RSoft Releases the New LED™ UTILITY

The use of LEDs has become commonplace for applications ranging from lighting, indicator lamps, and 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.

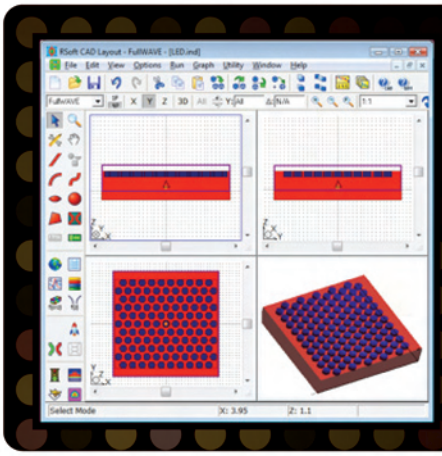

Figure 1: CAD layout of the structure under test.

RSoft has developed an LED Utility™ to simplify and automate the simulation procedure for modeling LEDs. The utility is built on top of RSoft's flagship simulation tool FullWAVE™ and automatically incorporates the necessary incoherent aspects, performs all the necessary pre- and post-processing to generate desired results.

The LED Utility simulates an incoherent and unpolarized light source by treating the source as a collection of point current sources. Each of these sources is simulated coherently using FullWAVE and the individual results are combined incoherently. Since the LED Utility is based on FullWAVE, which is an ab-initio approach for solving Maxwell's equations with no inherent approximation, it is well suited to accurately model the complexities of LED structures. Moreover, the LED Utility can utilize the clustering feature of FullWAVE to distribute the simulation workload over several cores and computers on a network resulting in faster and larger simulations.

For a typical GaN-based LED, only about 4% of light can be extracted due to total internal reflection. Several techniques can be applied to improve extraction efficiency including antireflective coatings, micro-structured surfaces with random roughness, or regular photonic crystal gratings (PhC). Consider this example that illustrates the

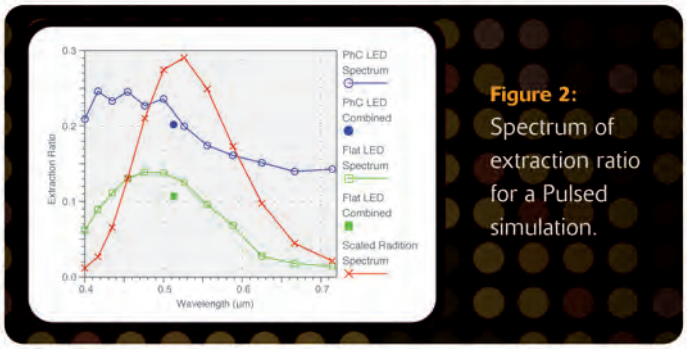

Figure 2: Spectrum of extraction ratio for a Pulsed simulation.

effect of a surface grating on the extraction efficiency and radiation pattern of a LED. The structure used in this example is shown in Figure 1, and two simulations are performed, one with (PhC) and other without (Flat) the hexagonal PhC gratings on top[1].

The extraction efficiencies obtained for the two cases are shown in Figure 2. The plot illustrates several important results: first, as expected, the extraction ratio is significantly wavelength dependent for both the Flat and PhC LED structures. Second, the normalized extraction efficiency for the LED with the PhC (blue line) is significantly higher than that for the Flat LED (green line) over the entire spectral range. The combined extraction ratio over all frequencies is obtained by weighting the normalized LED spectra with the incident source spectra, which is assumed to be Gaussian for this example.

As can be seen, the combined extraction ratio for the PhC LED (solid blue dot) shows almost 90% enhancement over the Flat LED (solid green square). The combined radiation pattern is shown in Figure 3. It shows that the radiation pattern of the PhC LED with hexagonal PhC grating is significantly different than that of the Flat LED.

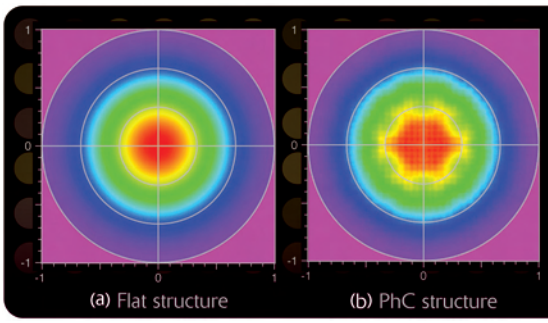

Figure 3: Combined radiation patterns of pulsed simulations.

RSoft's optimization tool MOST can be used in conjunction with the LED Utility to optimize various aspects of the LED structure. For example the hexagonal grating on top can be optimized for improved extraction efficiency and to obtain a desired radiation pattern. RSoft's LED Utility provides an ideal platform, accurate and user-friendly, for a wide range of LED applications and should significantly simplify the tasks for an LED designer. ■■

References
[1] A. Chutinan et al., Organic Electronics 6 (2005) 3–9.