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A scattered volume emitter micropixel architecture for ultra efficient light extraction from DUV LEDs
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Abstract
Deep ultraviolet light-emitting diodes (DUV LEDs) typically suffer from strong parasitic absorption in the p-epitaxial layer and rear metal contact/mirror. This problem is exacerbated by a substantial portion of the multiple quantum well (MQW) emissions having a strong out-of-plane dipole component, contributing to emission in widely oblique directions outside the exit cone of the front semiconductor emitting surface. To address this, we propose an architecture that leverages such a heavily oblique angular emission profile by utilizing spaced-apart or scattered volume emitter micropixels that are embedded in a low-index dielectric buffer film with a patterned top surface. This approach achieves high light extraction efficiency at the expense of enlarging the effective emission area, however, it does not require a high-index (e.g., sapphire) substrate or a lens or a nanotextured epi for outcoupling purposes. Hybrid wave and ray optical simulations demonstrated a remarkable larger than three to sixfold increase in light extraction efficiency as compared to that of a conventional planar LED design with a sapphire substrate depending on the assumed epi layer absorption, pixel size, and ratio of light emission area to the MQW active area. An extraction efficiency three times greater than that of a recent nanotextured DUV LED design was also demonstrated. This architecture paves the way for DUV LEDs to have a plug efficiency comparable to that of mercury lamps while being significantly smaller.

Index Keywords
buffer, mercury; absorption, article, dipole, epitaxy, lens (optics), light, light emitting diode, semiconductor, simulation, ultraviolet radiation

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