

1.3-1.5 μ m wavelength quantum dots self-formed in GaAs/InAs superlattices grown on InP (411) substrates

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Recently, we have reported the self-formation of high lateral density and well-aligned QD structures by growing the $(\text{GaP})_{1.5}(\text{InP})_{1.88}$ short period superlattices (SLs) on GaAs (311)A and (411)A substrates by gas source MBE [1]. In the STM images, we observed a high lateral density ($\sim 10^{11} \text{ cm}^{-2}$) of self-formed QD structures. They are aligned along two perpendicular directions ([0-11] and [-233] directions on GaAs (311)A substrate) [2]. In the STS measurement, we found the periodic variation of the bandgap energy along the lateral direction. These QDs showed the narrow PL spectra at the red wavelength region and the current injection laser operation was achieved [3]. In this paper, we report on the self-formed QDs by growing the GaAs/InAs SLs on InP (411)A substrate, which emit at the wavelength region of 1.3 - 1.5 μ m.

$(\text{GaAs})_2(\text{InAs})_2$ SLs were grown on InP (411)A substrate by gas source MBE. Sources used were elemental Ga and In and thermally cracked AsH_3 and PH_3 . Self-formation of QDs were confirmed with STM. Multilayer QD (MQD) structures were fabricated by growing (i) a 300-nm-thick InP buffer layer, (ii) 5 cycles of $(\text{GaAs})_2(\text{InAs})_2$ SL (P-periods)/10-nm-thick InP multilayers and (iii) 300-nm-thick InP cap layer, as shown in Figure 1. Figure 2 shows the 77K PL spectra for the $(\text{GaAs})_2(\text{InAs})_2$ SL MQD as a function of superlattice period ($P = 3, 5, 10$). PL peak wavelength becomes shorter with decreasing the superlattice period P due to the quantum size effect along the growth direction (vertical direction). PL emission wavelength can be easily changed from 1.3 μ m to 1.5 μ m by controlling superlattice period P .

Figure 3 shows the temperature dependence of integrated PL intensity. The PL integrated intensity was decreased much slower ($\sim 10^{-2}$) than that of GaP/InP QDs ($\sim 10^{-4}$). This implies the superiority of the GaAs/InAs system over the GaP/InP system. However, in the present stage, the PL linewidth of GaAs/InAs QDs (30meV at 10K) is a little bit wider than that of GaP/InP QDs (20meV at 10K). Optimization in the growth of the GaAs/InAs QDs were further improve their optical properties.

References

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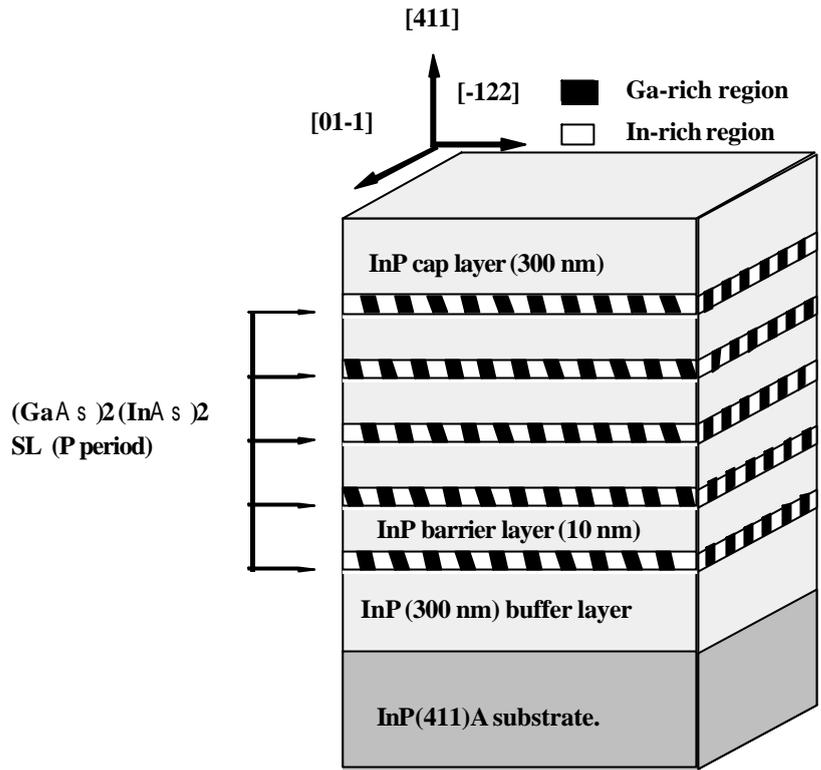


Fig.1 Schematic drawing of multilayer quantum dot (MQD) structure

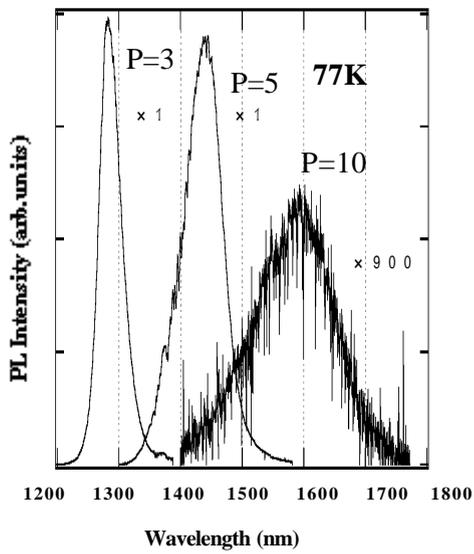


Fig.2 PL spectra of (GaAs)₂(InAs)₂ MQD (P=3,5,10)

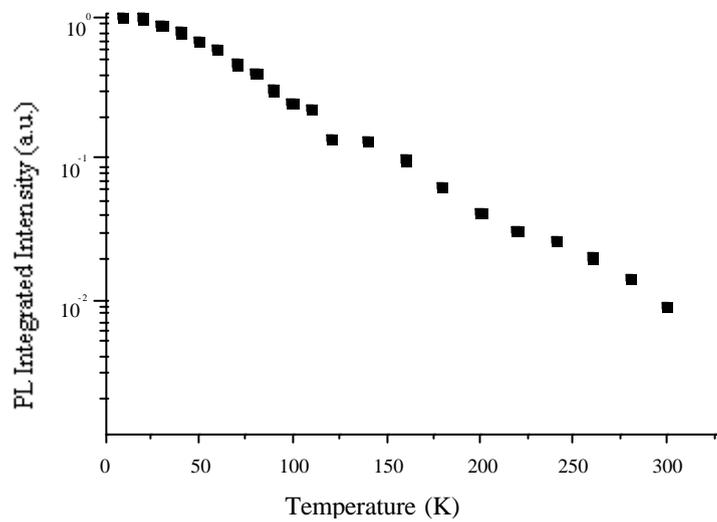


Fig.3 Temperature dependence of PL integrated intensity