Simulation of a silicon 3D betavoltaic element with two-sided transformation performance

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For the design optimization and the conversion efficiency of the betavoltaic converters improvement, a mathematical simulation of a silicon 3D betavoltaic element with two-sided energy conversion was carried out. The usage of microchannel silicon made it possible to increase the active surface area of the transformer by 15 times and thereby increase the cell efficiency for 0.02 μW / cm^2.

Keywords: betavoltaic element, 3D structure, betavoltaic effect, isotope 63Ni, simulation.

The betavoltaic elements development is a very promising direction of research activity [1 - 4], since the power suppliers operating based on the betavoltaic effect have a long life time (depending on the radioisotope) and small overall dimensions. Betavoltaic batteries can provide the autonomy working of low-power electronic devices. Due to their advantages, such energy sources will be promising for the sensors power supply for special and civil applications, microelectromechanical systems, small space objects and medical implants [1].

In the present work, the performance of the 3D beta-voltaic element with double conversion in the Borland Delphi 7 software [5, 6] was carried out with the aim of the converter design optimizing.

As the converter structure, a 3D design was assumed (Figure 1). The front part of the element is a planar structure, and the rear part is a microchannel surface. The peculiarity of such design is that the radioactive isotope is applied from both sides and in conversion the betavoltaic element total volume is applied.

As a radioactive element, Ni-63 was selected with a thickness of 2 μm with an activity of 2.7 mCi.

As a simulation result of the silicon 3D betavoltaic element with two-way conversion, the following output parameters were obtained:

- Short-circuit current: I_{SC} = 276.1 nA / cm^2;
- Open-circuit voltage: U_{OC} = 148.96 mV;
- Power: P = 0.024 μW / cm^2.

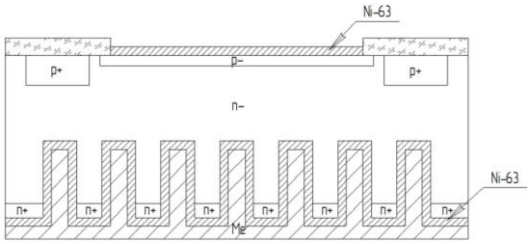

Fig. 1. 3D silicon double-conversion betavoltaic cell construction

The construction of a 3D beta-voltaic element with a double conversion is suggested, which allowed to increase the short-circuit current for 249.1 nA / cm^2, the open-circuit voltage for 30.96 mV and the output power for 0.02 μW / cm^2.

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