Optical properties of heterostructures with deep quantum wells AlSb/InAs$_{0.86}$Sb$_{0.14}$/AlSb

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Abstract — This paper the dimensional quantization energies, the absorption coefficient and the radiative recombination rate in the heterostructure with deep quantum well AlSb/InAs$_{0.86}$Sb$_{0.14}$/AlSb are calculated with the Kane model and with the simple parabolic model. It is shown that the carriers energy spectra nonparabolicity leads to sufficient corrections to the dimensional quantization energies, the absorption coefficient and the radiative recombination rate values in deep quantum wells.

Keywords — deep quantum wells, energy spectrum nonparabolicity

I. INTRODUCTION

Using heterostructures with InAsSb deep quantum wells (QW) is the actual trend of infrared optoelectronics \([1]\), because these compounds are characterized by the lowest band gap and the electron effective mass among \(A_3B_5\) semiconductors \([2]\). These heterostructures also have larger overlap integral value and larger recombination processes rate than bulk compounds. The small band gap \(E_g\) of the active region and the large valence band discontinuity \(U_c\) cause to an appreciable charge carriers energy spectra nonparabolicity which leads to significant corrections to dimensional quantization energies, absorption coefficient and radiative recombination rate in QW. This work we investigated optical properties of heterostructure with deep QW AlSb/InAs$_{0.86}$Sb$_{0.14}$/AlSb.

II. THEORETICAL ANALYSIS

For interband optical transitions absorption coefficient and radiative recombination rate calculations we used the Kane model \([3]\) which gives most exact carriers wave functions and energy spectra for narrow gap \(A_3B_5\) semiconductors. There is sufficient role of p-states mixing into s-states for conduction band electrons wave functions which leads forbidden transitions increasing. We accepted the QW width \(a=100\) A in our calculations.

It is shown that taking spectra nonparabolicity into account affects the number of levels. There are three dimensional quantization levels in the parabolic model and six levels in the four-band Kane model because high energy electrons effective mass in the Kane model four times exceeds the one in simple parabolic model. It is also shown that p-states mixing to s-states in electrons wave functions does not affect on overlap integral value but leads to sufficient density states function increase which causes to significant absorption coefficient especially for high energy states. Also taking nonparabolicity into account reduces the rate of interband optical transitions between the levels of the same parity and increases the ones of different parity. Transition between first excited electron subband and first excited heavy hole subband has the lowest radiative recombination time in both models.

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REFERENCES