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Active Elements on a Basis of ZnO Nanorods for Energy Harvesting Devices

A. Orlov[1*], V. Ulianova[1], A. Zazerin[1***], O. Bogdan[1], G. Pashkevich[2], and Y. Yakymenko[1]**

[1]*National Technical University of Ukraine "Kyiv Polytechnic Institute", Kyiv, Ukraine*
[2]*Institute of Physics of National Academy of Sciences of Belarus, Minsk, Republic of Belarus*
**ORCID: 0000-0001-9426-6317*
***ORCID: 0000-0002-8334-2756*
****ORCID: 0000-0002-9407-7388, e-mail: exeterza@gmail.com*

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Abstract—It is represented the research of piezoelectric properties of nanorods and their application in energy harvesting devices. According to the simulation results with method of finite elements the value of electromechanic coupling coefficient of monolayer from ZnO nanorods is greater than one in compare to uniform film application. The sample manufacturing method consists of application of traditional microelectronic technique for shaping of top and bottom electrodes and also application of two-steps low-temperature chemical synthesis for ZnO nanorods. To provide acoustic perturbation of the sample the piezoceramic element is used in multilayer structure fixed on the glassceramic substrate. The results are obtained for two measurement modes, providing oscillations perturbation by rectangular pulses source and by harmonic generator. Obtained results demonstrate high efficiency of piezoelectric transformation for monolayer, which consists of ZnO nanorods that is possible to be used in different self-powered devices.

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1. INTRODUCTION

Piezoelectric nanostructured materials are promising building blocks in nanoelectronics, sensing and energy harvesting systems. Creation of a universal high-performance power supply for micro- and nanoelectronic devices, such as wireless sensors, mobile communication devices, medical implants, and wireless electronic systems is a task of great practical importance.

ZnO nanorods are one of the first nanomaterials applied for nanogenerator development. Nanowires from the other piezoelectric materials, including $BaTiO_3$, PZT, and PVDF are researched actively, but the most nanogenerator designs are based on nanowires arrays from ZnO [1]. Research of mechanic and elastic properties of ZnO nanowires are considered in theoretical and experimental papers [2, 3].

ZnO nanowires are applied for self-powered devices of different design as the parts of sensor systems. In [4] there are represented the device which consists of 700 rows of ZnO nanorods, producing voltage of 1.26 V. Three layer combination of such arrays allows to obtain peak power density of 2.7 $mW \cdot cm^{-3}$.

Arrays or monolayers consist of ZnO nanostructures with different geometric parameters are shaped with methods of low-temperature chemical synthesis, at that integral properties of a layer are varied dependently on nanostructures parameters, their shapes and location at the substrate.

The most important problems appearing at wide practical application of energy harvesting devices based on efficiency enhancement and elimination of the reasons of performance degradation of nanostructured layers and whole cell as well. Therefore the design of energy harvesting device, the influence of nanoatructured layer on efficiency of the energy harvesting, its manufacturing technology and physical processes have to be researched and analyzed.

In this paper there are represented analysis of piezoelectric properties of monolayer from ZnO nanorods, practical results of multilayer energy harvesting device development and results of research of piezoelectric properties of monolayer applied as energy converter.