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Comments

Comments are short papers which criticize or correct papers of other authors previously published in the **Physical Review**. *Each Comment should state clearly to which paper it refers and must be accompanied by a brief abstract. The same publication schedule as for regular articles is followed, and page proofs are sent to authors.*

Comment on "Radiative recombination processes of the many-body states in multiple quantum wells"

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In our comment on the study of radiative recombination processes by Cingolani *et al.*, we emphasize that lateral transport of a two-component carrier system is very difficult to describe, especially for high carrier densities. To complete the results of Cingolani *et al.*, we give a brief overview of characteristic transport behavior in several temperature ranges for different carrier densities. To explain the observed emission 700 μm apart from the excitation spot we propose waveguiding of recombination light in lateral directions.

Cingolani *et al.*[1] have recently studied, among other points, the influence of lateral transport in $GaAs/Al_{0.36}Ga_{0.64}As$ quantum-well (QW) structures on the line shape of photoluminescence spectra. We would like to add some remarks regarding electron-hole plasma and exciton transport. Lateral transport of electron-hole plasma is a rather complex problem, especially in this case where we have a two-component system (electron-hole plasma and excitons), strong variations of the carrier density in the two-dimensional (2D) carrier cloud, and strong temperature gradients.

In a number of recent papers, we have extensively studied the lateral transport in ambipolar carrier systems for different materials as a function of various parameters: well widths, temperature, carrier density, and barrier composition.[2-8] In this comment we wish to give a short overview of the main transport effects at different temperatures. This should complete the results of Cingolani *et al.*[1] obtained only for $T = 10$ K.

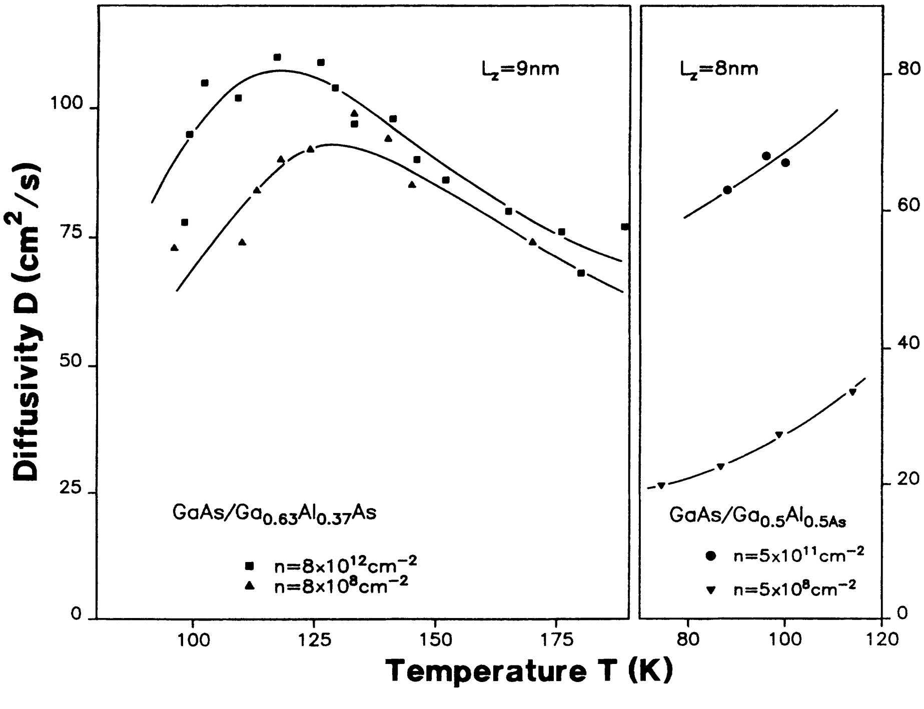

FIG. 1. Diffusivities as a function of temperature for high and low carrier densities. Left: $x_{AL}=0.37$, $L_z=9$ nm; right: $x_{AL}=0.05$, $L_z=8$ nm.

EXCITON TRANSPORT

(i) For $T > 200$ K the excitons dissociate into free carriers. This causes an increase of the diffusivities with increasing temperature[4–6] since free carriers reveal a smaller scattering rate than excitons.[3]

(ii) For $50 < T < 200$ K we observed an isothermal diffusion, which can be described by the diffusion equation consisting of a diffusion and a recombination term. The diffusivities were determined as a function of temperature, well width and barrier composition,[3–8] as well as a function of interface quality.[4,6–8]

(iii) For $T < 50$ K the diffusivities obtained approximately by a pure diffusive description show an increase with decreasing temperature.[4–6]

ELECTRON-HOLE PLASMA TRANSPORT

(i) In the temperature range between 70 and 180 K we observed an isothermal diffusion.[2,4] At a given temperature and well width the diffusivities of an electron-hole plasma are generally higher than those for excitons and depend on the plasma density. Figure 1 displays diffusivities obtained by our time-of-flight technique for two different densities. The largest density dependence is observed below 120 K where the diffusivities increase with growing temperature. The density dependence may be due to a different scattering behavior of excitons and electron-hole plasma, as well as a density dependence in the interface roughness scattering, acoustic deformation-potential scattering and barrier alloy-disorder scattering for the plasma. The diffusivity arising from acoustic deformation-potential scattering in a 2D carrier system was studied by Van Trong, Mahler, and Fourikis[9] as a function of density and temperature. Figure 2 displays the variation of the diffusivity versus density which we calculated according to Ref. 9. We observe a strong increase of the diffusivities for higher densities due to a decreasing acoustic deformation-potential scattering rate.

(ii) For $T < 50$ K, a correct description has to include various effects, e.g., (a) thermodiffusion due to temperature gradients, (b) phonon wind[5,10] and ballistic transport. These effects probably cannot be described by a drift term added to the diffusion equation [Eq. (4) in Ref. 1].

The last point we would like to make concerns the very large transport distance of 700 μm reported in Ref. 1. This is rather a large distance in view of the short plasma lifetime [we measured $\tau=290$ ps ($T=30$ K, $L_z=9$ nm), $\tau=270$ ps ($T=30$ K, $L_z=8$ nm)]. In order to explain the emission 700 μm apart from the excitation spot, Cingolani *et al.* claimed an additional drift mechanism. In our experiments we also observe a faster transport at these low temperatures than at higher temperatures. However, other effects than a carrier drift may also be responsible: The GaAs/$Al_{0.36}Ga_{0.64}As$ multiple-QW structures used in Ref. 1 are efficient waveguides for the QW emission. We have calculated the field distribution for photons of $\lambda=808$ nm in the growth direction by solving the wave equation for the layered structure of Ref. 1 including 25 QW's. We obtain a strongly guided TE_{00} mode based on an effective refractive index of 3.467. Hence, light-induced transport by reabsorption and reemission may also be responsible for the emission of light at a distance 700 μm from the excitation spot.

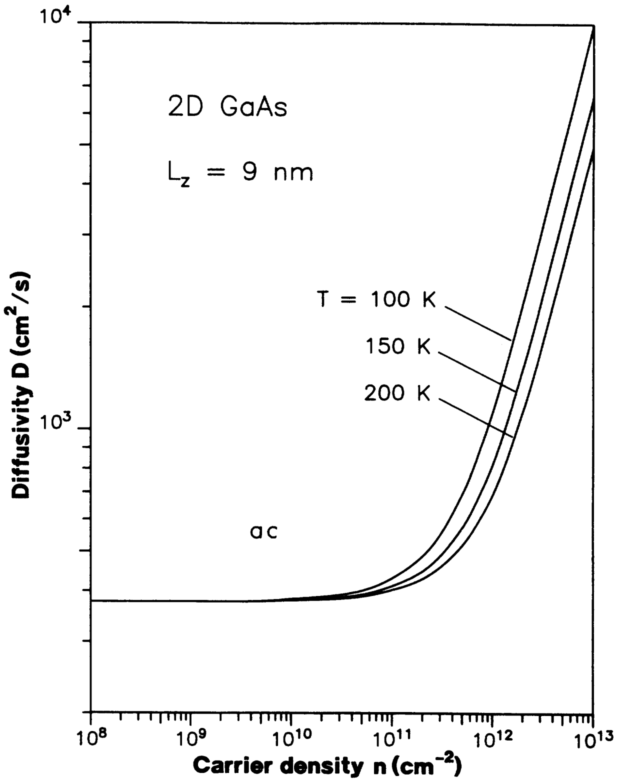

FIG. 2. Ambipolar diffusivities for an electron-hole plasma in GaAs/$Al_{1-x}Ga_xAs$ QW's for acoustic deformation-potential scattering plotted as a function of the carrier density at three different temperatures.

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