Growth of strain-compensated GaInNAs/GaAsP quantum wells for 1.3 μm lasers

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In this paper we report on growth of highly strained GaInNAs layers with strain-compensating GaAsP barriers. Especially, effects of rapid thermal annealing (RTA) on the optical properties of GaInNAs/GaAsP quantum well structures as well as laser diodes are examined.

The structures were grown by the gas-source molecular beam epitaxy method. A radio frequency-coupled nitrogen plasma source was used to generate reactive nitrogen species. To determine the N and In mole fractions, x-ray diffraction measurements were performed. After growth, RTA was applied.

Growth of GaInNAs was studied by changing the growth temperature and AsH_3 pressure. Fig.1 shows the room temperature photoluminescence (PL) of a 7 nm $Ga_{0.6}In_{0.4}$(N)As/GaAsP single quantum well. All samples were annealed at 750 ^oC for 10 s. A strong emission band (FWHM = 19.85 meV) at 1.15 μm indicates that this structure is of good structural quality. Peak intensity remains nearly the same and the linewidth increases slightly when only a small amount of nitrogen is incorporated. At a higher nitrogen concentration the peak intensity decreases significantly, and the peak broadens.

The PL intensity of as-grown GaInNAs/GaAsP QWs is weak, due to defects induced by the high density of N ions in the GaInNAs layer. In order to improve the crystalline quality we have studied the PL features of the samples annealed at different temperatures for various time intervals. For both GaInAs/GaAsP and GaInNAs/GaAsP structures the PL intensity were improved significantly. Fig.2 shows the effects of RTA on the optical properties of a GaInNAs/GaAsP sample. The PL intensity increases with annealing temperature to a maximum at 750 ^oC for 10 s (FWHM = 22.8 meV). With increasing RTA temperature, the PL peaks blue shift for all the QWs, mainly due to interdiffusion of Ga and In. At 750 ^oC the PL intensity increases in the beginning of RTA and reaches its maximum in 10 s. As annealing continues, the intensity decreases. The linewidth also changes rapidly in the initial stage of RTA. This could be caused by interdiffusion of Ga and In atoms that is very high in the beginning of RTA for a defect-rich GaInNAs/GaAsP interface, and decreases gradually, as the defects are removed by annealing.

Effects of RTA on the lasing properties of GaInNAs/GaInP SQW laser diodes are also studied. Fig.3 shows the threshold current density (J_{th}) and emission wavelength of lasers as a function of RTA temperature. J_{th} decreases significantly as RTA temperature increases, while the lasing wavelength slightly blue shifts.

Our preliminary results show that RTA has a significant effect on optical quality of GaInNAs/GaAsP QW structures and performance of laser diodes processed from these materials. More detailed investigation of RTA effect will be presented and discussed in the Workshop.

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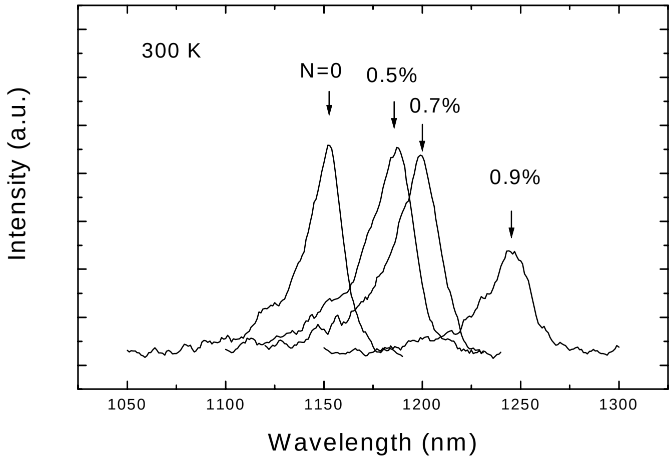

Fig.1. Room temperature PL from 7nm $Ga_{0.6}In_{0.4}(N)As/GaAsP$ SQW with different N composition.

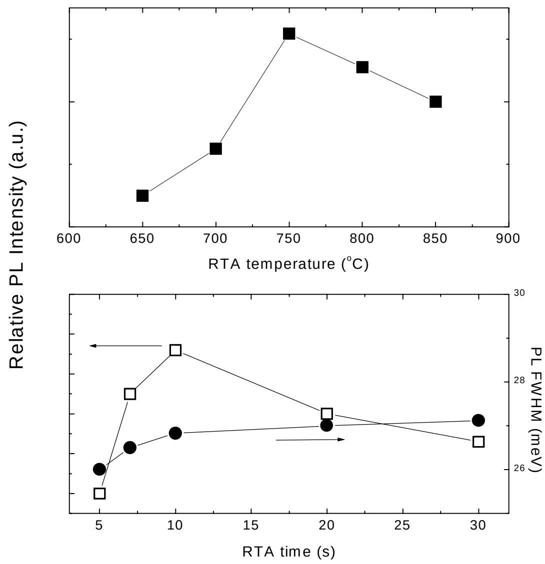

Fig.2. Threshold current density and lasing wavelength for GaInNAs/GaInP SQW broad area lasers at room temperature as a function of RTA temperature.

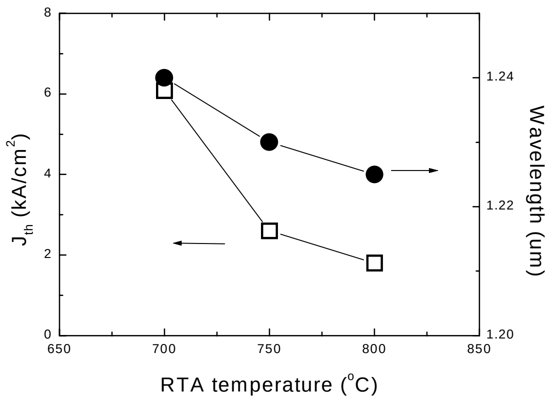

Fig.3. Threshold current density and lasing wavelength for GaInNAs SQW broad area lasers at room temperature as a function of RTA temperature.