TuP50

Confinement of Excitons in Strain-engineered InAs/InGaAs/GaAs Metamorphic Quantum Dots

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Lasers based on self-assembled quantum dots (QDs) emitting at 1.3 µm are commercially available, but producing longer wavelength devices has proven challenging. In both cases strain-engineered InAs/$In_xGa_{1-x}As$/GaAs metamorphic structures are exploited, with the InGaAs layers above and below the QDs called upper and lower confining layers (CLs).

The emission wavelength may be controlled by changing two independent parameters of the relaxed $In_xGa_{1-x}As$ lower CL [1]. (1) Changing x results in modifications of the band discontinuities between the QDs and CLs and also affects the QD-CL mismatch f that determines the QD strain. (2) Changing the lower CL thickness, d, only affects f [1].

By this method it should be possible to optimize the confinement of exciton whilst also extending the wavelength to 1.55 µm: emission as long as 1.59 µm in similar metamorphic nanostructures has been reported [2]. Measuring the emission wavelength is straightforward, but how about the confinement? Here we do this by studying exciton properties (Bohr radius, a_B and reduced mass, μ) using low temperature magneto-photoluminescence [3].

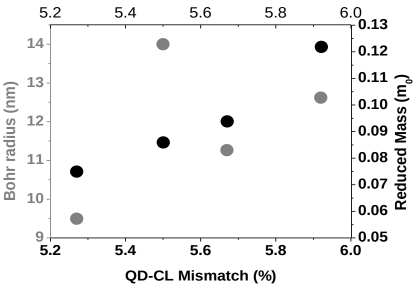

Figure 1

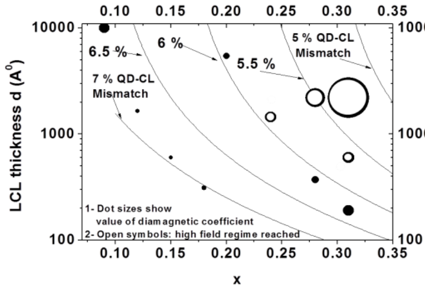

Figure 2

We have studied eleven InAs/$In_xGa_{1-x}As$/GaAs QD samples at 2 K and in magnetic fields up to 17 T (with another 15 in progress). AFM measurements confirm that the dot morphology is independent of both d and x. [1] Fig. 1 shows that reduced mass of exciton, μ increases with increasing mismatch for samples where the mismatch is low, but there is no clear trend in a_B with mismatch. Fig. 2 shows that diamagnetic coefficient, Γ, decreases with increasing mismatch for all samples, consistent with trend in μ ($\Gamma \propto a_B^2/\mu$). For samples where the QD-CL mismatch is low (5 to 6%), the high-field regime (where the magnetic length is $<a_B/\sqrt{2}$) is reached, but not when it is high ($\gtrsim$ 6%) implying that $a_B < 9$ nm. For samples where x is same (0.31), Γ decreases with decreasing d. Similarly for the samples where the d is same (600 Å), Γ decreases with decreasing x. Irrespective of x, when d is small (≤ 370 Å) the high-field regime is not reached, and when x is low (≤ 0.2) the high field regime is not reached irrespective of d.

[1] L. Seravalli et al, J. Appl. Phys. **101**, 024313 (2007) ; L. Seravalli et al, ibid **108**, 064324 (2010).
[2] L. Seravalli et al, Appl. Phys. Lett. **92**, 213104 (2008).
[3] M. Hayne and B. Bansal, Luminescence **27**, 179 (2012).