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Photocurrent spectroscopy of self assembled InAs/GaInAsP/InP(113)B quantum dots.

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1- Introduction

In this paper we present photocurrent (PC) spectroscopy of InAs/InP(113)B quantum dots (QD) as a function of bias and temperature. The PC spectra reflect the optical absorption of the QDs layers and reveal the QD electronic structure. A simple model, used to determine the energy levels into the QDs, gives results consistent with the PC spectra. Moreover, the PC signal is governed by a competition between recombination and escape processes (thermal and tunneling escape) of photogenerated carriers.

2- Experiments

We have investigated InAs/GaInAsP/InP(331)B QDs buried in a p-i-n laser junction. The growth on InP(113)B substrate yields smaller QDs with higher density than on InP (100) substrate [1]. Moreover, the QDs are performed with the double cap (DC) growth technique which enables us to control their average height at 3nm. Lasing emission has been observed on laser structure respectively at 1.4 μ m and 1.5 μ m at room temperature on the ground (GS) and the first excited states of such QDs[2].

As shown in figure 1, the QDs PC signal obtained at 4K rise with increasing the reverse bias. Evolution spectra shows saturation effects for bias below -3V. This value is in agreement with C(V) measurements. The QD energy states redshift weakly with increasing reverse bias. This shift may be due to a size selective tunneling effects [3] and a quantum confined Stark effect (QCSE) [4, 5].

We show (figure 2) the dependence temperature PC spectra. We observed that carriers extraction from QDs to the barrier is governed by faster thermal escape at high temperatures and by tunneling escape process at low temperatures.

3- Simulation

Simple calculations of the electronic levels have also been performed by solving the single particle Schrodinger equation in cylindrical coordinates [4]. A one band model with effective masses taking into account strain effects in the dots gives results consistent with PC experiments. It allows us to identify the 1s-1s (GS) and 1p-1p (ES) transitions occurring.

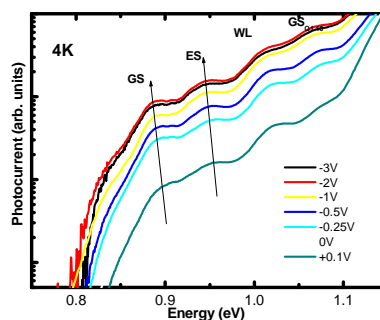


Figure 1 : photocurrent (PC) spectra measurement as function of reverse bias at T=4K for bias (V=0.1V ; 0V ; -0.25V ; -0.5V ; -1V ; -2V ; -3V).

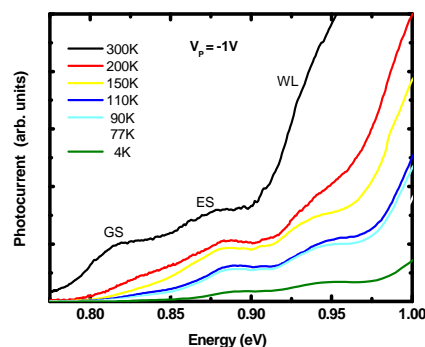


Figure 2 : The temperature dependence PC spectra at bias $V_p = -1V$.

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