

3D Patterned LED Simulation

Introduction

Tools used: FullWAVE, LED Utility

The use of LEDs has become commonplace for applications ranging from lighting and indicator lamps to displays for mobile phones, tablet PCs, and TVs. LEDs offer high relative efficiency, lower energy consumption, high reliability, sharper colors, and smaller sizes, all important factors for these applications.

Numerical simulations are tedious since LEDs are inherently incoherent. Most traditional simulation techniques cannot easily manage incoherence since they are based on directly solving Maxwell's equations or some derived form such as the Wave equation. Moreover, the optical design for LEDs is further complicated due to factors like multiple interfaces, the use of novel materials and structures, dispersion, surface roughness, and the use of gratings to enhance efficiency, etc.

This application note uses **FullWAVE** and the **LED utility**. It describes the simulation of the 3D gallium nitride (GaN)-based LED structure shown in Figure 1 and is based on Ref. 1. It has a hexagonal photonic crystal (PhC) etched into the top).

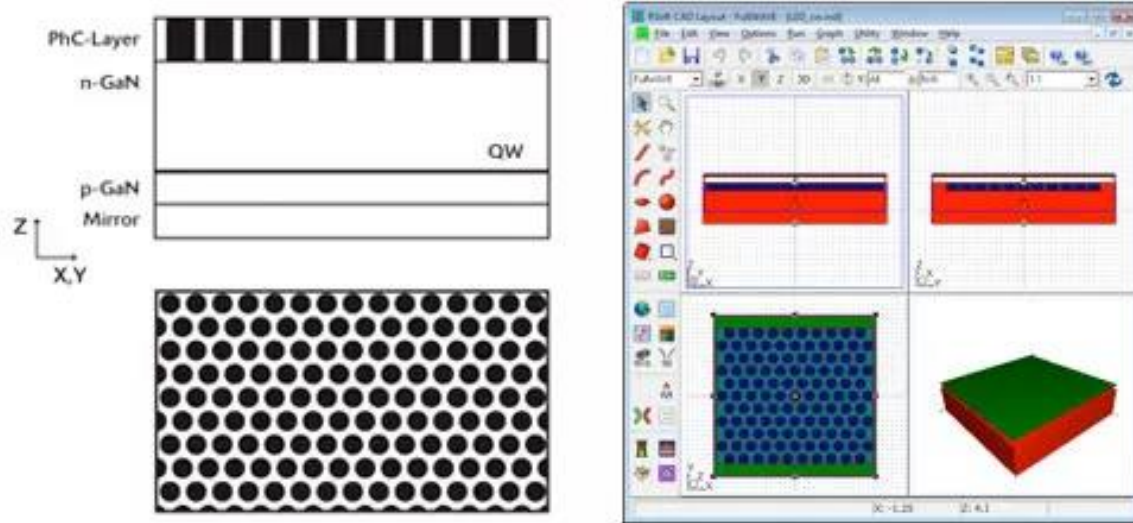


Figure 1. Schematic of patterned LED structure: cross-section (top left), photonic crystal (PhC) (bottom left), and the structure drawn in the RSoft CAD (right).

This structure, as shown in Figure 1, consists of a PhC object created using a dynamically-sized array and a mirror at the back fast via a perfect electrical conductor (PEC) boundary, and uses a built-in material library for GaN material properties.

The first two simulations were run using a continuous (CW) excitation at a single wavelength, one with the PhC and one without (flat). The far-field results are shown in Figure 2.

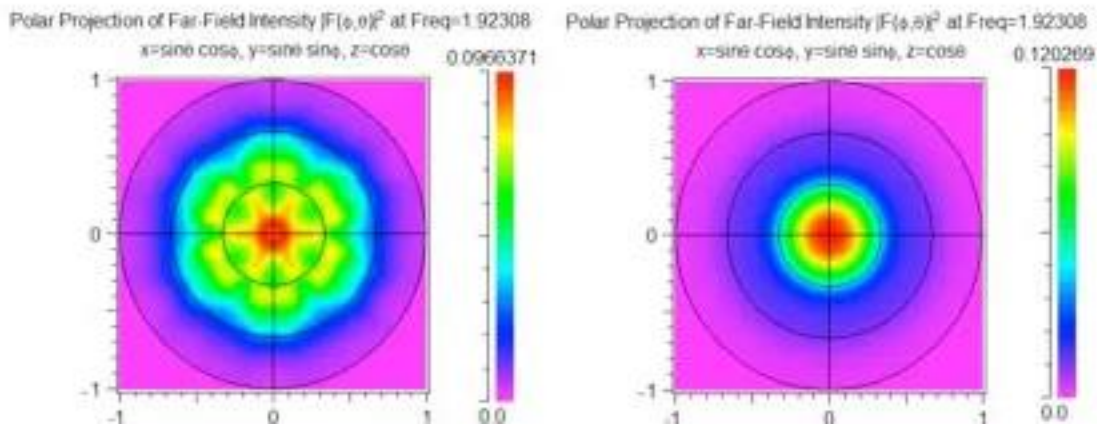


Figure 2. Computed far-field for PhC case (left) and flat case (right).

Next, two pulsed simulations were run over a range of wavelengths. The far-field results are shown in Figure 3 and the extraction efficiencies are shown in Figure 4.

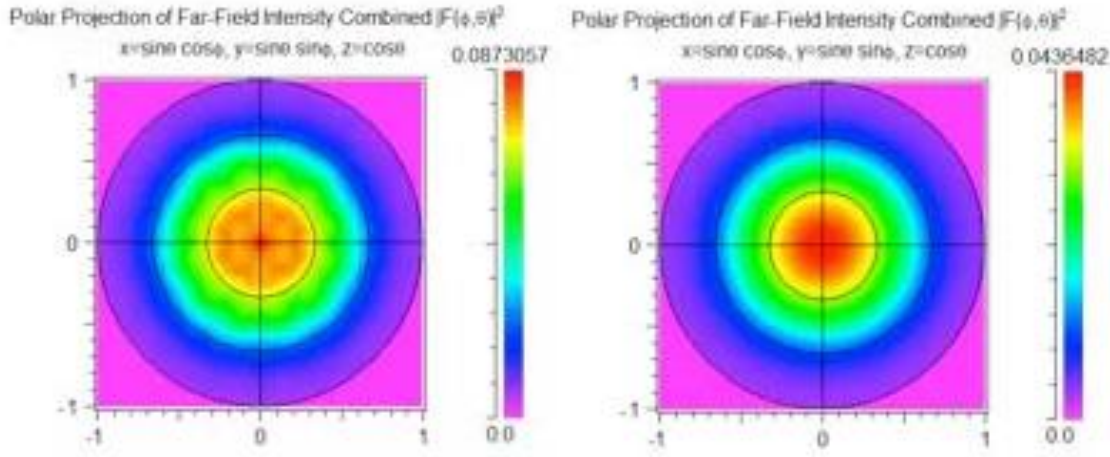


Figure 3. Combined far-field plots from a pulsed simulation for PhC case (left), and flat case (right).

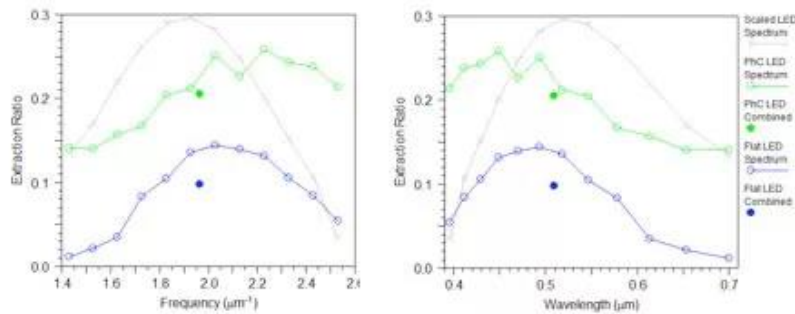


Figure 4. Extraction ratio spectrum for a pulsed simulation for PhC and flat cases as a function of frequency (left) and wavelength (right).

References

- [1] Ch. Wiesmann, K. Bergenek, N. Linder, and U. T. Schwarz, Analysis of the emission characteristics of photonic crystal LEDs, Proc. SPIE 6989, Light Emission I, 69890L (2008).

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