UV-Ozone-Assisted Performance Improving of Metal Mesh / Graphene Hybrid Transparent Electrodes

Je-Sung Lee[1,2]
Jung-Hong Min[1,2], Kyung-Pil Kim[1,2], Woo-Lim Jeong[1,2], Dong-Seon Lee*[1,2]

[1]*School of Electrical Engineering and Computer Science, Gwangju Institute of Science and Technology, Gwangju 61005, South Korea.*
[2]*Research Institute for Solar and Sustainable Energies, Gwangju 61005, South Korea*

dslee66@gist.ac.kr

The most widely used transparent electrode material for Light Emitting Diodes (LEDs) is Indium Tin Oxide (ITO) which meets the industrial requirements: transmittance over 85 % and sheet resistance below 10 Ω/□ [1]. However, transmittance decrease in ultraviolet (UV) region [2] has been pointed out as one of drawbacks of ITO. The weakness causes the limitation of manufacturing UV LEDs using ITO transparent electrodes (TEs). To complement the shortcoming, hybrid TEs combined with graphene that has high transmittance in the UV region, and metal mesh that has low sheet resistance are introduced [3]. Additionally, we applied the UV-Ozone treatment for hybrid TEs to improve the performance by concurrent effects of the graphene surface cleaning and oxidation. It is known that the cleaning effect enhances the contact characteristic with metal by reducing contaminations [4] and that the oxidation induces p-doping [5] which advances the ohmic contact property with p-gallium nitride [3]. Raman spectra (Figure 1) shows that graphene oxidation and p-doping aspects over treat time. Furthermore, through measuring sheet resistance and transmittance of UV-Ozone treated graphene, the existence of optimal treatment time has been unveiled. Then, contact resistance changes between Cr/Cu metal mesh and treated graphene was inspected by transmittance line method (TLM), and the evidence of contact characteristic improvement with graphene surface cleaning is observed by using atomic force microscopy(AFM). Finally, we fabricated the gallium nitride-based 450 nm blue LEDs applied with UV-Ozone assisted hybrid TEs, and electro-luminescence (EL) spectra were measured (Figure 2). The luminescence characteristics were enhanced until 300 secs and then decreased again. The 300-sec-treated device presented 47% more improved light output power at 100 mA current injection than pristine hybrid transparent electrode.

References

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Figures

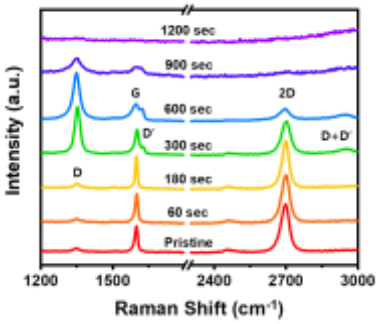

Figure 1: Raman spectra of transferred graphene on sapphire over UV-Ozone time

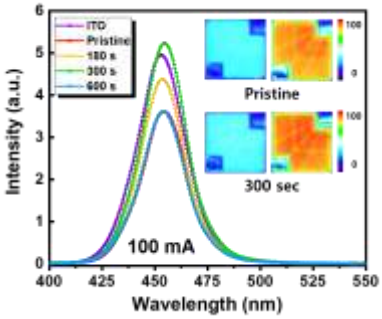

Figure 2: EL spectra and contour images of LEDs applied hybrid TEs with different treatment times