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Studies on improving the external quantum efficiency of deep ultraviolet light emitting diodes

III-nitride based Deep Ultraviolet Light Emitting Diodes (DUV LEDs) are promising candidates for replacing conventional mercury DUV light sources due to being environment-friendly. However, the External Quantum Efficiency (EQE) of the DUV LEDs is pretty low at the current stage, primarily attributed to the low internal quantum efficiency (IQE) and Low Light Extraction Efficiency (LEE). Therefore, solving the issues hindering the IQE and the LEE is of importance for advancing the DUV LEDs towards various applications such as in medical, air and water purification, etc. In this talk, we will review the current status and key factors affecting the IQE and LEE of DUV LEDs and present our research on improving both. Examples include proposing a charge inverter made of an electrode-insulator-semiconductor. We will demonstrate the effectiveness of the charge inverter in improving the whole transport and injection from the p-electrode into the p^+-GaN layer/LEDs, which in turn will enhance the IQE and the output power. To improve the LEE for DUV LEDs, we propose an inclined sidewall scattering structure imbedded with air cavities that is formed by a metal bottom and a flat parallel top (Bottom-metal) and studied its light extraction properties using three-Dimensional Finite Difference Time Domain (3D FDTD) simulations. We find that the imbedded air cavity helps the bottom-metal structured DUV LEDs to scatter the light into the escape cone via total internal reflection and Fresnel scattering, thus avoiding the light absorption from the sidewall metal mirror in the reported inclined sidewall metal structure (sidewall-metal). In addition, the unique air cavity having a bottom metal also increases the scattering ability of the bottom-metal structured DUV LEDs owing to the fact that light within the air cavity directing downwards will be reflected back towards the parallel top interface of the air cavity/AlGaN and will not be subject to total internal reflection.

Biography

Wengang Bi is an elected Fellow of the Optical Society of America (OSA). He has received his PhD from University of California, San Diego, Department of Electrical and Computer Engineering in 1997. After devoting his career to forefront research and development at Hewlett Packard Laboratories, Agilent Technologies Inc. and Philips-Lumileds, he is currently working at Hebei University of Technology, Tianjin, China as a Distinguished Professor and Chief Scientist in the State Key Laboratory of Reliability and Intelligence of Electrical Equipment. His research interests include GaN-based semiconductor materials and devices, colloidal quantum dots and their applications to lighting and display. He is the Editor of the book *Handbook of GaN Semiconductor Materials and Devices*. He has published more than 80 papers and holds more than 25 patents and served as a member of the technical committee or organizing committee for a number of international conferences.

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