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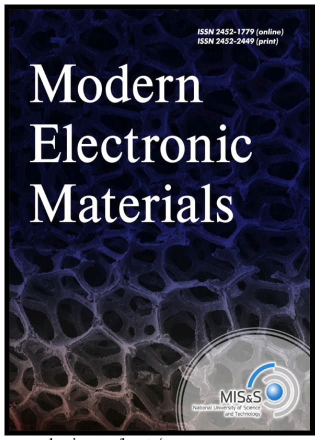

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Research of acceptor impurity thermal activation in GaN:Mg epitaxial layers

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Abstract. 3rd group element nitride based semiconductor compounds are widely used in various optical and electronic devices. One problem in the fabrication of GaN based device heterostructures is the synthesis of *p* conductivity epitaxial layers. Magnesium is a typical doping impurity for GaN. The choice of optimum doping and thermal activation conditions is of utmost importance for the synthesis of low-ohmic *p*-GaN epitaxial layers.
The effect of thermal annealing of GaN:Mg layers on acceptor impurity activation has been investigated. Hole concentration increased and mobility decreased with an increase in thermal annealing temperature. The sample annealed at 1000 ^{o}C demonstrated the lowest value of resistivity. Rapid thermal annealing (annealing with high heating speed) considerably improved the efficiency of Mg activation in the GaN layers. The optimum time of annealing at 1000 ^{o}C has been determined. The hole concentration increased by up to 4 times compared to specimens after conventional annealing.

Keywords: gallium nitride, GaN, MOCVD, Metal-organic chemical vapor deposition, rapid thermal annealing, magnesium bis-cyclopentadienyl, (Cp_2Mg), doping, *p*-type.

Introduction

3rd group element nitride based semiconductor compounds are widely used in various optical and electronic devices [1]. One problem in the fabrication of GaN based device heterostructures is the synthesis of *p* conductivity epitaxial layers because conventional acceptor impurity doping (Zn, Cd) of 3-5 semiconductors does not give the expected result. Magnesium is a typical doping impurity for GaN [2]. Efficient operation of many device structures requires high free carrier concentrations in *p*-GaN layers. To form a good Ohmic contact one should provide a concentration of holes in the surface layer of at least 10^{18} cm^{-3} [3].
However, obtaining *p* conductivity by magnesium doping of GaN epitaxial layers by MOC-hydride epitaxy is hindered by the formation of electrically neutral complexes of hydrogen and magnesium atoms (Mg^-–H^+). There are several approaches to the activation of magnesium atoms e.g. exposure to low energy electron beams, microwaves, RF and laser radiation and thermal annealing. One of the most efficient and process adaptable magnesium activation methods is post-growth thermal annealing in a nitrogen atmosphere. This treatment destructs the Mg–H complexes and removes hydrogen H^+ by diffusion towards the specimen surface [4].
One obstacle to the achievement of high hole concentrations in *p*-GaN is the high activation energy of magnesium atoms [1]. As a result, only part of the acceptor impurity contributes to carrier generation at room temperature. Therefore to obtain *p*-GaN layers with a low electrical resistivity one should provide a high concentration of magnesium atoms in epitaxial layers. However, excess magnesium increases the probability of the formation of donor type structural defects some of which have an