Simulation of 3D InGaN/GaN MQW LED with textured surface

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Software Inc.

Introduction

Step1:

3D structure built by Csuprem

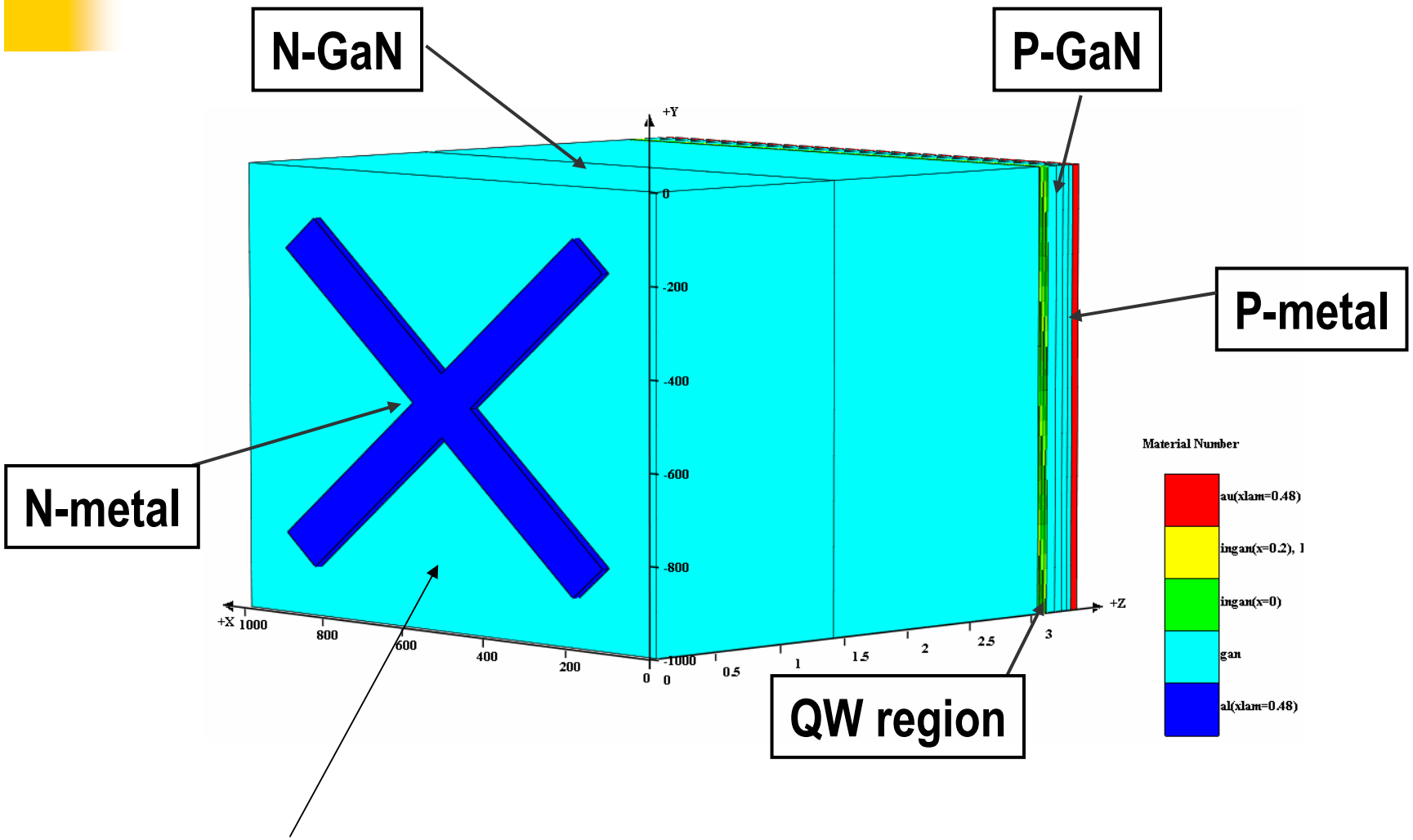
Step2:

Texture modeling by Apsys and FDTD

Step3:

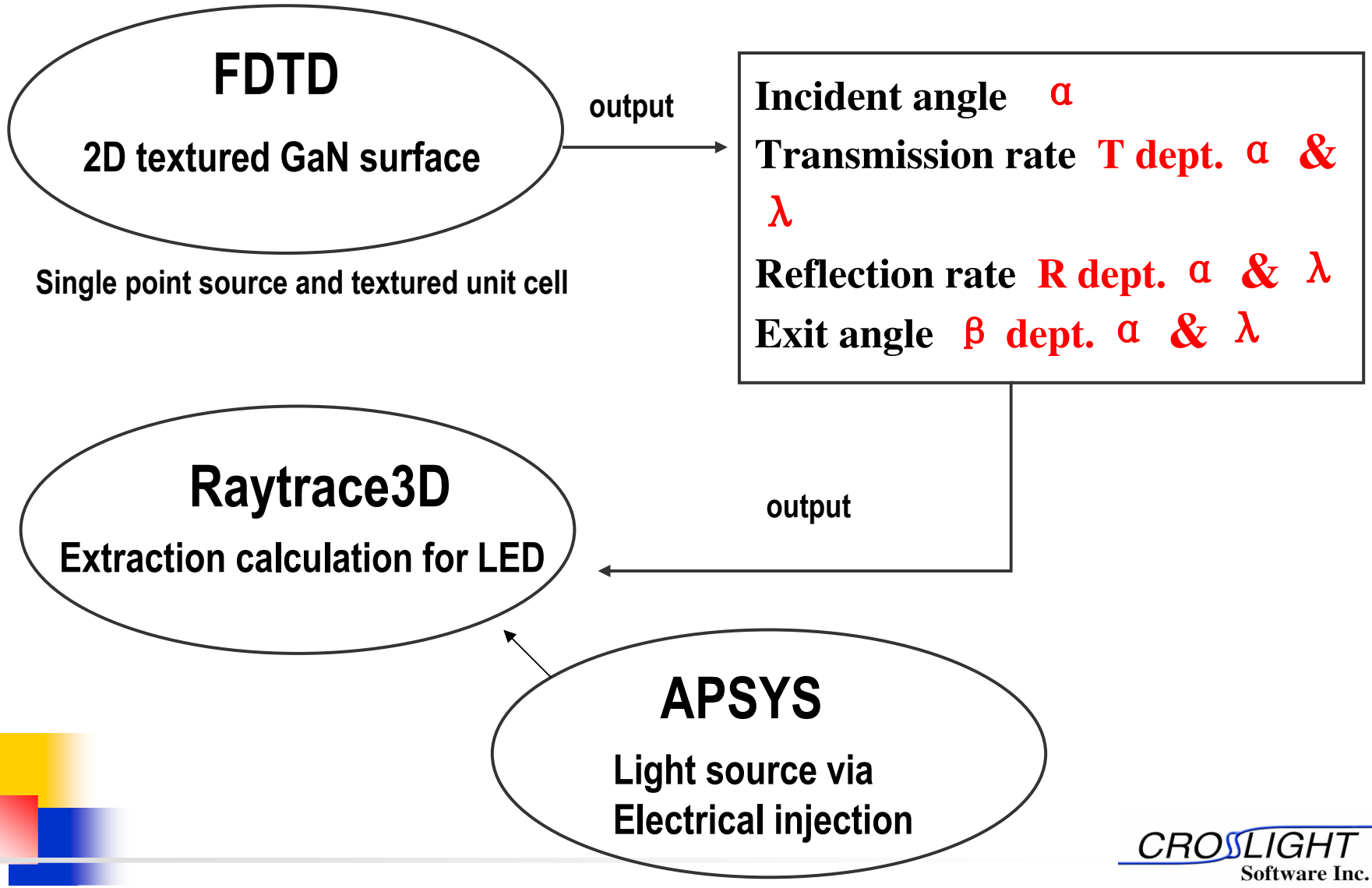
Calculation of electrical and optical properties by Apsys and Raytrace-3D (RT3D)

3D structure



Assume N-type GaN surface is textured

Texture modeling



Texture modeling by FDTD

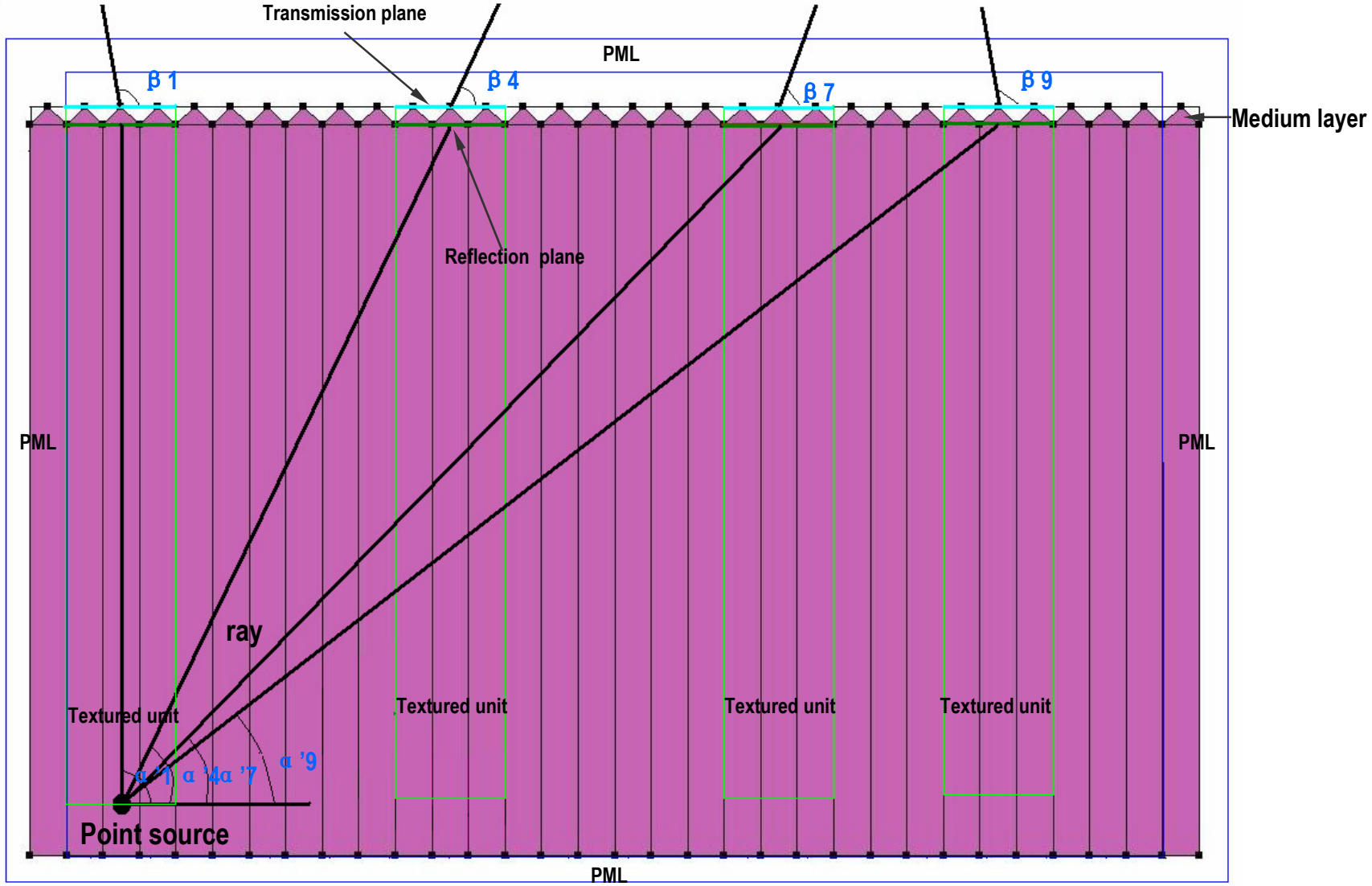
1. Setup a portion of LED surface suitable for FDTD.

2. Set a single point source at a proper distance from textured surface.

3. Division of texture units into blocks to extract transmission/reflection coefficient as a function of incident angles.

4. Calculate the far field distribution of optical energy from each block to extract the average emission angle.

Texture modeling



FDTD Cell (33 x 23.5 um)

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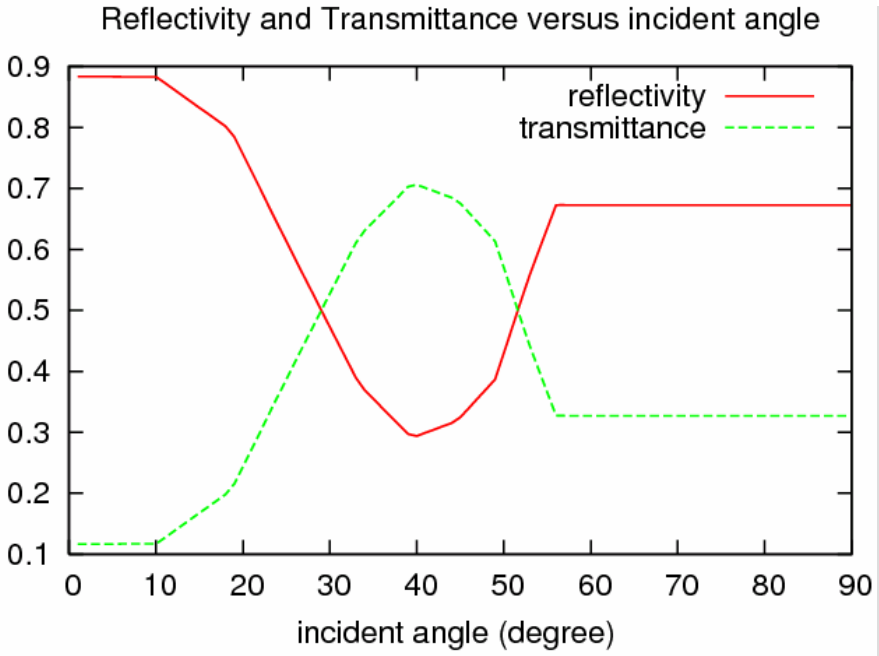
RT3D simulation with FDTD data

Note:

The textured surface is treated as a special boundary in RT3D simulation, which means that at this special boundary, reflection, transmission will not be calculated according to Fresnel equations for geometrical optics, but be calculated according to data extracted from FDTD.

RT3D simulation with FDTD data

Data extracted from FDTD



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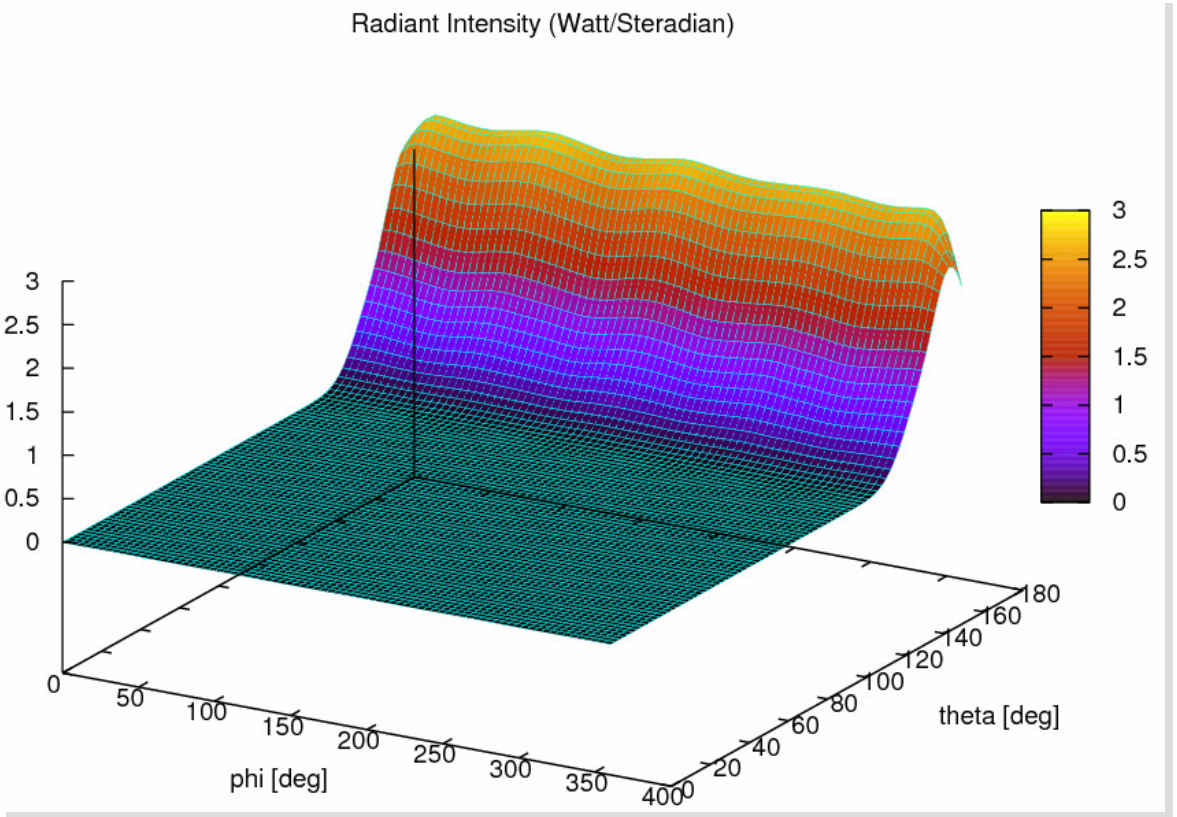
Raytracing using FDTD data

Result: power distribution

Result shows that output is mainly outwards from the textured surface (– Z direction).



Power distribution in spherical coordinates

RT3D simulation with FDTD data

Result: power extraction efficiency

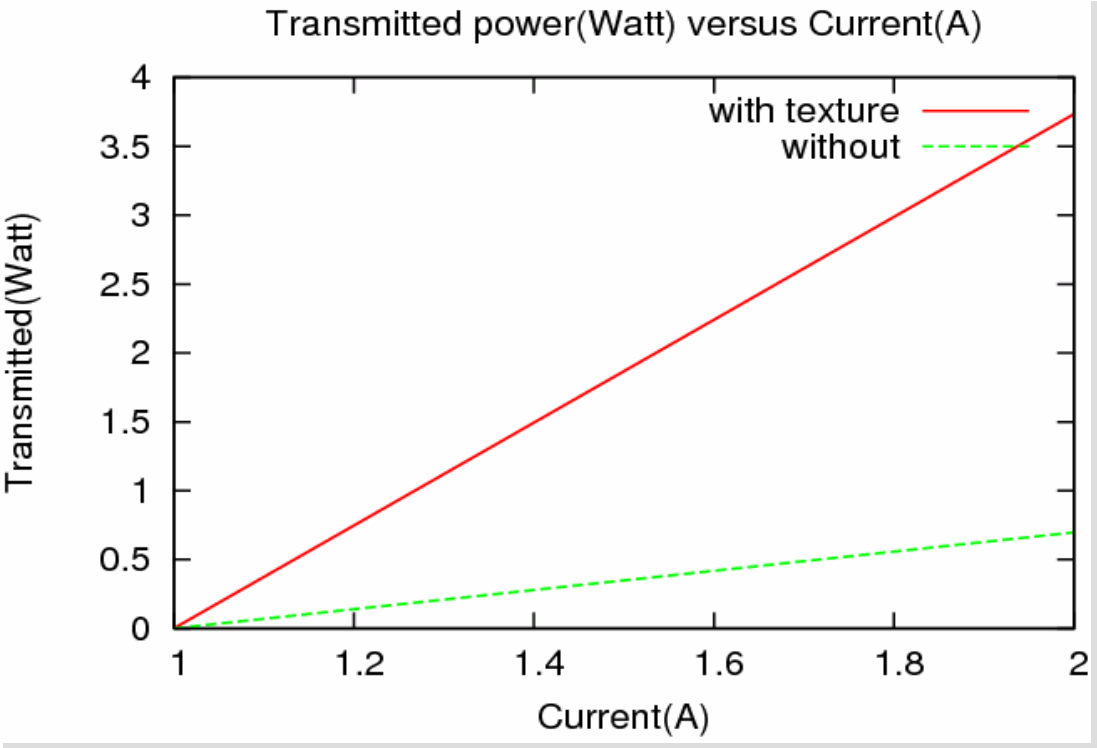
Total source power (W)
4.78620413176667
TRANSMITTED POWER in absolute and relative to emitted (%) units
0.6969 14.56
SEMICONDUCTOR ABSORBED POWER in absolute and relative to emitted (%) units
4.0893 85.44

Total source power (W)
4.78620413176667
TRANSMITTED POWER in absolute and relative to emitted (%) units
3.735 78.03
SEMICONDUCTOR ABSORBED POWER in absolute and relative to emitted (%) units
1.052 21.97

Results shows that power extraction efficiency is much enhanced .

RT3D simulation with FDTD data

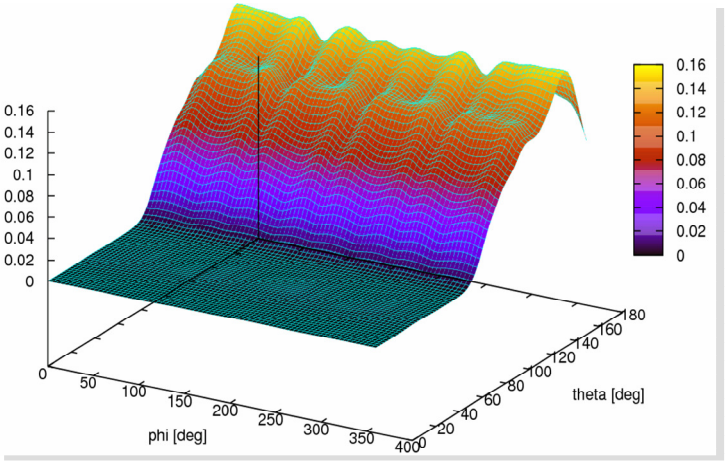
Compare: power extraction



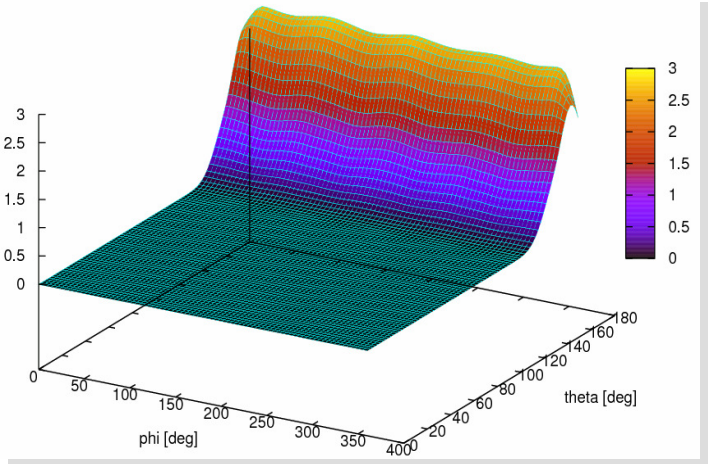
Result shows emission power enhanced by a factor of five or more.

RT3D simulation with FDTD data

Compare: power distribution



Transmitted light power distribution
without textured surface



Transmitted light power distribution
with textured surface

More uniform angular distribution obtained with texture.

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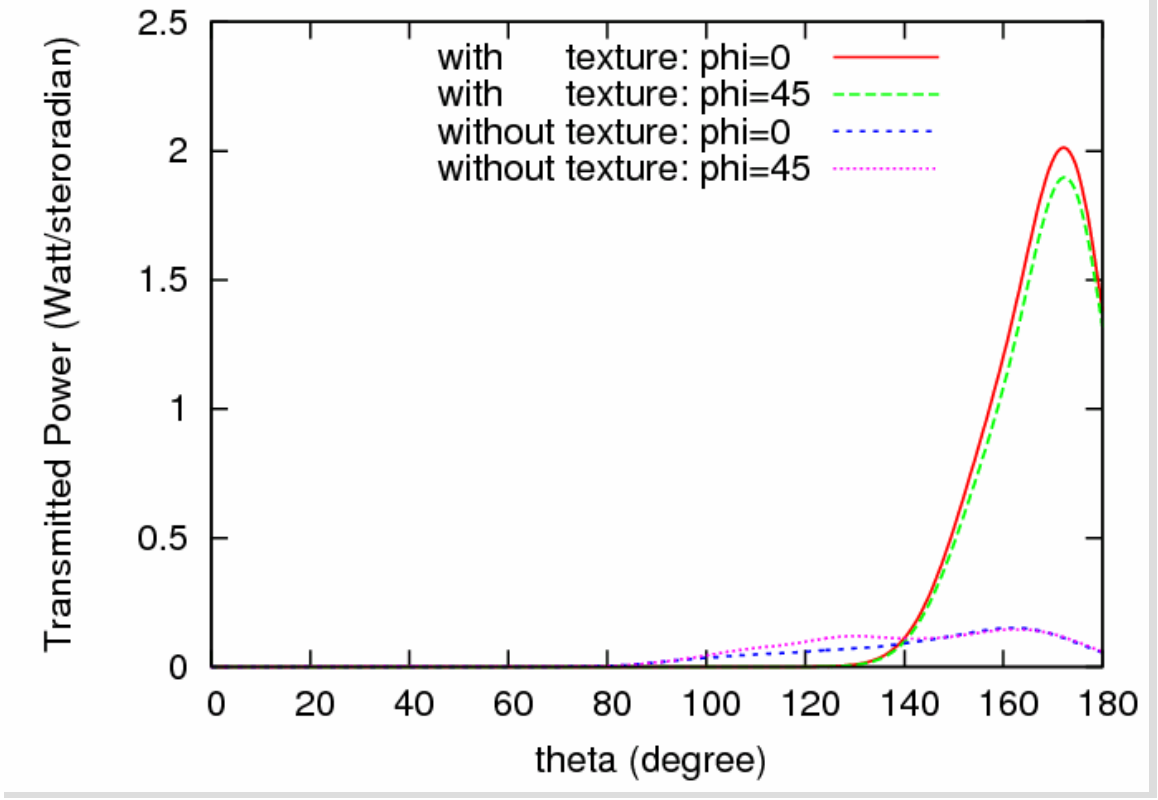
RT3D simulation with FDTD data

Compare: power distribution



- theta dependence for transmitted power at phi=0,45 degrees.
- It indicates power emission is nearly symmetric with respect to phi angle.

Summary

Accurate simulation of textured light emitting diode achieved through integration of several modules of Crosslight Software.

CSuprem+Apsys provide the basic device structure and electrical injection modeling.

FDTD+Raytrace-3D provide the optical power extraction simulation.