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# The impact of morphology upon the radiation hardness of ZnO layers

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**Abstract**
It is shown that ZnO nanorods and nanodots 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 $1.5 \times 10^{14}$ cm$^{-2}$ in ZnO nanorods is nearly identical to that induced by a dose of $6 \times 10^{12}$ cm$^{-2}$ in bulk layers. The damage introduced by irradiation is shown to change the nature of electronic transitions responsible for luminescence. The change of excitonic luminescence to the luminescence related to the tailing of the density of states caused by potential fluctuations occurs at an irradiation dose around $1 \times 10^{14}$ cm$^{-2}$ and $5 \times 10^{12}$ cm$^{-2}$ in nanorods and bulk layers, respectively. More than one order of magnitude enhancement of radiation hardness of ZnO nanorods grown by MOCVD as compared to bulk layers is also confirmed by the analysis of the near-bandgap photoluminescence band broadening and the behavior of resonant Raman scattering lines. The resonant Raman scattering analysis demonstrates that ZnO nanostructures are more radiation-hard as compared to nanostructured GaN layers. High energy heavy ion irradiation followed by thermal annealing is shown to be a way for the improvement of the quality of ZnO nanorods grown by electrodeposition and chemical bath deposition.

## 1. Introduction

ZnO is an important semiconducting and piezoelectric material which has high potential for applications such as phosphors, transparent conducting films, field emission devices, varistors, piezoelectric transducers, resonators and sensors [1, 2]. 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 [1]. Due to the possibility of multiple and switchable growth directions of the wurtzite structure and the high ionicity of its polar surfaces, ZnO provides conditions for the formation of a rich diversity of micro/nanostructures ([3, 4] and references therein). This peculiarity, along with the large exciton binding energy and the ability to grow high quality single-crystal substrates, brings forward ZnO as a serious competitor to GaN and related nitride materials for the blue and ultraviolet wavelength range.

It is known that ZnO is much more resistant to radiation damage than other common semiconductor materials, such as Si, GaAs, CdS and GaN [5]. The strong radiation hardness of ZnO coupled with excellent optical and electrical properties suggest that ZnO devices are promising for space applications [5]. The previous work on the investigation of radiation damage in ZnO was focused either on light particle irradiation (electrons or protons) [5–15] or on ion implantation with energies ranging from several tens of keV to several MeV [16–20]. In the only work on high energy heavy ion irradiation of ZnO, bulk crystals were irradiated with 100 MeV oxygen and carbon ions and the distribution of irradiation damage has been analyzed by means

 