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ELECTRICAL PRECISION TREATMENT OF MATERIALS

The Impact of High Energy Ion Irradiation upon CO Gas Sensitivity of Nanostructured GaN Epilayers[1]

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Abstract—Photoelectrochemically nanostructured GaN epilayers were found to exhibit good sensitivity towards CO in the temperature range from 180 to 280°C. We show that subjection of nanostructured GaN samples to 166 MeV Xe^{+23} ion irradiation causes considerable reduction of the gas sensitivity, while post-irradiation rapid thermal annealing results in sensitivity restoration, the effect being dependent upon the dose of irradiation and annealing temperature. A 50% restoration of the relative sensitivity is demonstrated after rapid thermal annealing for 1 min at 800°C in samples irradiated by Xe^{+23} ions at a dose of 10^{12} cm^{-2}.

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INTRODUCTION

GaN is a high temperature material with excellent potential for use in various fields including high power electronics, light emitting devices, and sensors. It exhibits pronounced chemical stability and radiation hardness, the latter property being considerably enhanced by nanostructuring of the compound by means of photoelectrochemical (PEC) etching techniques [1]. Recently we found that nanostructuring is an effective tool for improving the sensitivity and selectivity of GaN-based gas sensors [2]. This paper reports the investigation of the influence of high energy heavy ion irradiation and subsequent annealing on CO gas sensitivity of photoelectrochemically nanostructured GaN epilayers.

EXPERIMENTAL DETAILS

The unintentionally doped GaN layers used in our experiments were grown by low-pressure metalorganic chemical-vapor deposition (MOCVD) on (0001) *c*-plane sapphire substrates. The thickness of the layers was 2.7 μm and the concentration of free electrons was of about 10^{17} cm^{-3}. Ti/Au ohmic contacts of concentric annular design were deposited by lift-off on the GaN epilayers. Subsequently the samples were subjected to PEC etching in 0.1 M of KOH solution for 20 min at room temperature under illumination of a 350 W Hg lamp focused on a spot of 5 mm in diameter. The obtained morphology represents a uniform distribution of conical nanostructures, as illustrated in Fig. 1. The origin of these nanostructures is related to threading dislocations inherent to GaN epilayers grown on lattice-mismatched substrates [3]. The electrochemically treated samples were irradiated at room temperature by 166 MeV Xe^{+23} ions at doses 10^{10}, 10^{11} and 10^{12} cm^{-2}. The irradiation was carried out on the IC-100 cyclotron at the Joint Institute for Nuclear Research in Dubna, Russia. After ion irradiation and preliminary gas sensitivity exploration, the GaN samples were subjected to rapid thermal annealing in N_2 atmosphere for 1 min. For the gas response investigation the samples were mounted in a cell where the CO gas concentration was varied from 200 to 2000 ppm, whereas the sample temperature was increased from 180 to 280°C.

RESULTS AND DISCUSSION

The relative sensitivity S was calculated using the equation:

$$S = \frac{R_{N_2} - R_{CO}}{R_{N_2}} \times 100\%,$$

[1] The article is published in the original.