Photosensitive heterostructures based on island-grid films and nanoporous matrices and sulphide nanostructures

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Abstract. The photosensitive heterostructures of ZnS/SnS_x systems deposited onto island-grid films and nanoporous matrices by ion layering were investigated by scanning electron microscopy and photovoltaic measurements. The obtained nanostructured heterostructures were characterized by low electrical resistance of 140-80 Ohm with the semiconductor character of the temperature dependence have shown photoelectric EMF of about 230 mV.

1. Introduction

An important trend in the development of the modern optoelectronic devices is the transition from the simple materials and homojunctions to the composite materials and heterojunctions .The formation of semiconductor heterostructures with nanoscale layers of semiconductor allows to improve the parameters of the optoelectronic devices, but also to create devices with new functional capabilities [1].

This paper presents the results of the formation and investigation of nanoporous anodic alumina films and Ta_2O_5/Ta matrix island-grid films with deposited by ion-layering nanosized ZnS and SnS_x layers.

2. Experimental

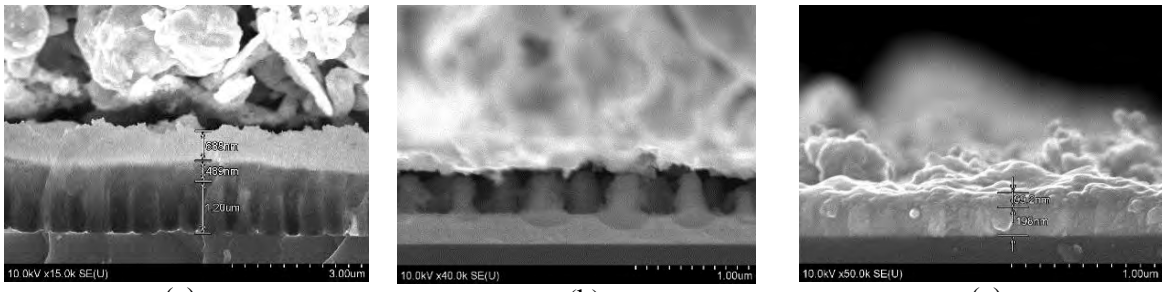
Nanoporous anodic alumina were formed by anodizing of the aluminum films on the Si substrate by multi-step anodizing process in 0.4 mol/dm^3 tartaric acid electrolyte at anodic potential of 185 V [1]. To increase the surface-to-volume ratio, the films were subjected to pore modification in mixture of phosphoric and chromic acids at 333K during 7 minutes. The pore diameters were ~ 220 nm.

The island-grid films were formed by electrochemical anodizing of two-layer Ta/Al thin-film system (50 nm – Ta and 1 μm – Al) on the Si substrate in 0.4 M oxalic acid solution at voltage of 53 V. Following anodizing, the specimen is reanodized up to 150 V (anodized again to a substantially higher voltage) in an aqueous electrolyte for compact-type anodic film formation. The discrete regions continued to grow in sizes gradually filling the pores and getting a shape of island and around the islands were not oxidized tantalum sections, which formed a metal grid. Then the specimen can be solution treated to selectively dissolve away the overlying alumina film and release the tantalum oxide film for deposition sulphide films.

ZnS and SnS_x films were deposited by ion-layering on the surfaces of nanoporous matrices and island-grid films, as well as on smooth glass substrates. Each surface of the samples was coated with 20 sulphide nanolayers.

3. Results and discussion

Investigation of the ionic layering of Zn, Sn sulfide layers on the surface of Al_2O_3/Si and Ta_2O_5/Si matrix substrates has shown that the deposition of functional layers is dominated by the horizontal deposition mechanism, which leads to the formation of structures such as profile matrix/planar layer. Formation of ZnS/SnS_x film heterostructure on smooth substrate occurs only after the use of washing in polar organic solvents and ultrasonic treatment of the substrate surface. The cross-sections of the island-grid films, nanoporous matrices and glass substrates with deposited thin film system of ZnS/SnS_x were presented in the Figure 1.



(a) (b) (c)

Figure 1 (a–c). SEM microphotographs of the cross-section of the structures:
(a) ZnS/SnS_x/Al_2O_3/Si, **(b)** ZnS/SnS_x/Ta_2O_5/Si, **(c)** ZnS/SnS_x/ITO/glass.

The electrophysical investigations have showed that the formed nanostructures is characterized by low electrical resistance of 140-80 Ohm and demonstrates the semiconductor character of the temperature dependence of the electrical resistivity in the temperature range 20-200°C with weakly expressed h-stasis phenomena.

Photovoltaic measurements during irradiation of the nanostructured ZnS/SnS_x surfaces with about 11 W of white light have shown that photoelectric EMF of about 230 mV is generated in the formed functional contacts, which is 35% higher than the result for similar structure obtained by electrochemical deposition [2].

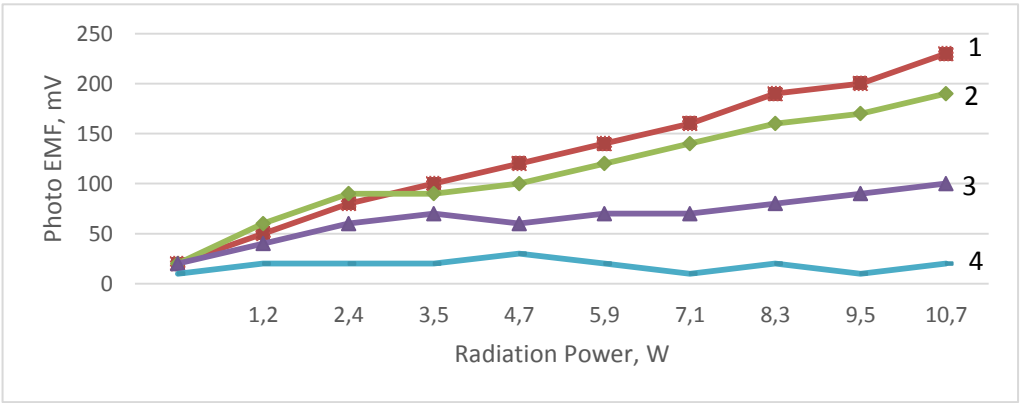


Figure 2. The dependences of the photoelectric EMF of the nanostructured heterostructures on the radiation source power.

References

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