Radiative and nonradiative exciton recombination in quantum dots unintentionally formed in AlGaN

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Abstract

Carrier localization is an inherent property of III-nitrides used extensively for production of visible (InGaN-based) and UV (AlGaN-based) light-emitting diodes and laser diodes. The carrier localization increases the light emission efficiency of these devices. Our previous data obtained by the luminescence spectroscopy and light-induced transient grating techniques and the Monte Carlo simulations of carrier dynamics in these materials indicate that the nonequilibrium electrons and holes accumulate in submicrometer scale regions of lower average potential and are localized in the minima of small-scale potential fluctuations like excitons in quantum dots (QDs).

In this report, we present the experimental data on the photoluminescence (PL) spectroscopy of AlGaN epitaxial layers and multiple quantum wells under quasi-steady-state excitation and in time-resolved PL mode in a wide range of excitation intensities in the temperature range between 10 and 300 K. The key new features observed at low temperatures are: a nonmonotonous PL band peak shift with increasing excitation, the persistence of a fast PL decay component throughout the entire PL band, and the decrease in the PL decay time on the low-energy slope of the PL band. The dynamics of these features at elevated temperatures is also studied. We interpret our experimental results by localization and delocalization of excitons in the QDs and transfer of the excitons between the neighboring QDs. Radiative and nonradiative recombination of the localized excitons are under discussion.