Correlation between p-GaN growth environment with electrical and optical properties of blue LEDs

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Light-emitting diodes based on Group III Nitrides (such as gallium nitride) are very promising optoelectronic light sources for the nearest future common lightning and find application in a number of areas including general lightning, automotive headlights, traffic lights, various size and application displays, medical lightning, optical data transmission, etc. [1]. One of the most practical technological ways to achieve white light from LED is to use a blue color LED with a coating of phosphor, YAG:RE, ($Y_3Al_5O_{12}$). The mix between blue color and down converted yellow, produce light that appears to be white [2]. To acquire the best white light characteristics, the blue light LED has to be most efficient in all parameters [3].

Two identical blue LED structures which only differ in top epi-layer were investigated. The sample A had a p-GaN top epi layer grown in pure nitrogen (N_2) environment, and the sample B had a p-GaN top layer grown in hydrogen/nitrogen (H_2/N_2, ratio 1:1) gas mixture environment. The contact pads (electrodes) on top were made of Ni/Au (p-type). The blue LED structures were developed in the Ioffe Physico-Technical Institute, then they were processed by (CSTG) and measured by Photonics & Nanoscience group. All measurements were done using Keithley 4200 semiconductor characterization system. The current-voltage, electroluminance, apparent charge concentration profile and transfer resistance of contact pads were measured. Current-voltage characteristic (Fig. 1) shows that the sample A has lower voltage values than the sample B. Electroluminance graph (Fig. 2) shows that the sample A is twice luminous than the sample B, and charge concentration profile (Fig. 3) indicates lower doping in the sample A. Transfer resistance graph (Fig. 4) points out that the sample A has lower sheet resistance than the sample B, which is due to p-type electrode fabricated on top of p-GaN layer, grown in pure N_2 environment.

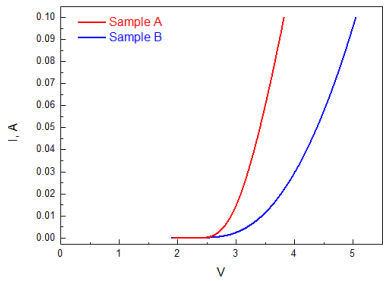

Fig 1. Current-voltage characteristics of samples A, B.

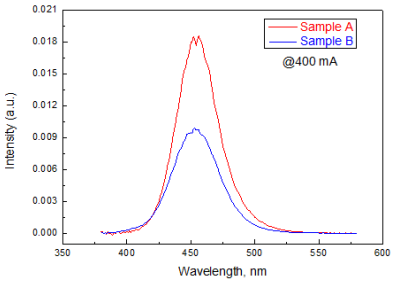

Fig 2. Electroluminance vs. wavelength of samples A, B.

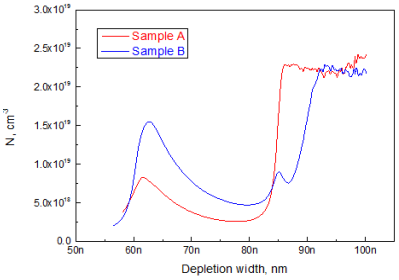

Fig 3. Charge concentration in depletion region of samples A, B.

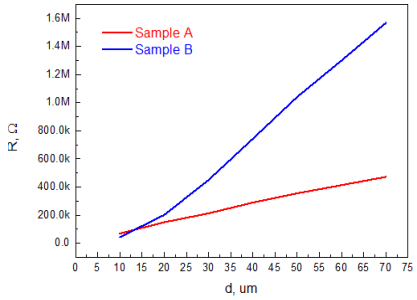

Fig. 4. Transfer resistance vs. contact pad distance of samples A, B.

In conclusion, two identical blue LED structures, which only differ in top p-GaN layer, were investigated. It was clearly noticable the difference in data of measured samples and correlation with a specific growing environment where the top p-GaN layers were grown in. Structure grown in pure N_2 environment has better parameters than structure grown in H_2/N_2 ratio. Different growing environment (N_2 or H_2/N_2) has strong characteristical influence to blue color GaN based light emitting diodes.

References

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