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Temperature dependence of the radiative recombination coefficient in (Al,Ga)As quantum wells.

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The density of states for electrons and holes in bulk GaAs increases in first approximation as the square root of the energy. Consequently, the radiative recombination rate of band-to-band transitions, the density of electrons, n, and of holes, p, will all three show, apart from Fermi integrals, a $T^{3/2}$-dependence. The radiative recombination rate and the p.n-product, will therefore reveal a $T^{-3/2}$-dependence. Detailed calculations [1] as well as experiment [2] have confirmed the above reasoning. Furthermore, this explains why the phenomenological coefficient T_0 of conventional double heterostructure lasers is at best 200 K.

For a quantum well, however, the density of states between two successive energy levels is constant. When the energy level separation is large with respect to kT, the radiative recombination rate and the electron and hole densities are directly proportional to temperature, again apart from Fermi integrals. The radiative recombination coefficient, B, will therefore be inversely proportional to temperature.
Experimentally, we have investigated the temperature dependence of B in GaAs-(Al,Ga)As quantum wells grown by metal organic vapour phase epitaxy. From the minority carrier lifetime as measured by photoluminescence decay between 77 K and 300 K it is inferred that B is proportional to T^{-a} where a = 0.8 - 1.0, for small well thicknesses (100 Å) and an increse to 1.4 for large well thicknesses (ca. 300 Å). This is in agreement with theoretical expectations. This explains why T_0 of quantum well lasers can be as high as 300 K around room temperature.

1 F. Stern, I.E.E.E. J. Quan. Electron. QE-9 (1973) 290.
2 G.W. 't Hooft and C. v. Opdorp, Appl. Phys. Lett. 42 (1983) 813.

3次元　$\tau_r \propto T^{3/2}$

2次元　$\tau_r \propto T$　　実験も

exp 小なのは non-rad rec.
のためか

QWLでは T0 1.5倍になる.