Crosslight 3D PCSEL Simulation

App. Note by Simon Li & Michel Lestrade

www.crosslight.com





PCSEL to become mainstream



Kyoto University establishes theory of large-area photonic-crystal surface-emitting laser (PCSEL) for 3mm to 10mm single mode lasing: — They aim to achieve 50- to 100-Watt-class continuous wave (CW) lasing within a year

https://sj.jst.go.jp/news/202209/n0901-01k.html



Challenges in 3D PCSEL simulation

- Larger size than conventional laser
- Detailed air hole design needed
- Interaction of the large optical profile with quantum well transitions
- Thermal modeling needed for high power emission
- This demo adopts a multi-scale approach combining conventional 2nd order grating DFB model with the large 3D PCSEL modeling





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Vertical MQW and air hole details



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

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



Treating PC as 2nd order grating

grating_model real_index_high=3.5 real_index_low=1. && d_high=0.2 d_low=0.2 && grating_xrange=[1.7 1.9] grating_yrange=[0.1 0.9] && grating_order=2 print_data=gratingpara.txt

PICS3D extracts the 2nd order grating parameters ====> Grating Reg. Opt. Conf.= 4.779947042956008E-002 2nd order (180 degree diffraction) Real coupling coefficient (h2 or kappa) [1/m]4.84417641387488 2nd order (180 degree diffraction) Imag coupling coefficient (h2 or kappa) [1/m]0.00000000000000E+000 1st order (90 degree diffraction) Real coupling coefficient (h1) [1/m] 2072.50459011233 1st order (90 degree diffraction) Imag coupling coefficient (h1) [1/m] 0.00000000000000000E+000





Sliver is cut from the 3D PCSEL





2nd order DFB simulation is performed on the sliver





Optical wave intensity profile (sliver-vertical)



Optical wave intensity profile (sliver-longitudinal)







3D structure (1/4 of PCSEL)





3D wave intensity (1/4 of PCSEL)





Efficiency and power (1/4 PCSEL)



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With proper design possible to achieve highly efficient emission

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Various injection analysis (1/4 PCSEL)







Summary

- Crosslight offers an efficient (runs in minutes) 3D PCSEL simulation tool
- Well integrated multi-scale models covering quantum well optical transition, current injection/recombination, all the way to multi-watt photon emission
- Suitable for contact optimization, MQW design as well as thermal analysis
- Available in Crosslight version 2024 in beta form

