# Temperature Dependent Operation of Different AlGaAs barrier Matrix and GaAs Quantum Nanodisks LED

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Quantum dots (QDs) laserdiodes have been extensively investigated for last decades due to their device characteristics benefits. However, realization of a high density and uniform two-dimensional array of QDs is still a big challenge. We have developed a damage-less top-down approach to make GaAs/AlGaAs QD-LEDs by combining a bio-template [1] and a neutral beam (NB) etching [2]. The bio-nano-process consists of a high-density, two-dimensional array of cage-shaped proteins called ferritins with encapsulated metal oxide nanoparticles (NPs). Ferritins can be functionalized with polyethylene glycol (PEG) to control the distance between them and avoid QDs in-plane coupling. After removal of the protein shell, iron oxide NPs were used as etching masks. The NB etching consists of an inductively coupled plasma chamber separated from the process chamber by a carbon electrode with a high-aspect-ratio aperture array. As a result, the charged particles are efficiently neutralized and almost no UV photons can reach the sample. Multiple quantum wells (MQWs) samples of GaAs/AlGaAs were grown by metalorganic vapor phase epitaxy (MOVPE). After the formation of a self-assembled monolayer of ferritin proteins by spin-coating, the protein shell was removed by an oxygen treatment in vacuum at a temperature at 110 ºC. Removal of the surface oxide was performed by hydrogen radical irradiation at 75 ºC prior pure chlorine NB etching. NB etching was performed through the MQWs to form GaAs QNDs after MOVPE regrowth. Temperature dependence of the E-L spectra from the different AlGaAs barrier matrix of QND-LEDs were measured between 4 K and 293 K as shown in Fig. 1. The E-L intensities for these QND LEDs were found to monotonically decrease, and the E-L peak energy was observed to have shifted to lower energies with increasing temperature.

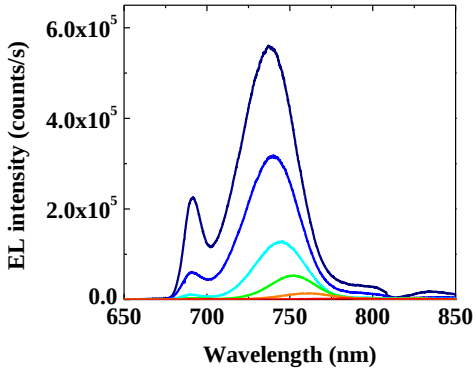


Fig. 1: Temperature dependent operation of QND-LEDs with different AlGaAs barriers matrix

[1] I. Yamashita *et al.* Biochim. Biophys. Acta **1800** (2010) 846.

[2] S. Samukawa, Jpn. J. Appl. Phys. **45** (2006) 2395

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