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Fermi Level Control of Point Defects During Growth of Mg-Doped GaN

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In this study, Fermi level control of point defects during metalorganic chemical vapor deposition (MOCVD) of Mg-doped GaN has been demonstrated by above-bandgap illumination. Resistivity and photoluminescence (PL) measurements are used to investigate the Mg dopant activation of samples with Mg concentration of 2×10^{19} cm^{-3} grown with and without exposure to ultraviolet (UV) illumination. Samples grown under UV illumination have five orders of magnitude lower resistivity values compared with typical unannealed GaN:Mg samples. The PL spectra of samples grown with UV exposure are similar to the spectra of those grown without UV exposure that were subsequently annealed, indicating a different incorporation of compensating defects during growth. Based on PL and resistivity measurements we show that Fermi level control of point defects during growth of III-nitrides is feasible.

Key words: Mg, GaN, UV excitation, Photoluminescence, Metal-organic chemical vapordeposition (MOCVD)

INTRODUCTION

Mg is utilized as a *p*-type dopant for GaN because its relatively low thermal ionization energy, estimated at 250 meV, and relatively high solubility have enabled the achievement of technologically useful hole concentrations.[1] In the past 20 years, GaN-based light-emitting diodes, laser diodes, and photodetectors have been developed, but the optical transitions in GaN:Mg are still not well understood.[2] Mg doping of GaN is complicated by compensation of Mg ions by H through the formation of a neutral Mg-H complex during growth.[3] A post-growth thermal anneal is typically employed to dissociate the Mg-H complex and obtain *p*-type conductivity.[3–5] It has been shown that, in GaN:Mg grown by metalorganic chemical vapor deposition (MOCVD), a maximum hole concentration of mid 10^{17} cm^{-3} can be achieved, at room temperature, with Mg concentrations of 2×10^{19} cm^{-3} to 3×10^{19} cm^{-3}.[6] At higher Mg concentrations, there is overcompensation, which means there is an increase in the concentration of compensating donors different from H.[7] Ideally, point defect control during growth would allow for a reduction of this overcompensation.

Illumination by UV lamps or lasers during MOCVD growth of II-VI compounds such as ZnO, ZnSe, ZnS, and CdTe has led to lower growth temperatures, enhancement of the growth rate, reduction of compensating defects, and an increase in *p*-type conductivity.[8–12] Photoassisted MOCVD growth of GaAs has also been explored; illumination during growth enhanced the incorporation of Si at low growth temperatures and increased the growth rate of the material.[13] These results gathered from II-VI and III-V compounds indicated that UV

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