Optical properties of small $Al_{0.1}Ga_{0.9}N/Al_{0.5}Ga_{0.5}N$ polar quantum dots

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Realisation of nitride-based single photon sources with photon statistic unaltered by the temperature *up to room temperature* was recently demonstrated using specifically grown GaN quantum dots (QDs) with crescent–shape deposited at the apex of nanowires [1]. The temperature activated non radiative recombination channels reported in case of dots grown along the polar orientation on two-dimensional (2D) substrates are linked to the cristallinity of nitrides on one hand and to the huge Quantum Confined Stark Effect (QCSE) on the other hand. It makes the wave functions of the carriers peaking at hetero-interfaces that are still substantially defective and is also detrimental to get an emission at shorter wavelengths, i.e. in the UV range. However, up to now, even growth of QCSE-free QDs along nonpolar directions has not led to improved luminescence efficiencies. We previously grew $GaN/Al_{0.5}Ga_{0.5}N$ QDs on (11-22)-oriented 2D semi-polar templates. We reported that the robustness of the photoluminescence with temperature of such QDs was substantially enhanced compared with the quantum well case [2]. To go further into the UV range, we have decided to grow $Al_yGa_{1-y}N$ (y ~ 0.1) QDs. As a first step towards growth of such QDs on semi polar substrates, we fabricated $Al_yGa_{1-y}N$ QDs along the polar orientation. QDs with nominal deposited thicknesses of 8 and 10 monolayers (MLs, 1ML ~ 2.6 nm) were grown. A single plane of dots was embedded into an $Al_{0.5}Ga_{0.5}N$ barrier layer. As reported in figure 1-a and 1-b, the photoluminescence transients at 8K exhibit a two-decay behaviour, typical of the presence of non-radiative recombination channels unsaturated in the photo-injection conditions [3]. We have fitted the spectral dependence of the fast and long decay times as well as the spectral dependence of the fast and slow decays (see figures 2-a and 2-b). The linear dependence of the spectral dependence of the decay times is attributed to fluctuations of the dot size (note the camel back shapes of the PL spectra which is attributed to two main distributions of dots heights in these samples with a 5 Mvolt/cm internal electric field) rather than fluctuations of alloy composition. Second, the relative proportion of fast (non radiative) decay relatively to the slow (radiative) decay decreases when decreasing energy (figure 2-b) as expected. The cross talk between the populations of QDs is evidenced at the scale of the spectral dependence of A_{fast}/A_{slow} in figure 2(b) and at the scale of the spectral internal quantum efficiencies (IQEs) figure 3(a). The integrated intensity photoluminescence of such dots is reduced by a factor 5 between 8K and room temperature (Fig 3-b). This indicates that the IQE is reduced by a factor of about 5 from low temperature to room temperature.

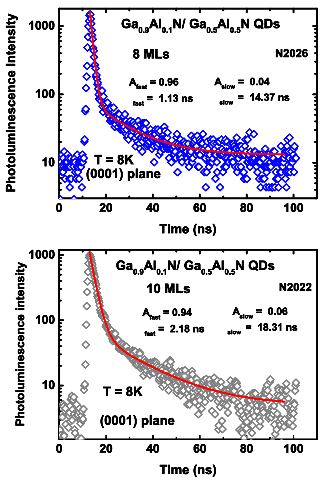

Figure 1 (a): 8K PL decay (blue) and its fit (red) for the 10MLs sample. **(b)**: 8K PL decay (grey) and its fit (red) for the 8MLs sample

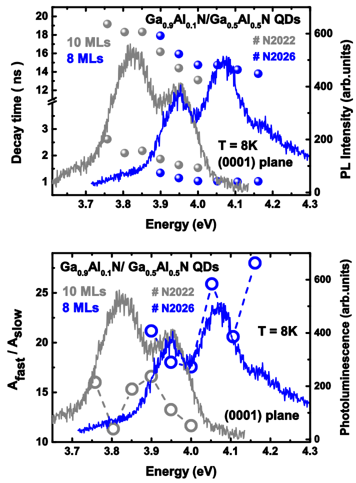

Figure 2(a): 8K PL and decay times (dots). **(b)**: 8K PL and spectral dependence of ratio A_{fast}/A_{slow} (circles)

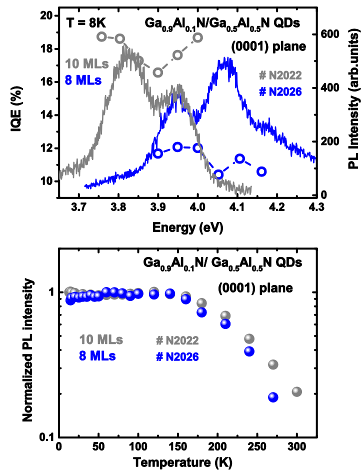

Figure 3(a): 8K IQEs for the 8MLs (blue) and 10MLs (grey) samples.**(b)** robustness of the PL for the 8MLs QD sample (blue) the 10ML one (grey)

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