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Optical Properties of Nitride-Based Structures Grown on 6H-SiC

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The luminescent properties of AlGaN epitaxial layers with AlN mole fractions up to 30% and various types of AlGaN/GaN-based heterostructures have been studied. The structures were grown on 6H-SiC substrates by MOCVD [metal-organic chemical vapor deposition]. The structures' cathodoluminescence and electroluminescence were measured. A "blue" shift of the edge luminescent peak position for AlGaN alloys was measured to be a nonlinear function on the AlN mole fraction. For p-AlGaN/n-GaN double heterostructures (DH), the edge peak position was detected at 365 nm (300 K). For a p-$\mathrm{Al_{0.05}Ga_{0.95}N}$/ n-$\mathrm{Al_{0.03}Ga_{0.97}N}$ heterostructure, the electroluminescent edge peak was observed at 355 nm (300 K). The effects of temperature and forward current on the edge electroluminescence of the AlGaN/GaN DHs were investigated.

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High Resistivity $\mathrm{Al}_x\mathrm{Ga}_{1-x}\mathrm{N}$ Layers Grown by MOCVD

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Undoped $\mathrm{Al}_x\mathrm{Ga}_{1-x}\mathrm{N}$ layers with good surface morphology and very low electron concentration have been grown by MOCVD [metalorganic chemical vapor deposition] on sapphire substrates. The observed electrical and optical properties depend strongly on the growth temperature. Layers grown at 1000°C exhibited low resistivity and strong optical absorption below the bandgap. In contrast, layers grown at 1050°C had low carrier concentrations and good mobilities. Virtually no optical absorption near the band edge was observed as opposed to the usual situation in $\mathrm{Al}_x\mathrm{Ga}_{1-x}\mathrm{N}$. The electrical properties of these layers can be explained by the presence of donor centers whose energy increases with composition, and deeper lying compensating defects. The interaction of these centers renders the samples with $x < 0.2$ highly resistive, with room temperature resistivity higher than 10^6 ohm-cm. SIMS data strongly suggest that the electrically active centers in our AlGaN layers are native defect-related. Implantation of Si ions into $\mathrm{Al_{0.12}Ga_{0.88}N}$, and subsequent annealing at 1140°C resulted in layers with electron concentration of 4.6×10^{17} cm^{-3}.

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Radiative Lifetime of Excitons in GaInN/GaN Quantum-Wells

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We have studied GaInN/GaN quantum-well structures grown by LP-MOVPE [metal-organic vapor-phase epitaxy] by picosecond time-resolved photoluminescence spectroscopy. For the quantum-wells we find rather long PL decay times of up to 600 ps at low temperature. At temperatures higher than about 100 K, the decay time decreases rapidly, reaching about 75 ps at room temperature. From measurements of the integrated PL intensity, we conclude that this decrease of the decay time is due to non-radiative recombination processes. By combining our data for the lifetime and the intensity, we derive the radiative lifetime, which is constant at low temperature and increases at elevated temperatures. We explain this behavior on the basis of the interface roughness at low temperature and thermal dissociation of excitons at higher temperatures.

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Fabrication of GaN Mesa Structures

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We report on nickel-based technology for the fabrication of GaN mesa structures. Ti/Ni ohmic contacts for n-doped GaN with contact resistivity $R_c \sim 2 \times 10^{-5}\ \Omega \times \mathrm{cm}^2$ and Ni ohmic contacts for p-doped GaN with $R_c \sim 4 \times 10^{-2}\ \Omega \times \mathrm{cm}^2$ were formed. Both types of contacts were used as masks for GaN reactive ion etching (RIE) in a $\mathrm{CCl_2F_2}$/Ar gas mixture. Maximum etch rates of ~40 nm/min were obtained. Mesa structures up to 3 μm in height were formed.

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