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# High-performance group-III-nitride-based light-emitting solar cells (LESCs)

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**Abstract** – We successfully fabricated green-light-emitting solar cells (LESCs). The external quntum efficiency of an LESC reaches 65% at approximatly 355 nm to 375 nm. This dual functional device is very promising for realizing a compact lighting system with a low production cost and low fossil-fuel consumption.

High-brightness blue- and green-light-emitting diodes (LEDs), and high-power violet laser diodes have been achieved using group III nitrides. GaInN ternary alloys have a broad bandgap range from 0.65 to 3.43eV: thus, they are suitable for high-efficiency tandem solar cells [1]. The fundamental structure of a solar cell is similar to that of an LED, which includes a GaInN active layer and a p-n junction. Therefore, single-chip GaInN-based solar cells can be operated as LEDs and are called light-emitting solar cells (LESCs). In this report, we present the performance of GaInN/GaN double-heterojunction *p-i-n* LESCs. We also discuss the potential of a nitride-based solar cell system.

The samples used were grown on sapphire (0001) substrates by metalorganic vapor-phase epitaxy. Figures 1 and 2 respectively show the typical device structure and a top view of an LESC with a GaInN active layer grown on a GaN template. Semitransparent Ni/Au (5/5 nm) ohmic contacts to p-GaN were formed by electron-beam evaporation.

Figure 3 shows the external quantum efficiency (EQE) spectra of the LESC with an optimized GaInN active layer thickness. The EQE reaches the 65% at around 355 nm to 375 nm. The transparency of the Ni/Au electrode is approximetly 68%. Therefore, internal quantum efficiency is higher than 95%. Figures 4 (a) and (b) respectively show the electroluminescence (EL) spectra and image of the device at injection current of 20 mA. The EL peak wavelength is approximatly 525 nm, which is much longer than the EQE peak wavelength. This large shift is caused by In segregation or the relaxation-induced increase in In composition.

In summary, LESCs are very promising for realizing a compact lighting system with a low production cost and low fossil fuel consumption. Moreover, their conversion efficiency can be improved using a high-In-content GaInN active layer. We will present the key technology for the improvement of LESCs, such as p-type high-In-content GaInN and high-crystallne-quality thick GaInN templates.

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Ref.: [1] H. Hamzaoui, A. S. Bouazzi and B. Rezig, *Sol. Energy Mater. Sol. Cells* **87,** *595, 2005.*

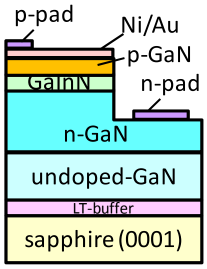


**Figure 1:** Schematic view of sample structure

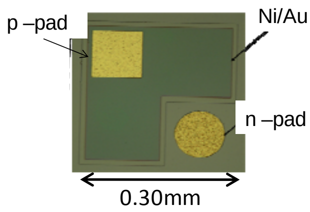


**Figure 2:** Top view of LESC

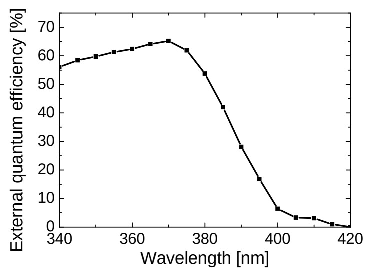


**Figure 3:** EQE spectra of LESC

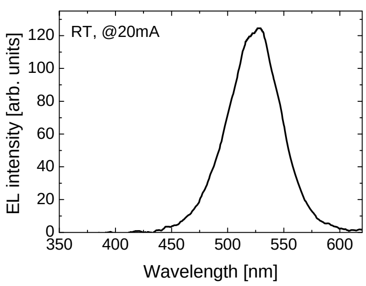


**Figure 4(a):** EL spectra of LESC

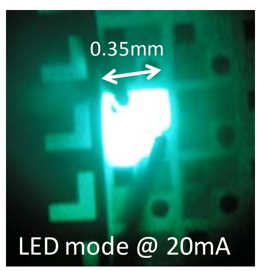


**Figure 4(b):** EL image of LESC