

Optical and structural characterisation of highly Si doped InGaAs/AlAsSb heterostructures grown by molecular beam epitaxy

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In_{0.53}Ga_{0.47}As/AlAs_{0.56}Sb_{0.44} quantum wells (QWs) lattice-matched to InP substrates are recently attracting much attention for optical and electrical devices, because of their very large conduction band offsets of 1.6 eV¹⁾. We have reported the near-infrared intersubband transitions from this materials system²⁾. We have also reported the ultra-fast absorption recovery of 1.2 ps³⁾ and shown that this materials system is suited for the ultra high-speed optical devices used in the optical communication network. However, it is pretty difficult to obtain the shorter wavelength intersubband absorption because of the difficulty of achieving abrupt heterointerfaces, especially when it is heavily doped. This paper reports the photoluminescence (PL), high resolution transmission electron microscopy (HRTEM), and Fourier transform infrared spectroscopy (FTIR) study of the highly Si doped In_{0.53}Ga_{0.47}As/AlAs_{0.56}Sb_{0.44} QWs lattice-matched to InP grown by molecular beam epitaxy (MBE).

The InGaAs/AlAsSb quantum-wells (QWs) were grown on Fe-doped (001) InP substrate by solid source MBE. Elemental Ga, In, and Al were used for the group III growth species, and Sb₂ and As₂ were used for the group V growth species. As₂ was supplied using a valved cracker cell.

Figure 1 shows the band diagram of a C-DQW and wavefunctions. Figure 2 shows the FTIR spectra of coupled double QWs (C-DQWs) samples. The InGaAs well width is 7 monolayers (MLs) and the barrier between the wells is 3 ML AlAs. The barrier layers between the C-DQWs were 10 nm AlAsSb. The number of period of the C-DQWs is 80. All samples are doped to the wells. (a) is for 1x10¹⁸ cm⁻³ doped sample, (b) is for 5x10¹⁸ cm⁻³ doped sample, and (c) is for 1x10¹⁹ cm⁻³ doped sample. Two peaks are observed in samples (b) and (c). These 2 peaks can be attributed to the 1 – 4 and 2 – 3 subband transitions in the conduction band well. Sample (a) and (b) show the 1.35 μm transition. This is one of the shortest intersubband transition ever reported. Clear red shift of the absorption peak is observed as the doping concentration is increased. This red shift can be attributed to the doping induced interface disorder that is clearly observed by HRTEM lattice images.

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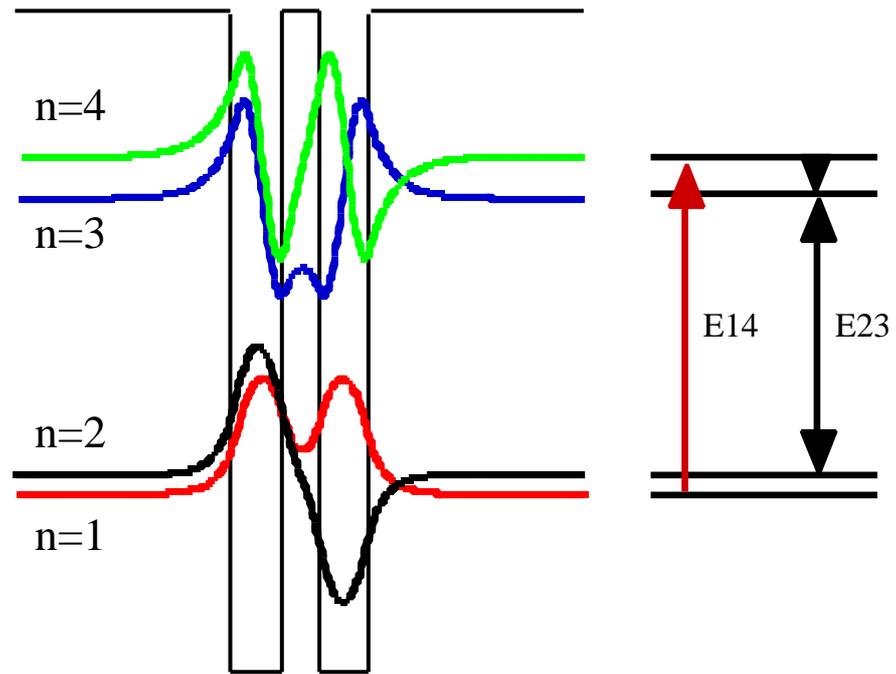


Fig. 1 band diagram for a C-DQW and calculated wave functions

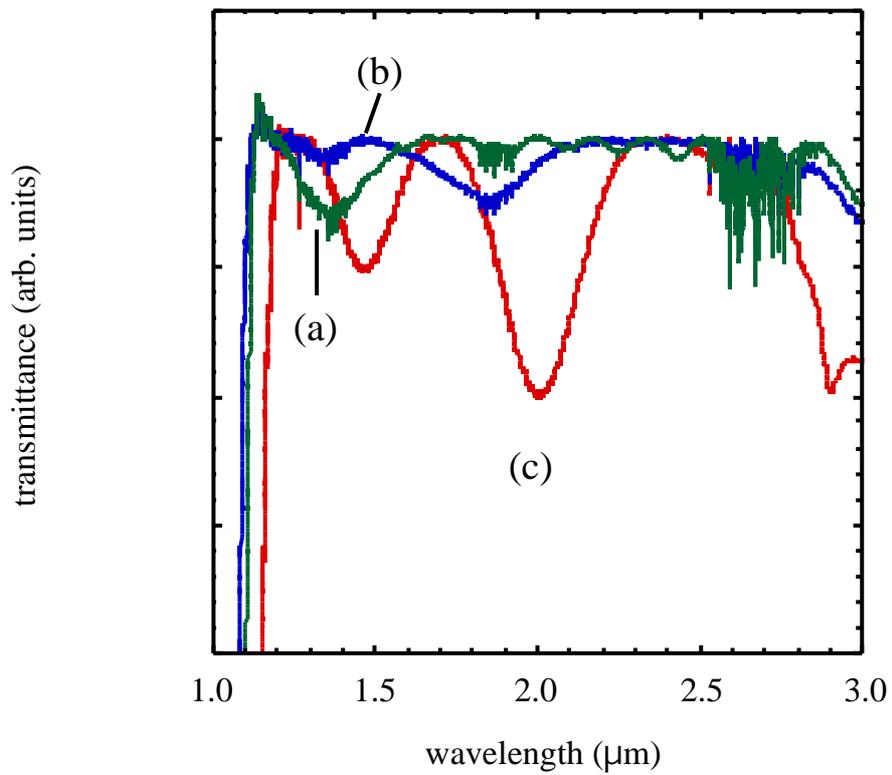


Fig. 2 Doping concentration dependence of the intersubband absorption energy in InGaAs/AlAsSb C-DQWs