11th International Conference
on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

Hydrostatic pressure and electric field effects on excitons in coupled double quantum wells

R. L. Restrepo(1)*, W. Ospina(1), G. Miranda(1), E. Giraldo(1) and C. A. Duque(2)

(1) Escuela de Ingeniería de Antioquia, AA 7516, Medellín, Colombia, e-mail: pfrire@eia.edu.co
(2) Instituto de Física, Universidad de Antioquia, AA 1226, Medellín, Colombia
* Corresponding author.

Abstract – A study of the simultaneous effects of hydrostatic pressure and in-growth direction applied electric field on the correlated electron-hole energy transitions in GaAs/(Ga,Al)As coupled double quantum wells is presented. Theoretical calculations have been made in the framework of the effective mass and parabolic band approximations and using a variational procedure. The results show that the hydrostatic pressure and the applied electric field are useful tools to tune the direct and indirect exciton transitions in such heterostructures.

A symmetric/asymmetric coupled double quantum well (CDQW) consists of two identical/different quantum wells (QW) separated by a thin barrier. For the symmetric case the eigenfunctions of such heterostructure have well-defined symmetries and only transitions between electron and hole states with the same symmetry are optically allowed. This condition can be reverted, for instance, by the inclusion of an in-growth direction applied electric field which will be responsible of the breaking of symmetries.

In this work it is made a study of the combined effects of hydrostatic pressure and in-growth direction applied electric on the photoluminescence peaks energy transitions for direct and indirect excitons in GaAs/(Ga,Al)As CDQW. The exciton envelope function in the semiconductor is obtained through a variational procedure using a hydrogenic 1s-like wave function and an expansion in a complete set of trigonometric functions for the electron and hole wave functions. We use the effective-mass and parabolic-band approximations. Calculations are performed for symmetric and asymmetric CDQW heterostructures.

Calculated results are found in good agreement with available experimental measurements for the recombination energy of indirect excitons as a function of the external applied electric field [1] and for the photoluminescence peak energies in GaAs/(Ga,Al)As CDQW under hydrostatic pressure [2]. It is also shown that the electron-hole recombination energy and photoluminescence peak energy transitions strongly depend of the external applied electric field and hydrostatic pressure.

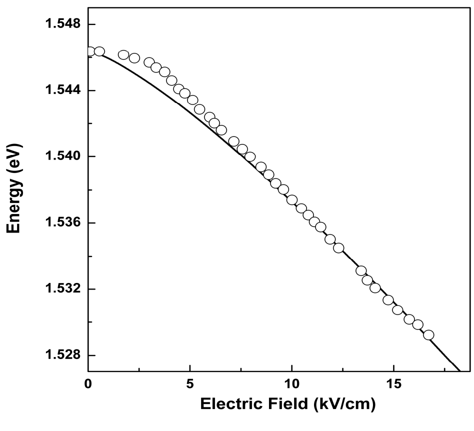

Figure 1: Recombination energy transition, for indirect excitons, as a function of the growth-direction applied electric field in GaAs-$Ga_{0.7}Al_{0.3}As$ CDQW. The solid line represents our calculated results and the symbols are the data from Solov'ev et al [1].

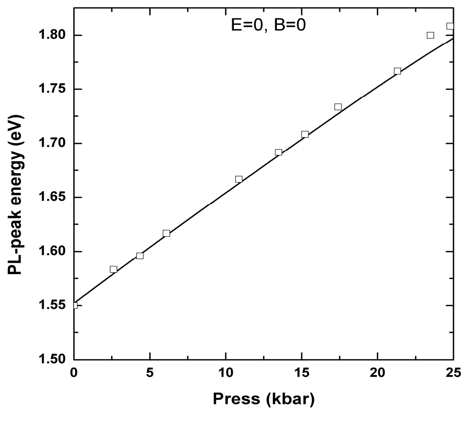

Figure 2: PL-peak energy transitions as a function of the hydrostatic pressure for direct excitons in GaAs-$Ga_{0.65}Al_{0.35}As$ CDQW. The solid line corresponds to our calculated results and the square symbols are the experimental data from Alexander et al [2].

[1] V. V. Solov'ev, I. V. Kukushkin, J. Smet, K. von Klitzing, W. Diestche, JETP Letters, **83**, (2006) 553-557.
[2] M. G. W. Alexander, M. Nido, K. Reimann, W. W. Rühle, and K. Köhler, Appl. Phys. Lett. **55**, (1989) 2517-2519.