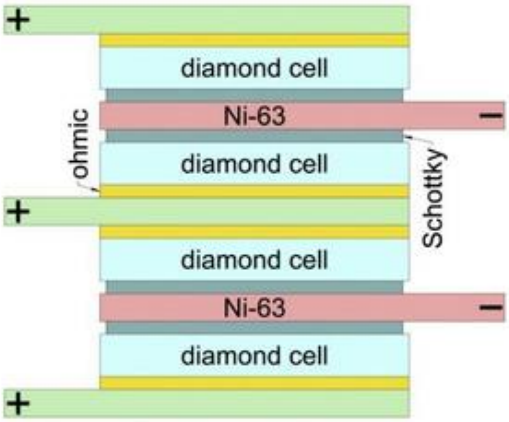
1. Implantable Medical Devices (IMD)
2. Radioactive Thermoelectric Generator (RTG)

IMD's are the instruments that are either wholly or partially introduces into the body. Most often, physicians implant these devices in surgery. Unlike surgical medical devices, these stay in the body after the procedure. In general cardiac pacemakers is about 10 cm^3 in size and requires 10 micro watt of power input. Also_peripheral pacemakers are one used in medical field where they need not to be replace to improve life of patients. Also in space industry the RTG's are used extensively. We rely on data centers to save imporant documents and soft data securely which run on local power. So we can replace these by NDB's to supply uninterrupted energy. It is a very safe and universally optable power source. Hence it is very much efficient to run in industries.

Also, NDB's can be a source of constant charging for small sized energy devices which is a cost effective solution too. Recently, the EV's that is the electric vehicles have come into implementation which require constant energy source. So, NDB can work effectively here too. As there is a demand for autonomous wireless external sensors and memory chips. Diamond Nuclear Batteries are used as radiation proof semi-conductors. It can operate in a wide range of temperature making it as a ideal material for Nuclear batteries. Satellites and space vehicles rely on solar power, which space hashes can disrupt. NDB can be utilised to power electrical aircrafts, space rovers and stations while allowing more prolonged activity and reduction of weight by removal of solar wings .

4.Advancements

1. Enriching the prototype Ni-63 in the radiation source would proportionally increase the battery power and enhancing the surface area of the converter would increase the no. of Ni-63 atoms on each converter which enriches the battery power.



2. The alternative for radioisotope for use in nuclear batteries i.e., Diamond converters could be made using radioactive carbon-14, which has an extremely life of 5700 years. Developing a diamond p-i-n structure.
3. A controlled depleting profile in the usage of the battery also enhances a proper constant power output without leading to any damage to the connected device and more efficient operation.
4. Nuclear Hydrogen Production : Nuclear hydrogen production is an emerging and promising alternative to steam-methane reforming for carbon-free hydrogen production in the future.

5.Conclusion

Hence, the Nuclear Powered Battery will have its pathbreaking applications by replacing all the convectional power sources and large sized solar power units right from the mid ocean to even to the space aircrafts. Its outstanding runtime of almost 28000 years will make it highly durable and reduces the constant replacing problem. Also, there is a problem of dispoasl of Nuclear wastes in the recent times. So, instead of dumping them under the earth leading to radioactive pollution, it is better to use them a electricity source without wasting the internal energy of the waste. Advancements in these processes will be able to replace all the convectional sources from small scale domestic batteries to arranging them in a proper grid to supply sufficient power to large industries too.This is important because UK has approximately 95000 tons of graphite blocks and by extracting Carbon-14 from them their radioactivity decreases which reduces the cost and challenges of safely storing them.

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