Growth and optoelectronic properties of erbium doped GaN

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Abstract

Erbium (Er) doped semiconductors provide possibilities to realize novel electrically pumped optical amplifiers that possess the advantages of both semiconductor amplifiers (small size, electrical pumping, ability for photonic integration) and Er-doped fiber amplifiers (minimal crosstalk between different wavelength channels in optical networks). Among all the semiconductors investigated, III-nitrides have shown to be excellent host materials for Er elements due to their wide bandgaps and structural and thermal stability. We summarize recent progresses on the growth by metal-organic chemical vapor deposition (MOCVD) of Er doped GaN epilayers (GaN:Er) [1,2]. The 1.54 μm emission intensity was monitored for GaN:Er epilyers grown at different growth temperatures and utilized to establish a value of 1.82 ± 0.1 eV for the formation energy (E_0) of the optically active Er^{3+} centers in GaN [3]. It was realized that relatively high growth temperatures are needed to improve the 1.54 μm emission efficiency in GaN:Er due to the large E_0 values. Strip waveguides based on GaN:Er have been fabricated. It was found that the propagation loss at 1.54 μm correlates strongly with the crystalline quality of GaN and increases almost linearly with the GaN (002) x-ray rocking curve linewidth. The optical excitation cross-section (σ_{exc}) of Er ions in GaN has been determined by time-resolved photoluminescence. The observed σ_{exc} for the above band gap excitation was found to be about three orders of magnitude larger than that using resonant excitation [4]. The concept of the large excitation cross-section with above band gap excitation was applied to demonstrate monolithic current injected p-i-n LEDs based on p-GaN/InGaN:Er/n-GaN structure [5] and waveguide amplifiers by heterogeneously integrating GaN:Er with III-nitride UV/blue LEDs [6].

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