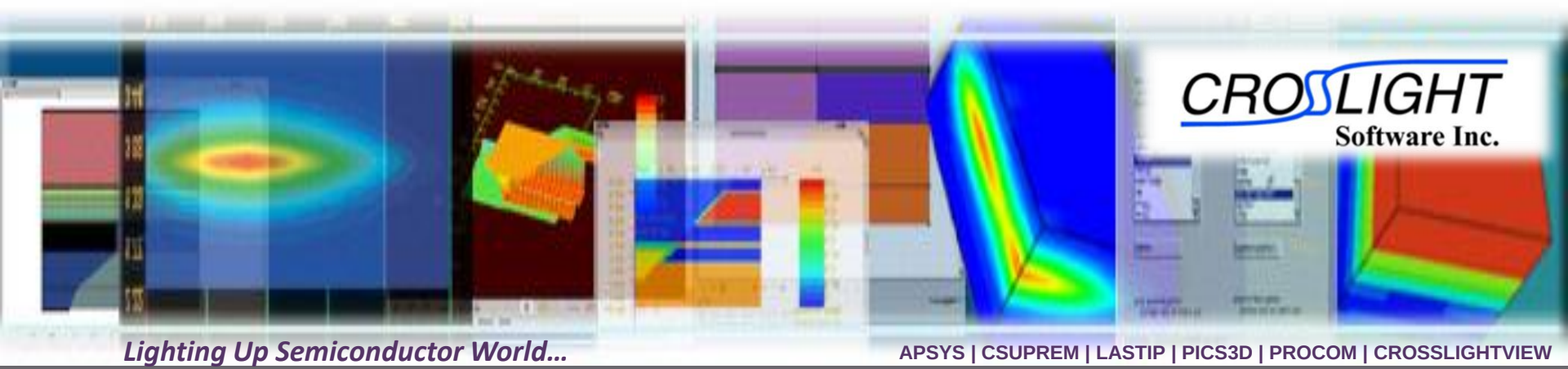


3D TCAD Simulation of Photonic Crystal Lasers

Introduction to Photonic Crystal Laser Diodes

- Directly modulated ultra-compact light source for CMOS-integrated photonic networks.
- Based on nano-cavity using high-Q photonic crystal.
- Ultra-low threshold and ultra-low energy consumption.
- Easy to integrate thousands of PhCLD into a single chip.

Optically-pumped PhCLD demonstrated

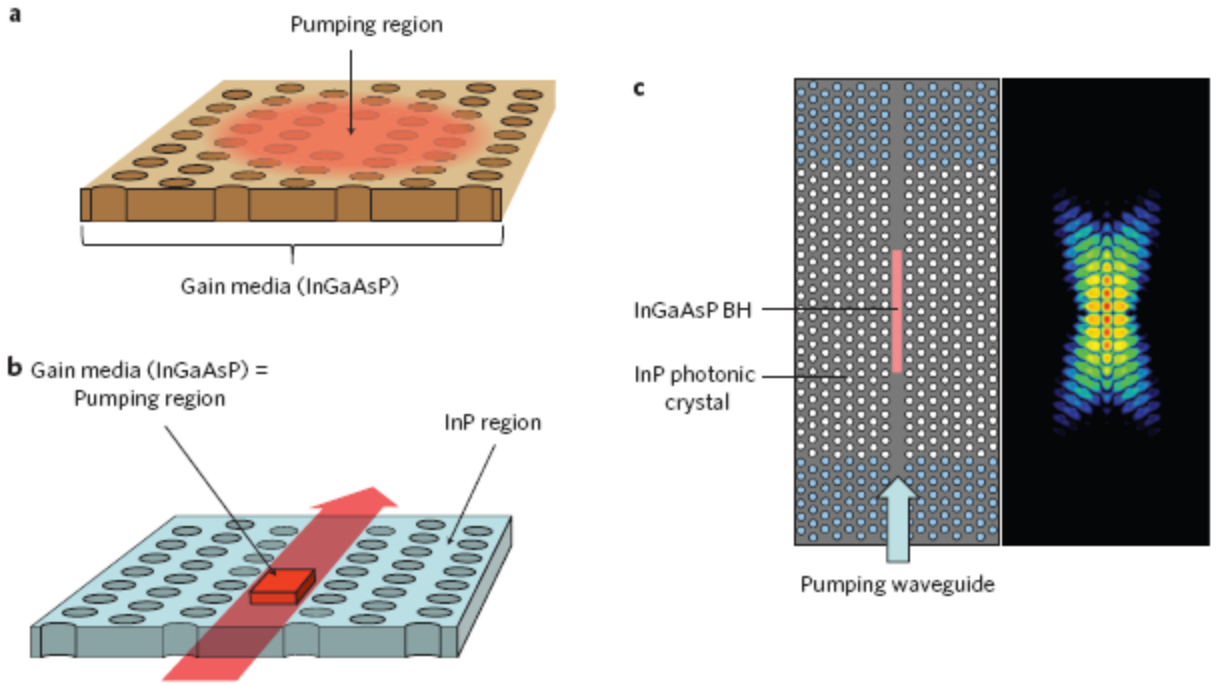


Figure 1 | Structure of the photonic-crystal nanocavity laser. a, Structure of previously reported photonic-crystal lasers. The photonic-crystal cavity is formed in a thin membrane consisting of a gain material (conventionally InGaAsP) suspended in air to achieve strong light confinement. **b**, Wavelength-sized BH photonic-crystal laser. The active region is embedded in an InP layer. **c**, Field profile of BH photonic-crystal nanocavity calculated by FDTD. The calculated modal volume and cavity Q are ~0.2 μm^3 and ~1.7 × 10^6, respectively.

Ref: “High-speed ultracompact buried heterostructure photonic-crystal laser with 13 fJ of energy consumed per bit transmitted,” Shinji Matsuo, et.al.,

http://www.nature.com/doifinder/10.1038/nphoton.2010.177

Modeling approaches: electrically pumped version

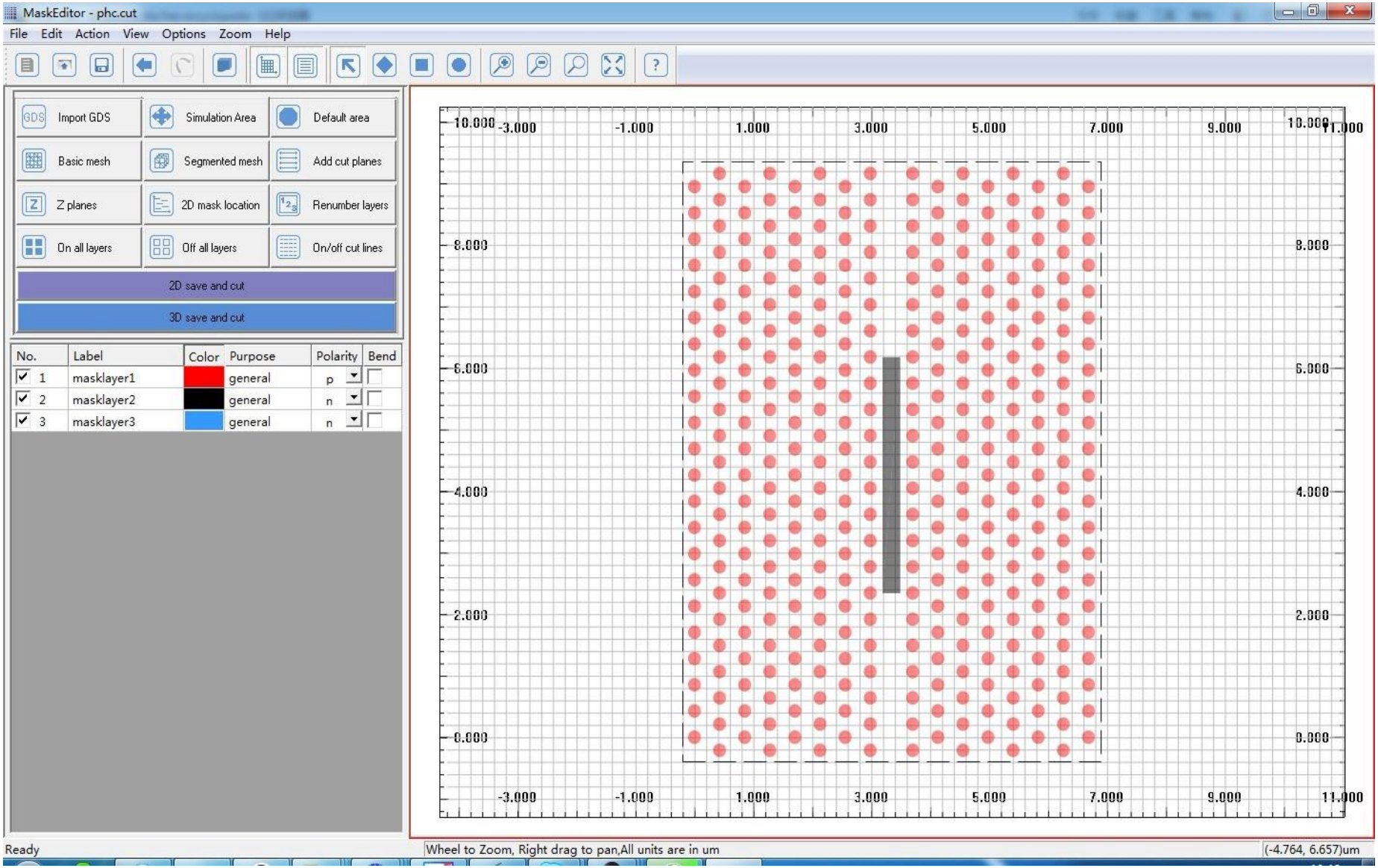
- Full device: PhC regarded as 2nd order grating in 3 directions. Grating parameters extracted from effective index models. Pro: most accurate; Con: time costly due to structural complexity.

- LD only: PhC regarded as effective mirror with mirror reflectivity from FDTD. Pro: efficient. Con: lost of electrical/optical coupling.

- LD + PhC portion: part of PhC holes near LD cavity taken into account. Reflectivity from FDTD used for other parts. Recommended here.

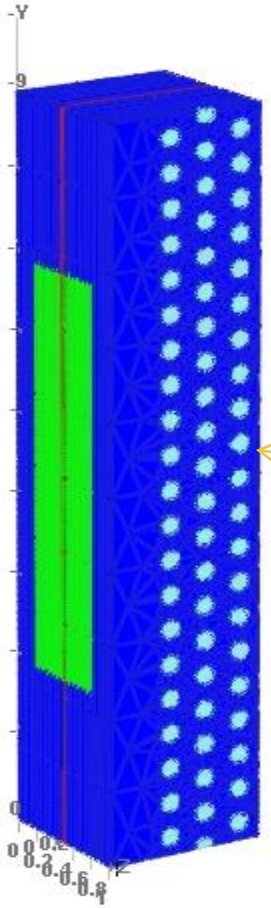
- All methods rely on FDTD for optical mode profiles within and around LD cavity.

Mesh generation starting from GDSII layout.



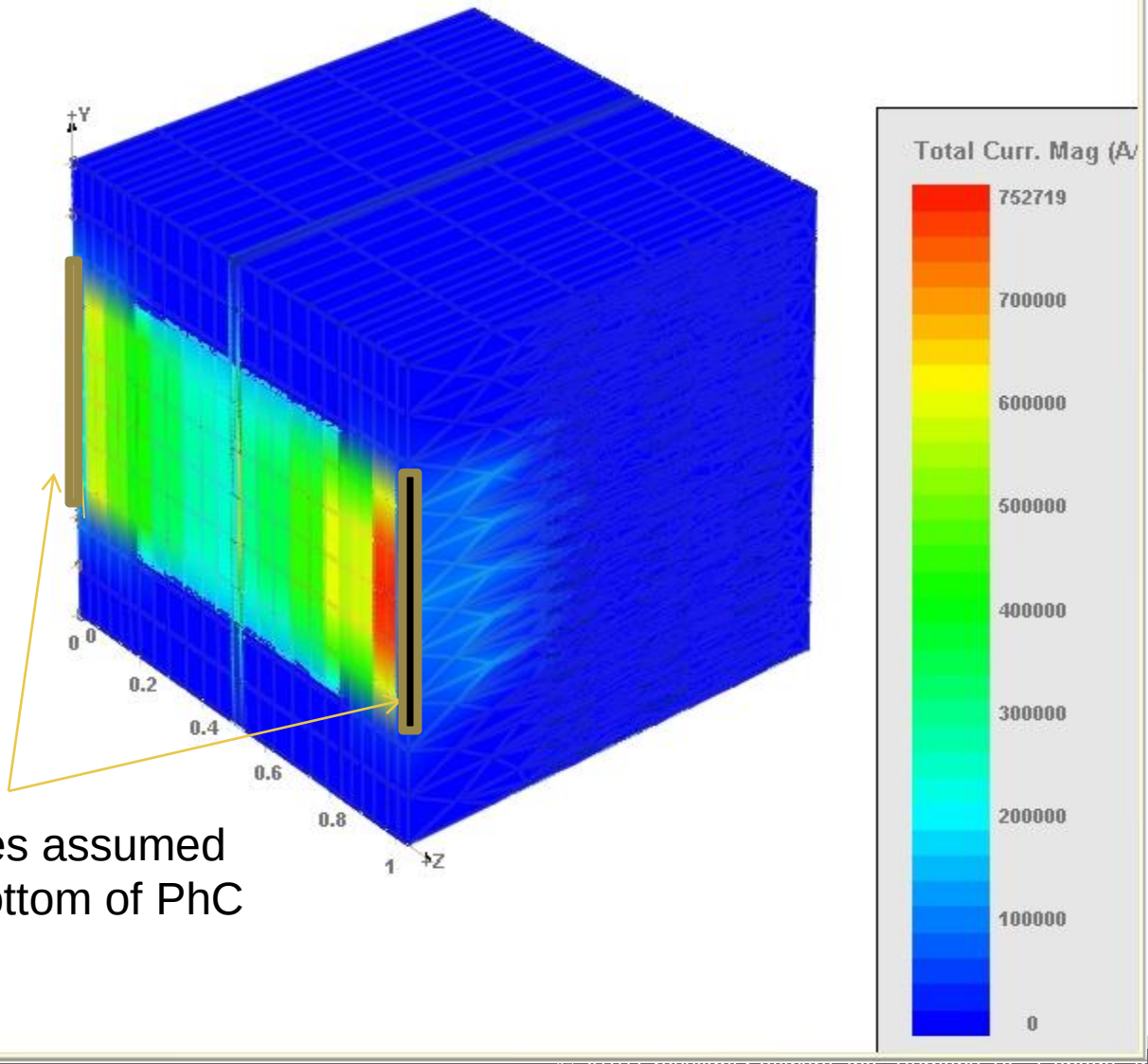
Structures constructed from CSuprem

Special cavity with propagation along y axis.



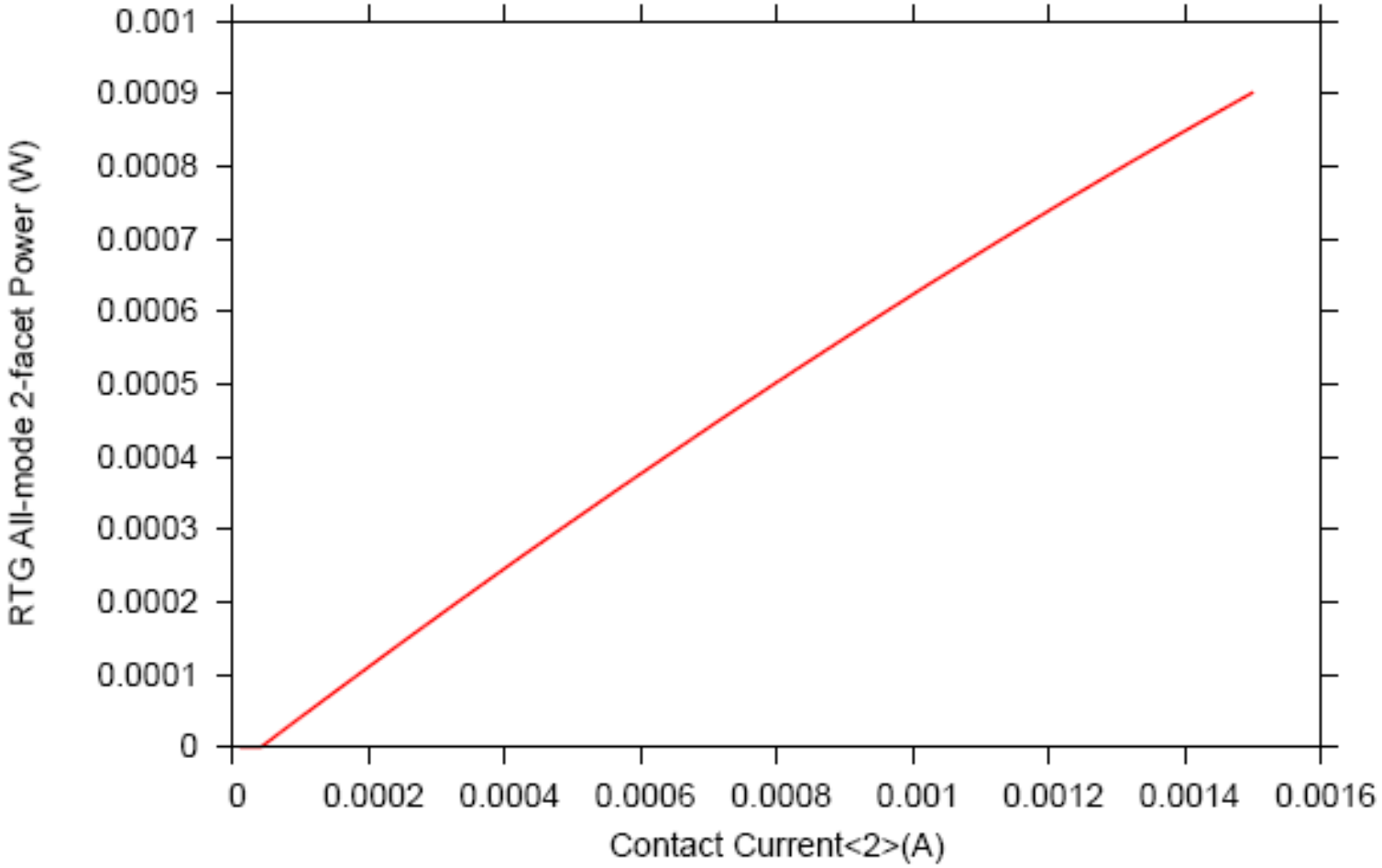
Photonic crystal air holes are conveniently generated on xy-plane using MaskEditor of CSuprem . GDSII format accepted.

Current injection

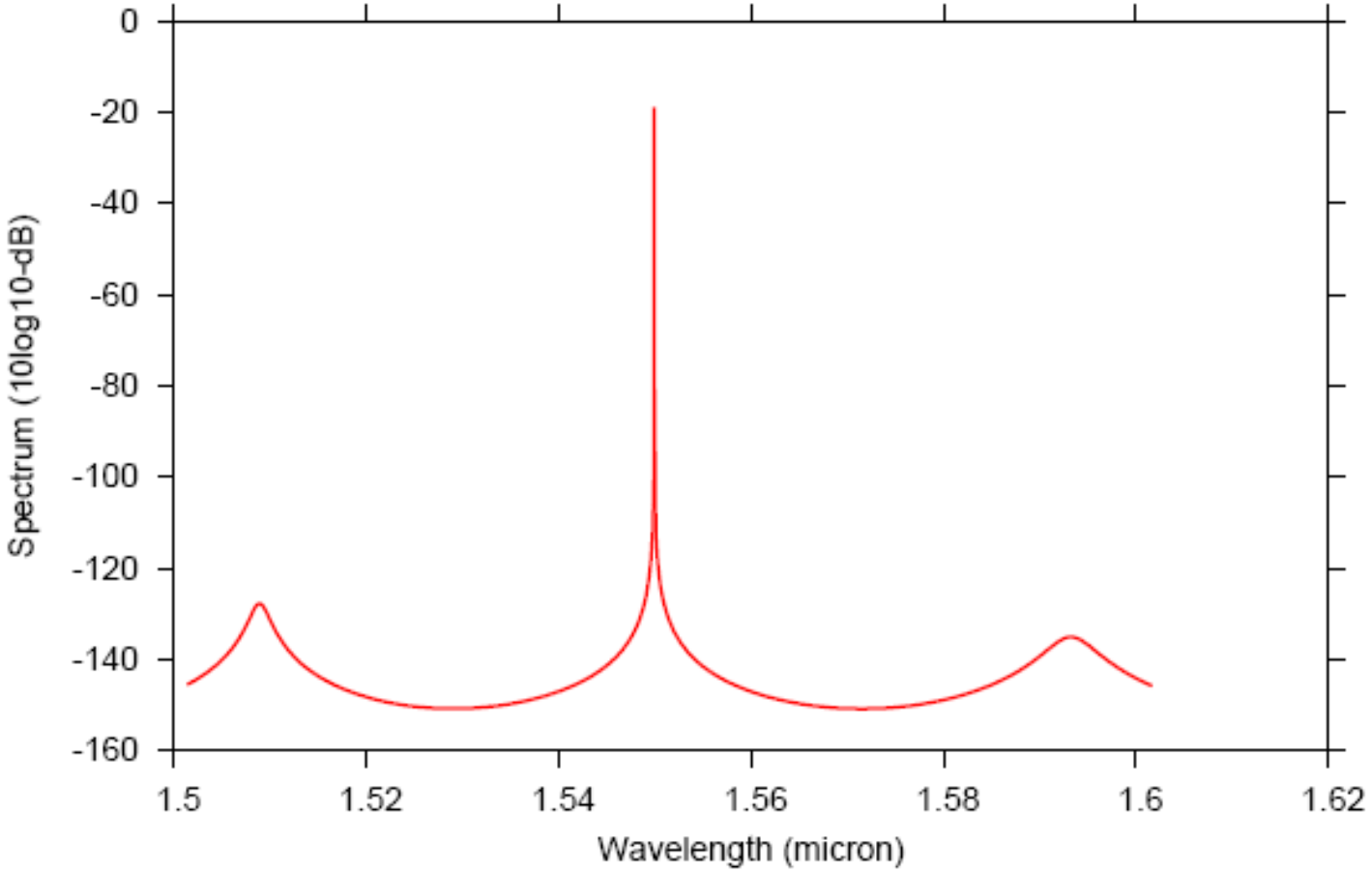


Electrodes assumed on top/bottom of PhC plane

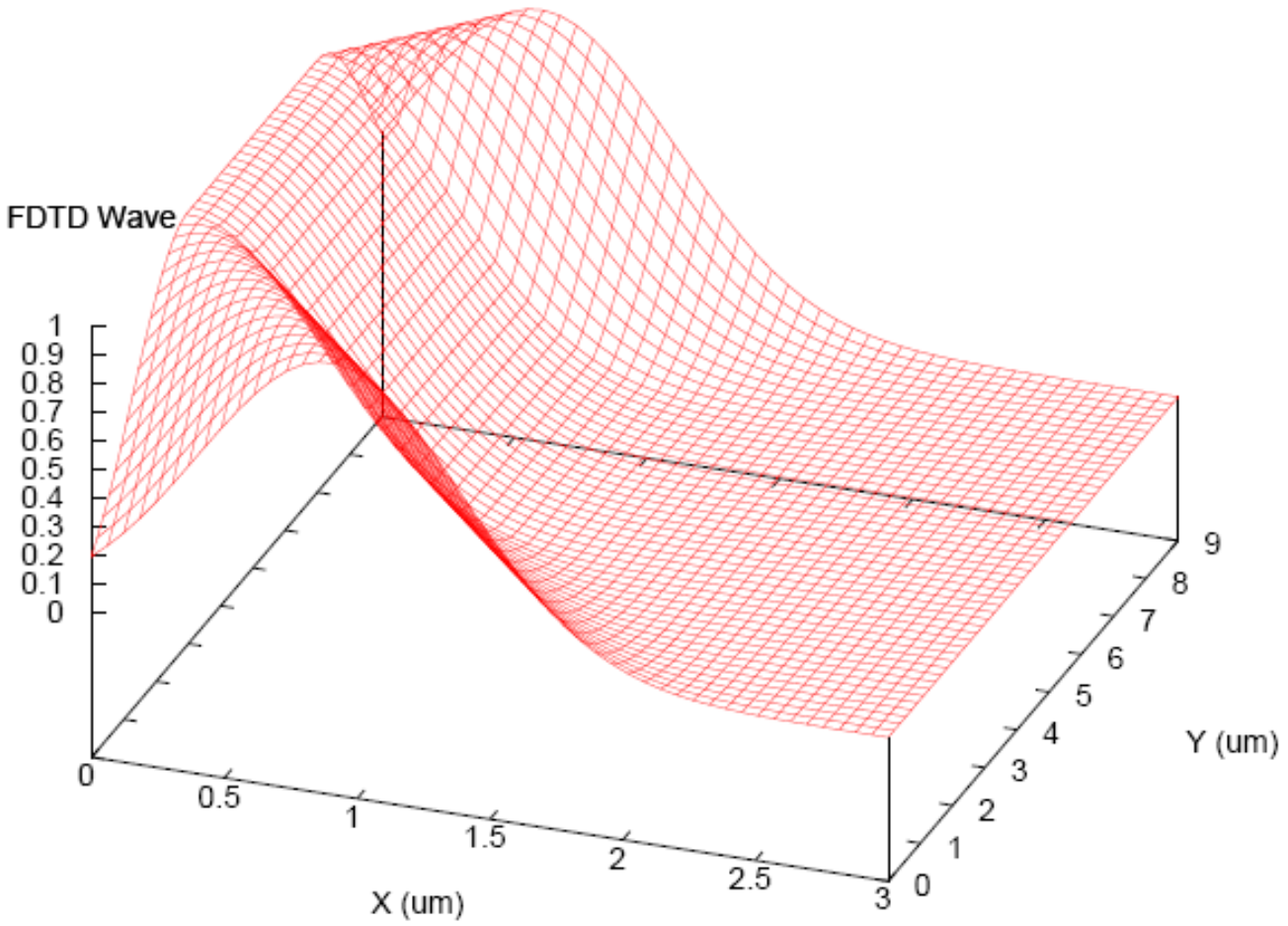
Lasing characteristics (ultra low threshold)



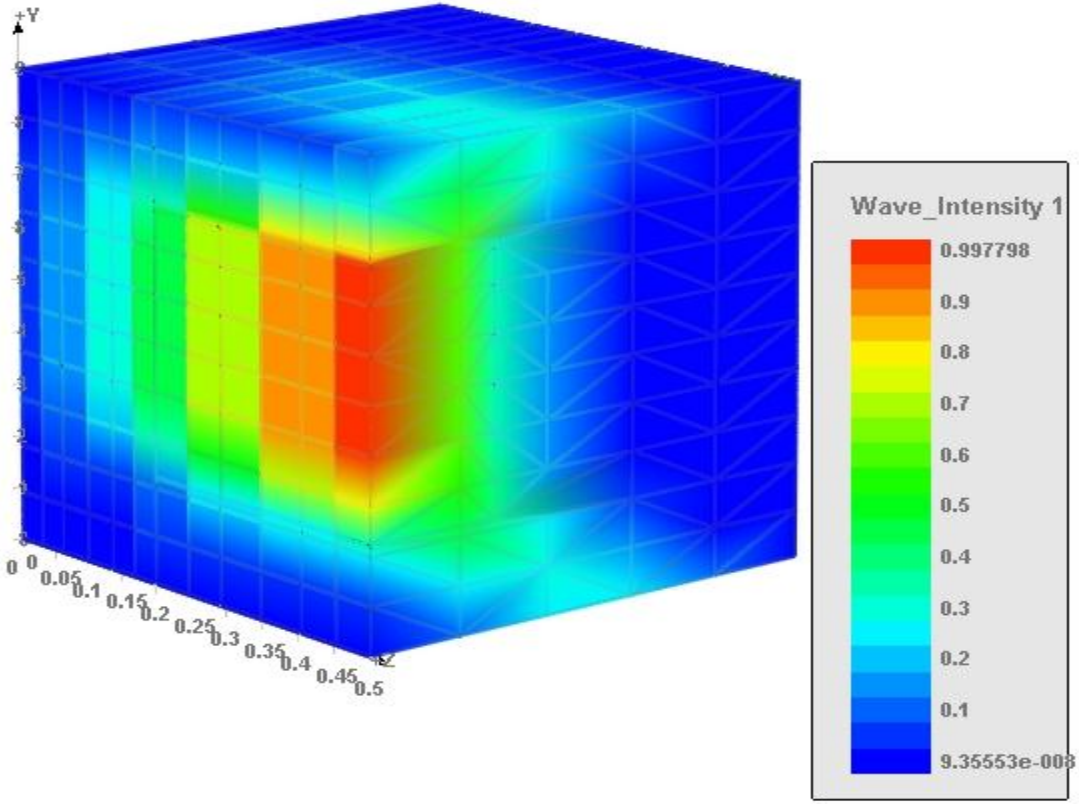
Spectrum of emission (nice and single).



Optical mode profile (FDTD does it all)



FDTD data imported into PICS3D simulation



Summary

- Most advanced integration of FDTD and PICS3D electrical-optical simulation for PhCLD application.
- 3D TCAD tools from Crosslight can be used to design and optimize electrically pumped PhCLD.
- User friendly and practical graphic user interface (GUI) covers all the way from original GDSII layout to final lasing characteristics.

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