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GaN-Based Blue Light Emitting Diodes Using Conducting Filament-Embedded Indium Tin Oxide Electrodes

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1. Introduction

Recently, global demand for gallium nitride (GaN) based light-emitting diodes (LEDs) have increased substantially. Along with such increasing demand, research on transparent conductive electrodes (TCEs) has been carried out intensively for improved uniform current injection and light extraction.

Indium tin oxide (ITO) is the most widely used commercial TCE for LEDs operating in the visible region. However, to form an ohmic contact with ITO, a delicate control in the deposition and annealing process is required which is a high-end technology. Therefore, it can be said that a new approach for creating an ohmic contact with less dependence in the deposition and annealing condition is in demand.

Herein, we proposed a novel method to produce an ohmic contact to the p-GaN (or p-AlGaN) layer while maintaining high transparency in the UV to IR region [1]. This method employs a conducting filament (CF) based TCEs via electrical forming process which is less dependent to the conventional ohmic methods.

2. Experiment & Results

In this work, to directly evaluate the feasibility of the CFs-based TCE, GaN based blue LED was fabricated using the CFs-based insulating ITO (i-ITO) TCEs and conventional metallic ITO (m-ITO; reference). Among the devices, forming both of the n-electrode and the p-electrode (n/p forming LED) showed the best results. Forward voltage of the n/p forming LED showed reduction of 1.7 V as compared to the non-forming device. Also, n/p forming LED has shown increase in the light output power by 11% at 350 mA. These results are comparable to that of the conventional LEDs, as can be seen in Figure 1 and Figure 2. Although, not visible in the abstract, light-emission is more uniformly distributed in the proposed LEDs at low current.

3. Conclusions

Both of the electrical and optical properties of the n/p forming LED has shown improvements compared to the non-forming LEDs. The reduction of forward voltage is attributed to the CFs-based TCEs which forms an ohmic contact to the p-GaN layer via electrical forming process. And the light output power of the n/p forming LED is increased due to the improved uniform injection of current. These results are comparable to the conventional LEDs thereby, proving the feasibility of the CFs-based TCE's applicability to GaN based blue LED.

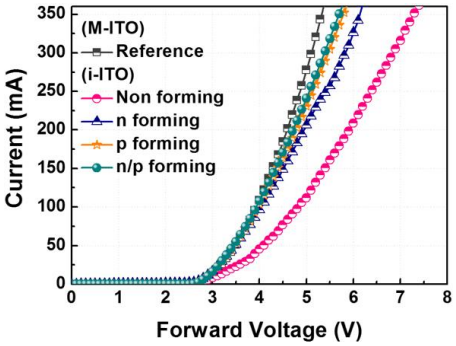

Figure 1. Forward Voltage (I-V) characteristics of the reference and proposed LEDs.

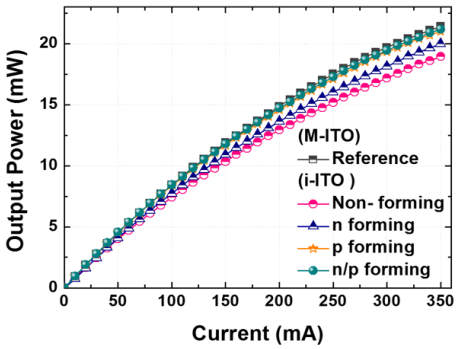

Figure 2. Output Power (L-I) characteristics of the reference and proposed LEDs.

Acknowledgements

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References

[1] Hee-Dong Kim, AFM, LED: **24**(2014) 1575