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Optical and Vibrational Characterizations of AlN:Er Epilayers

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Abstract:

Two sets of aluminum nitride (AlN) epilayers deposited on sapphire (0001) and silicon (100) substrates by molecular beam epitaxy were implanted with erbium ions at room temperature with an implanted ion fluence of 5.5×10^{15} at/cm^2 and ion energy range not exceeding 150 keV. The as-implanted samples were annealed at 1050 °C to remove defects and make Er^{3+} ions optically active. AlN:Er^{3+} samples were investigated by high resolution cathodoluminescence (CL) and Raman spectroscopy in the 7 K - 300 K temperature range. The comparison of the CL spectra measured for AlN:Er^{3+} grown on Sapphire and Silicon substrates shown a great similarity with slightly emission lines shift. In theoretical modeling we assumed that Er^{3+} ions are involved in substitutional Al-site. Simulations are carried out using crystal field parameters determined using electrostatic point charge model and crystal field theory. The Er^{3+} ion emission lines shift observed between CL spectra of AlN:Er^{3+} grown on sapphire and silicon substrates was explained by the presence of induced stress in AlN:Er^{3+} thin films and further studied by Raman spectroscopy. Using Raman scattering at different temperatures, we have shown the presence of the allowed E_2(high) and A_1(LO) phonon modes in AlN:Er^{3+} epilayers. The correspondent frequencies are in good agreement with theoretical predictions. It was observed that tensile stress exists in AlN:Er^{3+} epilayer grown on sapphire in contrast to compressive stress present in the AlN:Er^{3+} epilayer grown on silicon as indicated by the observed E_2(high) mode frequency shift and the broadening of vibrational linewidth. The stress value was calculated using the linear approximation. The temperature dependence of the E_2(high) frequency and the vibrational linewidth show that the tensile stress in AlN:Er^{3+} epilayer on sapphire decreases with increased temperature.