Light-Extraction Efficiency of Thin-Film Light-Emitting Diodes Analyzed by Ray Tracing Simulations

by

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ABSTRACT

Light-Extraction efficiency is an important parameter for evaluating the performance of light emitting diodes (LEDs) which can be influenced by many factors. An extensive simulation of various LED structures is required to improve the extraction efficiency.

In this thesis, an analytical model, to calculate the light-extraction efficiency of a conventional LED is developed to verify the ray tracing simulation results for the same. Various parameters which play an important role in the ray tracing simulation such as absorption coefficient and reflectivity of the metal reflector are measured or calculated.

Ray tracing simulations are then performed on various LED structures which include anti-reflection coatings, mirrors with high reflectivity and surface roughening. Micro-sized cones, lenses, pillars and frustums of cones are placed on the top surface of the simulation structure of the GaN LED to explore the scope of enhancing extraction efficiency. The size, refractive index of these patterns and ratio between various dimensions of these patterns are optimized for each pattern.

In addition some new structures, such as pillars and lenses with graded refractive index layers are designed and simulated for higher light-extraction efficiency.