C-BETAVOLTAIC ENERGYCONVERTER IN POR-SIC/SI

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Abstract. *The miniature and low-power devices with long service life in hard operating conditions like the ^{14}C ß-decay energyconverters indeed with eternal resource for integrated MEMS and NEMS are considered. Authors will discuss how to create a power source for MEMS devices, based on SiC/Si porous structure, which are tested to be used as the β-decay energyconverter of radioactive carbon-14 into electrical energy. This is based on the silicon carbide obtaining by self-organizing mono 3C-SiC endotaxi on the Si substrate.*

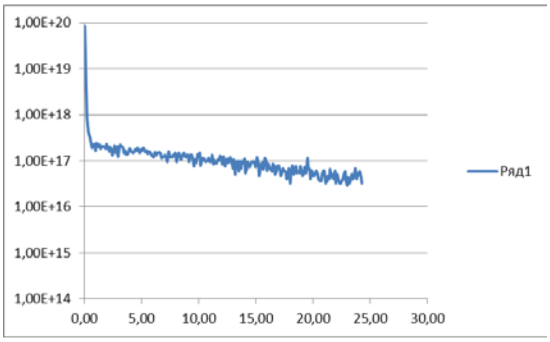
Introduction. The development of energy-saving technologies, the functioning of the MEMS devices, the reliability of their operation for a long time in offline conditions led to the search of appropriate means of generating energy for them. The work of authors will discuss how to create the power source for MEMS devices based on por-*SiC/Si* porous structure, which is tested to be used as the *β*-decay energy converter of radioactive carbon-14 into electrical energy [1,2,3,4]. This involves silicon carbide obtaining by self-organizing mono 3*C-SiC* endotaxi way on the *Si* substrate [5,6].

Energyconverters of beta radiation are based on isotopes transformations reactions with half-lives of more than 100 years. Energy converters are designed to secure operational performance, allowing reinstallation on the objects with the corresponding lifetime. Analogues were brought out to the laboratory samples level for two years. The groundwork of this project on the part of semiconductor technology: mastered growing por-*SiC/Si* heterostructures. The groundwork for the development of an energy source not specified. But there is information of methods and businesses with similar activities. The use of the product will effectively solve the following problems: the provision of energy for autonomous systems and devices, MEMS devices, sensors in oil capital constructions as example, information systems, systems, including medical direction and equipment.

Self-organizing mono 3*C-SiC* endotaxy technology. Authors present an original technology of manufacture and a model of the isotope energy converter based on the silicon carbide heterostructure, with carbon-14 as fuel. The radionuclide ^{14}C is incorporated into the *SiC* molecule instead ^{12}C in the por-SiC phase *in-por-SiC/SiC/Si* heterostructure. Beta-radiation generates nonequilibrium charge carriers, separated by the internal field of *p-n* junction in the *SiC*-phase. The concept is based on the semiconductor implantation technology of the solid-phase transformation according to the diffusion model of the *Si*-phase transformation into the *SiC*-phase, which allows the buildup of por-*SiC* heterostructures [6,7]. This is also possible to achieve by ion implantation of carbon-14 into the silicon carbide phase. The latter approach to the direct conversion can increase the effectiveness of beta-voltaic energyconverters.

The method of secondary ion mass spectrometry (SIMS) is used to analyze the composition of solid surfaces and thin substrates. The essence of the method is to irradiate the sample surface by a focused beam of ions (primary ions). When hitting the sample, the primary ions undergo multiple collisions, which are emitted from the sample atoms and clusters of atoms in the process of collisions, the latter spontaneously ionized (forming secondary ions). These secondary ions are collected in the secondary beam and analyzed.

KDB_C. The analyzed depth ranges from $5.3*10^{-8}$ to $24.3*10^{-6}$ m. The concentration of ^{12}C atoms, depending on the analyzed depth ranges from $8.4*10^{19}$ to $3.2*10^{16}$.



There are two competitive directions of the beta-voltaic converters development: the accumulation of charges in the reactions of transformation of elements using supercapacitors; the charge separation in *p-n* junction of the solar battery analogue; the combination of the two directions. In all cases, the main competitive advantage over other energy sources is the long life cycle of beta-converter. A disadvantage is due to low capacity and low efficiency, which is overcome technological way (a higher degree of enrichment of isotope using the developed nanoporous surfaces, reducing the leakage current of super capacitor and *p-n* junction, using a combination of several sources of beta-radiation flux; the system microcontroller, which controls the flow of the charge).

The ratio ‘price/performance' is determined by several factors: semiconductors heterostructures provide a price level conventional semiconductor discrete diodes or transistors, high power, the technology of nuclear fusion, the working fluid used in the operation of medical devices provide a level of price acceptable to the consumer, when there is no alternative.

Planning design parameters and performances are following: Voltage range ~ 2 mV, Size of the device ~ 10×10×(0.3÷0.5)mm, Mass of each structural element 0.17 g, Working current range 0.1μA, Working temperature range -50° ÷ 350° C.

Magnetooptic synthesis chamber. The synthesis of carbon-14 can be also performed by using the electronically controlled synthesis of nucleons in the 8-cyclic magnetooptic synthesis chamber. The setup consists of electronically controlled ion sources with magnetooptic flux concentration with the ion energy of up to 50 keV, electronically controlled pulsed accelerator sections that form discrete ion flux with the ion energy from 200 to 600 keV, combined with an 8-cyclic magnetooptic synthesis chamber and a controlled magnetodynamic trap for generating dense neutron fluxes. The synthesis of ^{14}C by neutrons goes in a 4-cycle magnetooptic chamber on a dense ion target. At the final stage, ^{14}C from the magnetooptic storage is deposited on the *SiC* substrate. Multilayer formation of ^{14}C on a *SiC* substrate or on substrates from other materials is also possible.

Comparison. Note the comparison with a technology that uses Nickel-63.

1. The production of ^{14}C in the dense ion plasma flow is much cheaper than the production of ^{63}Ni in Nickel target, due to the low cost of ^{14}N.

2. Ion-plasma implantation ^{14}C on *SiC* substrate allows to reduce the crystal production process and realize mass production on semiconductor converters ^{14}C.

3. At the same time, the production of ^{63}Ni by this technology is

possible, and the cost will be much reduced compared to traditional methods. Because of the greater mass of the ions, the equipment for ion-plasma sputtering with a seal of the flow of Nickel ions will be several times more expensive because of increased size of the installation. At this stage, it is more sophisticated to produce ^{14}C.

4. Specific activity of ^{14}C is different from the ^{63}Ni in terms of unit volume about 10 times, due to the huge difference in half-life times.

5. Self-absorption of ^{63}Ni is higher by approximately three times, which leads to the maximum optimal thickness of the layer to 4 microns, and for ^{14}C, this thickness is about 60 microns, which is better suited. The total quantity of the isotope ^{14}C may be an order of magnitude greater, therefore, guaranteed more power for the same size of power converters.

6. The specific power of ^{63}Ni per g of the substance 5 times (due to more activity) exceeds the power density of ^{14}C. But the maximum and average energies of electrons in the decay of ^{14}C is 2 to 3 times more than in the decay of ^{63}Ni.

7. The production cost of ^{14}C 12 mg will take 8 hours, taking into account equipment depreciation, will cost about 170$.

Summary. *This development is intended for practical applications in MEMS and NEMS systems and sensors that require long-term autonomous operation.*

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