CARRIER DYNAMICS IN N- AND P-TYPE InGaN LAYERS AND THE ROLE OF MAGNESIUM ACTIVATION

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Indium gallium nitride (InGaN) is a key material for optoelectronic devices such as light-emitting diodes, laser diodes, and solar cells, where high-quality n- and p-type layers are essential for optimal performance. While efficient n-type conductivity in III-nitrides is readily achieved using dopants such as Si or C, reliable p-type doping remains challenging because the dopant magnesium (Mg) acceptors are passivated by hydrogen through the formation of Mg–H complexes. Activation of Mg typically requires post-growth rapid thermal annealing (RTA) to dissociate these complexes; however, such processing can introduce nitrogen-vacancy (N_V)–related defects that degrade material properties. Despite extensive studies on the electrical behavior of Mg-doped InGaN, a detailed understanding of how Mg activation influences carrier dynamics remains incomplete, particularly regarding recombination and transport following annealing.

In this work, carrier dynamics in both n-type and Mg-doped p-type InGaN layers, including as-grown and annealed samples with varying indium compositions are investigated, using time-integrated photoluminescence (TIPL) and light-induced transient grating (LITG) techniques. The results show increased carrier diffusivity in annealed p-type layers, accompanied by a reduction in carrier lifetime. Internal quantum efficiency (IQE) analysis is used in combination with ABC modeling to extract recombination coefficients and quantitatively evaluate the dominant recombination and transport processes. This comparative approach elucidates the differences in carrier dynamics between n- and p-type InGaN and highlights the impact of Mg activation and annealing-induced defects on recombination pathways.