Progress of deep-UV LEDs by increasing light-extraction efficiency

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AlGaN UVC light-emitting diodes (LEDs) are attracting a great deal of attentions for applications of sterilization, water purification, in the medical fields, and so on. However, the wall-plug efficiency (WPE) of the UVC LED is still much smaller than that of blue LEDs, and the increase of WPE is a recent main subject for an AlGaN UVC LED. The main cause for reducing WPE is a significant reduction in light-extraction efficiency (LEE) owing to a heavy light absorption by p-GaN contact layer.

In the previous approach, we achieved dramatic increase of the external quantum efficiency (EQE) of 275 nm UVC LED by introduced a transparent p-AlGaN contact layer, a highly-reflective (HR) p-type electrode, an AlN template grown on patterned sapphire substrate (PSS) and a lens like mold, and obtained the EQE of 20.3 % due to increase in LEE. We also obtained the maximum WPE of 10.8 % for a 280 nm UVC LED under the injection current below 30mA for the LED with transparent p-AlGaN contact layer.

Far-UV light with a wavelength shorter than 230 nm are harmless to human body and have a strong effect for virus inactivation, and are attracting much attention as a light source for anti-virus measures “in manned spaces”. We developed 230 nm LED panel for conducting the inactivation of the SARS-COV-2 virus. The EQE drops rapidly in the wavelength shorter than 250 nm, so, we tried to increase the efficiency and output power of the 230 nm LEDs. AlGaN-based 230 nm LEDs were grown on a sapphire/AlN templates by a low pressure MOCVD. We have fabricated 1.1 x 1.2 mm flip-chip LEDs mounted on a ceramic square sub-mount after the process of the n-electrode of V/Al/Ni/Au and the p-electrode of Ni/Au. Quartz lenses (NGK Insulators Ltd.) were also attached to the ceramic sub-mount. The EQE and output power of the 232 nm LED were significantly increased by introducing “polarization doped transparent p-type contact layer” and demonstrated to be 0.53% and 3.2 mW in the maximum values, respectively. We mounted 42 pieces of 230 nm LEDs in parallel to produce a panel with an equivalent output power to 14.7 mW. The radiation pattern of the LED panel was improved drastically by attaching the lenses. We also conducted the SARS-COV-2 virus inactivation demonstration using the 230 nm LEDs at the same time.

We also demonstrated the LEE increase of the 230 nm and 280 nm LEDs by introducing the reflective photonic crystals (R-PhCs) fabricated on the p-contact layers.

References:

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