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Enhanced radiation hardness of ZnO nanorods versus bulk layers

A. Burlacu[1,2], V. V. Ursaki[*,1,2], D. Lincot[3], V. A. Skuratov[4], T. Pauporte[3], E. Rusu[1,2], and I. M. Tiginyanu[1,2]

[1] Laboratory of Low-Dimensional Semiconductor Structures, Institute of Applied Physics, Academy of Sciences of Moldova, 2028 Chisinau, Moldova
[2] National Center for Materials Study and Testing, Technical University of Moldova, 2004 Chisinau, Moldova
[3] Laboratoire d'Electrochimie et de Chimie Analytique, UMR 7575, ENSCP-CNRS, 11 rue Pierre et Marie Curie, 75231 Paris, France
[4] Flerov Laboratory of Nuclear Reactions, Joint Institute for Nuclear Research, 141980 Dubna, Moscow Region, Russian Federation

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* Corresponding author: e-mail ursaki@yahoo.com, Phone: +373 22 237508, Fax: +373 22 509920

It is shown that ZnO nanorods grown by MOCVD exhibit enhanced radiation hardness against high energy heavy ion irradiation as compared to bulk layers. The decrease of the luminescence intensity induced by 130 MeV Xe^{+23} irradiation at a dose of 1.5×10^{14} cm^{-2} in ZnO nanorods is nearly identical to that induced by a dose of 6×10^{12} cm^{-2} in bulk layers. The change in the nature of electronic transitions responsible for luminescence occurs at an irradiation dose around 1×10^{14} cm^{-2} and 5×10^{12} cm^{-2} in nanorods and bulk layers, respectively. High energy heavy ion irradiation followed by thermal annealing is also effective on the quality of ZnO nanorods grown by electrodeposition.

1 Introduction It has been recently shown that electrochemical nanostructuring of bulk GaN layers leads to the enhancement of radiation hardness against high energy heavy ion irradiation by more than one order of magnitude [1]. The nanostructuring induced enhancement of GaN radiation hardness was derived from photoluminescence (PL) and resonant Raman scattering (RRS) analysis.

It is known that ZnO is much more resistant to radiation damage than other common semiconductor materials, such as Si, GaAs, CdS and GaN [2]. Wurtzitic ZnO has many applications, such as piezoelectric transducers, varistors, phosphors, transparent conducting films, and gas sensors [3]. With a wide bandgap of 3.4 eV and large exciton binding energy of 60 meV at room temperature, ZnO holds also excellent promise for blue and ultraviolet optical devices. The advantage of large exciton binding energy along with the ability to grow high quality single crystal substrates and a variety of nanostructures with relative cost effectiveness brings forward ZnO as a serious competitor to GaN and GaN-based materials for the blue and ultraviolet wavelength range. The strong radiation hardness of ZnO coupled with excellent optical and electrical properties suggest that ZnO devices are promising for space applications [2].

Previous work on the investigation of radiation damage in ZnO was concentrated either on light particles irradiation (electrons or protons) [2, 4] or on ion implantation with energies ranging from several tens of keV to several MeV [5].

The aim of this letter is to compare the radiation damage introduced by 130 MeV Xe^{+23} ion irradiation in ZnO layers with different morphologies.

2 Experimental details ZnO layers were grown in a horizontal double furnace MOCVD set-up consisting of a source furnace and a main furnace. Zinc acetylacetonate hydrate (Aldrich) loaded into a quartz boat was used as source material introduced into the source furnace. The vapors were transported into the main furnace by Ar gas flow which was mixed with another flow of Ar and O_2 gases at the entrance of the main furnace. The source material was maintained at 130 °C, while the temperature of the Si or glass substrates in the main furnace was set at 500 °C. The deposition process was carried out for 1 h. The morphol-