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Extended Abstract

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Mathematical modeling of charges generation rate in the SiC semiconductor

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The miniature and low-power devices with long service life in hard operating conditions like beta-decay energy converters indeed as power supply for integrated MEMS and NEMS are actively modeled by several groups nowadays. The idea of the C-14 atoms including in silicon carbide porous structure molecules by endotaxy technology results to increase the efficiency of the converter due to the greater intensity of electron-hole pairs generation rate in the space charge region and due to the larger volume charge density. The development of energy-saving technologies, the functioning of the MEMS devices, the reliability of their operation for a longer time in offline conditions led to the search of appropriate means of generating energy for them. Especially in trends of the microelectronics into the 30-micron size benchmark active microprocessor board that hosts all the necessary devices. Author will discuss how to model the power source for MEMS/NEMS devices based on por-SiC/Si porous structure, which is to be tested and used as the beta-decay energy converter of radio Carbon-14 into electrical energy. This involves silicon carbide obtaining by self-organizing mono 3C-SiC endotaxy way on the Si substrate. The key interest in the present aspect has the systematic optimization of main parameters that affect the operational efficiency of the betavoltaic current source. The non-porous layer of n-type is determined by under the porous SiC, which is inevitably formed on the bottom of the pores and in fact is non-porous, i.e. p-n junction is the place to be in the right picture in figure 1 is still not in the porous layer, and indirectly associated with it and the space-charge region (SCR), between non-porous layers. To calculate the depth of the active layer, known methods of mathematical physics with partial differential equations for electron-hole pairs will be used, and the probabilistic approach is applied for the sorting of the electron energy and the construction of the loss function.

The modern computer and telecommunication industry relies heavily on the use and development of semiconductor devices. Since the first semiconductor device (a germanium transistor) has been built by Bardeen, Brattain and Shockley in 1947, a lot of different devices for special applications have been invented in the following decades. A very important fact of the success of semiconductor devices is that the device length is very small compared to previous electronic devices (like tube transistors). The first transistor of Bardeen, Brattain and Shockley had a characteristic length (the emitter-collector length) of 20 µm. Thanks to the progressive miniaturization of semiconductor devices, the transistors in a modern Pentium IV processor have a characteristic length of 0.18 µm. The device length of tunneling diodes, produced in laboratories, is only of the order of 0.075 µm.

Clearly, there are many other semiconductor devices which are not mentioned (for instance, bipolar transistors, Schottky barrier diodes, thyristors). Other new developments are, for instance, nanostructure devices (heterostructures) and solar cells made of amorphous silicon or organic semiconductor materials (see [14, 41]). Usually, a semiconductor device can be considered as a device which needs an input (an electronic signal or light) and produces an output (light or an electronic signal). The device is connected to the outside world by contacts at which a voltage (potential difference) is applied. We are mainly interested in devices which produce an electronic signal, for instance the macroscopically measurable electric current (electron flow), generated by the applied bias. In this situation, the input parameter is the applied voltage and the output parameter is the electric current through one contact. The relation between these two physical quantities is called current-voltage characteristic. It is a curve in the two-dimensional currentvoltage space. The current-voltage characteristic does not need to be a monotone function and it does not need to be a function (but a relation). The main objective of this book is to derive mathematical models which describe the electron flow through a semiconductor device due to the application of a voltage. Depending on the device structure, the main transport phenomena of the electrons may be very different, for instance, due to drift, diffusion, convection, or quantum mechanical effects. For this reason, we have to devise different mathematical models which are able to describe the main physical phenomena for a particular situation or for a particular device. This leads to a hierarchy of semiconductor models. Roughly speaking, we can divide semiconductor models in three classes: quantum models, kinetic models and fluiddynamical (macroscopic) models. In order to give some flavor of these models and the methods used to derive them, we explain these three view-points: quantum, kinetic and fluiddynamic in a simplified situation. Quantum devices are based on quantum mechanical phenomena, like tunneling of electrons through potential barriers which are impenetrable classically. Examples are resonant tunneling diodes, superlattices (multi-quantum-well structures), quantum wires in which the motion of carriers is restricted to one space dimension and confined quantum mechanically in the other two directions, and quantum dots.

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