

## Effect of Eu-implantation and annealing on the GaN QDs excitonic recombination

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Self-assembled GaN quantum dots (QDs) stacked in superlattices (SL) with AlN spacer layers were implanted with several fluences of Europium ions. The as-implanted samples were further submitted to thermal annealing treatments between 800°C to 1200°C and Eu<sup>3+</sup> optical activation is achieved in all the analyzed superlattices.

Due to the combined effects of quantum confinement of the carriers, strain state of the stacked heterostructures and quantum confined Stark effect, the excitonic recombination in the as-grown samples can be observed above and below the bulk GaN bandgap for small and larger GaN QDs as shown in Figure 1.

In order to analyse the effects of Eu-implantation on the GaN QDs excitonic recombination we have performed a detailed photoluminescence (PL) and photoluminescence excitation (PLE) study in the as-grown and implanted and annealed SL structures. In addition to the SL samples individual as-grown and Eu-implanted GaN and AlN hosts were also considered for comparison.

The peak position of the GaN QDs excitonic recombination is known to be very sensitive to the dots size, shape and thermal annealing treatments [1-3]. The effects of thermal annealing are also evidenced in Figure 1 where a high energy shift of the band maxima is identified for the SL samples annealed at the temperature of 1200°C.

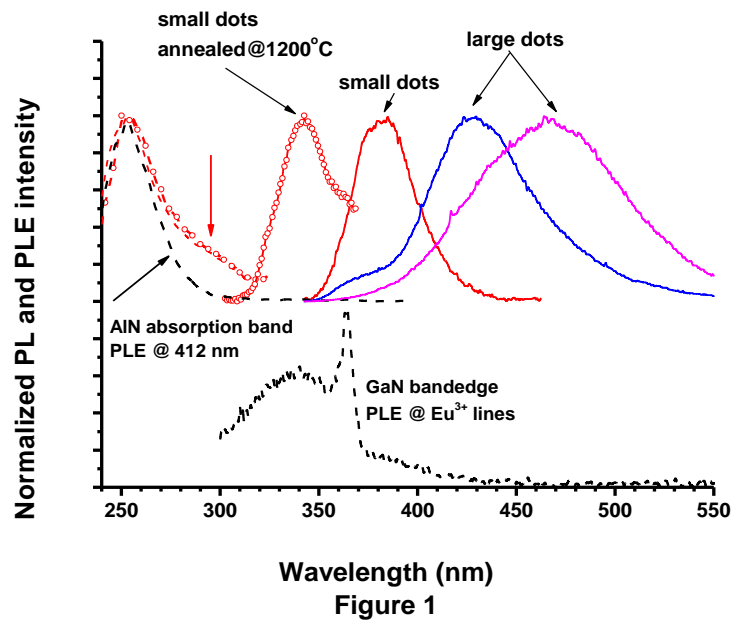
The PLE spectra monitored at the band maxima of the different as-grown and annealed SL samples are characterized by a broad absorption band peaked nearby 253 nm with a sample dependent onset absorption band, extending to wavelengths higher than 300 nm. For comparison we have plotted in Figure 1 the PLE spectra monitored at 415 nm luminescence band in AlN layers. As observed, the peak position of the absorption band occurs at the same wavelength of the GaN QDs. However, in this case no shoulder is observed on the low energy side of the onset absorption. As the peak position and shape of the absorption band is equal for the as-grown and annealed samples we believe that they represent the main population mechanism of the GaN QDs excitonic recombination.

After Eu-implantation and annealing we identify by PLE that the GaN QDs excitonic recombination is also populated by an Eu-related defect absorption band peaked at ~265 nm, the X<sub>2</sub> absorption band [4]. The presence of the multiple excitation paths and their influence on the thermal quenching of the GaN QDs excitonic recombination in the Eu-doped SL is discussed.

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**Figure 1** - RT PL (full lines) and PLE spectra (dashed lines) of as-grown and annealed at 1200°C (line and symbols) SL samples. For comparison, the RT PLE spectra of an undoped AlN sample (upper black dotted line) and the 14 K PLE spectra of a GaN:Eu (lower black dotted line) samples are shown.