Improvement of GaAs/Si epitaxial films optical properties by means of low-temperature GaAs intermediate layers

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Integration of silicon-based electronics and the element base on $A^{III}B^{V}$ compounds on the Si substrates is of great interest due to perspectives of various device realizations. One of the most interesting of $A^{III}B^{V}$/Si heterosystems is the GaAs/Si system, which allows to hope for the integration of already developed GaAs optoelectronic devices into the silicon technology. Due to difference of lattice parameters and thermal expansion coefficients of the Si and $A^{III}B^{V}$ materials mechanical stresses arise in epitaxial films. These stresses are relaxed by the formation of dislocations. As a result, the crystal structure of epitaxial layers is deteriorated, that adversely affects the quality of heterostructures and devices on their basis.

The influence of low-temperature GaAs (LT-GaAs) intermediate layers on the structural and optical properties of GaAs/Si films is investigated in this work. Vicinal (001) Si substrates with a 6° offcut towards the (111) plane was used to suppress the formation of antiphase domains. The GaAs nucleation was carried out at Ts=200°C by atomic-layer epitaxy (ALE) using GaP sublayers with different orientation. The LT-GaAs intermediate layers were grown both near the GaAs/Si interface and in a GaAs bulk. The growth temperatures of GaAs and LT-GaAs layers were 600°C and 200°C, respectively. The total thickness of GaAs/Si films was 2.5μm. The grown films were different in their crystallographic orientation ((001) or (00-1)) and the presence or absence of LT-GaAs layers.

The structural and optical properties of the grown structures were investigated by X-ray diffractometry (XRD) method and stationary photoluminescence (PL) spectroscopy. The structures surface morphology was investigated by atomic force microscopy (AFM).

According to XRD analysis of samples can be said that crystalline quality of films is not significantly affected by LT-GaAs layer. On the rocking curves the full width at half maximum (FWHM) of the films peak with LT-GaAs layers are comparable to the FWHM of the films peak without ones and are about 250 arc seconds. This indicates a close crystalline perfection of two different types of structures. However, the AFM data showed that the surface morphology of the structures with LT-GaAs layers is much better than at the structures without such layers. It was also found that the PL spectra of heterostructures with LT-GaAs layers are almost twice as intense as the spectra of structures without LT-GaAs layers. This fact indicates a decrease in the rate of nonradiative recombination of nonequilibrium charge carriers in the near-surface GaAs layers at the presence of LT-GaAs intermediate layers.

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