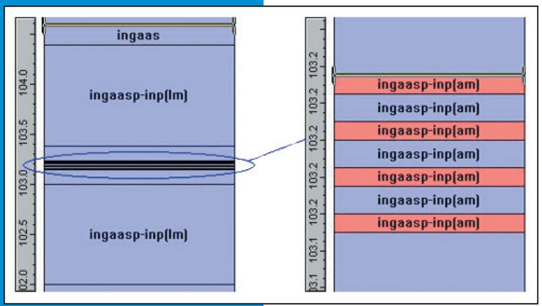
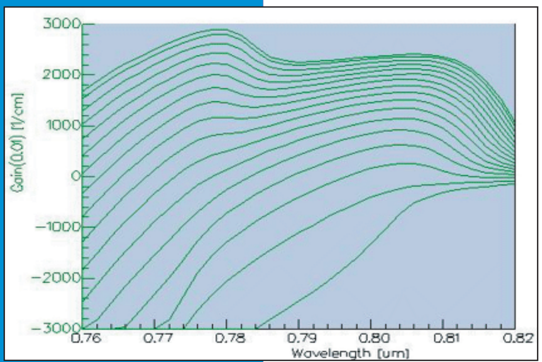
Harold

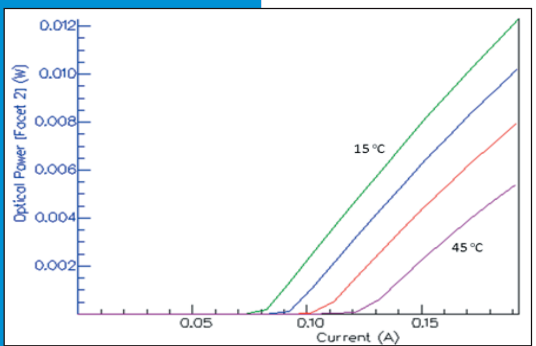
a hetero-structure and SOA/laser model



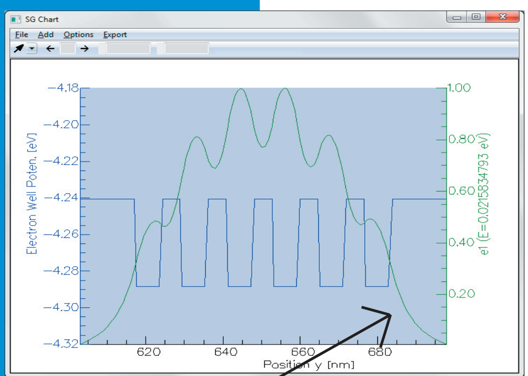
Epitaxial structure with quantum wells



Gain spectra for AlGaAs MQW



Laser LI curves showing T-dependence



Carrier wavefunction

☑ Advanced laser simulations

- Fabry Perot cavity modelling in 1D (Y) and 2D (YZ)
- pulsed (isothermal) or CW (self-heating) conditions
- Harold XY: laser cross-section modelling for e.g. SOI hybrid lasers
- gain curves export for laser / SOA modelling in e.g. PICWave

☑ Self-consistent solution of Poisson Equation

with drift-diffusion, capture/escape models for electrons and holes

☑ Full XY or YZ solution of the heat flow equation

- power dissipation: Joule, non-radiative recombination, free carrier absorption, excess power distribution, mirror scattering and mirror absorption
- heat-sink overhang in 2D (YZ) calculations

☑ 2D+Z waveguide mode solver

used to compute confinement factor and mode gain for TE and TM modes

☑ Capture/Escape balance equations

used to describe thermal equilibrium between confined and unconfined carriers in QW regions

☑ Gain model for QW lasers

- function of wavelength, carrier concentration and temperature
- parabolic band approximation
- can compute both TE and TM mode gain

☑ Support of multiple QW structures (MQW)

- supports non-indentical wells
- Schrödinger Equation solved over the whole MQW region to account for coupling between wells
- wavefunction overlaps included in recombination and gain model

☑ Carrier-induced bandgap narrowing

☑ Strain

- models effect of strain (in QW and barrier layers) on the QW levels
- Anisotropic hole masses resulting from biaxial strain can also be modelled.

☑ Recombination processes

- includes Shockley-Read-Hall, Auger, stimulated & spontaneous recombination
- advanced features, such as deep trap levels specified layer per layer
- surface recombination at the facets included via deep trap levels at the mirror.

☑ Non-injecting and absorbing mirrors

- Non-injecting mirror: suppression of current injection at the mirrors
- Absorbing mirror: photon absorption, attenuation at the mirrors is implemented

☑ Material database

- full support of quartenary alloys
- includes materials such as AlGaAs, InGaAsP, InGaAlAs, gold, copper etc.
- data includes band gap, effective masses, refractive index, etc.
- ASCII format allowing you to add your own materials

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What is Harold?

HAROLD is an advanced heterostructure simulator for modelling Fabry-Perot quantum well lasers with near-arbitrary vertical structure and layer compositions.

It is based on well-established physical models which account for a large number of physical processes, enabling one to obtain a very comprehensive set of simulation results by which one can test and improve one's laser designs.

Devices can be simulated in both 1D (vertical) and 2D (vertical-longitudinal), operating under pulsed (isothermal) or CW (self-heating) conditions.

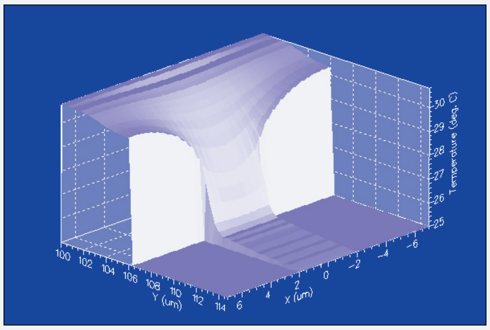
As well as being a laser simulator in its own right, Harold can export material models to Photon Design's circuit simulator, PICWave, thereby allowing results from its detailed physical model to be incorporated into larger, more complex devices for fast simulation in the time domain.

Harold XY module

Harold's XY Laser Module extends Harold's capability to modelling lateral structures. It uses the same physical model as a Harold 1D simulation but solves the electrical/optical/thermal problem on a 2D (XY) grid.

In addition, it supports insulating layers and graded etching and allows n and p-contacts can be on the top of the structure.

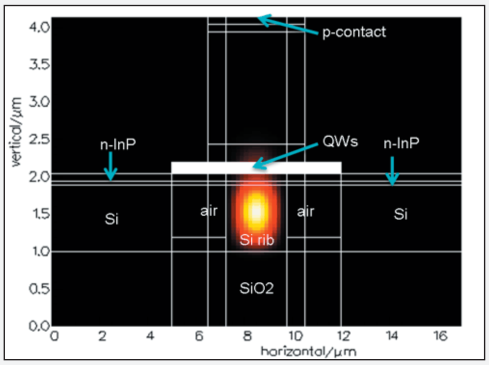
All this makes it ideal for the detailed modelling of simple ridge waveguide and SOI hybrid laser structures alike.



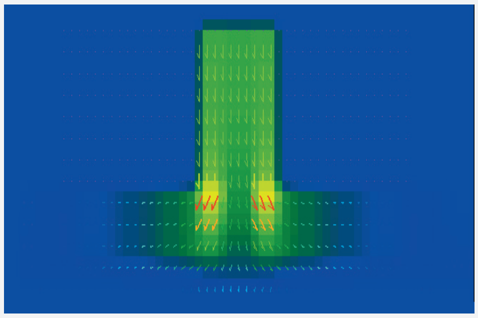
2D temperature profile in a ridge waveguide laser

Features

- 2D cross-section editor: supports graded etching, insulating layers and multiple contacts on same side
- Simulation results include 2D vertical-lateral profiles of numerous quantities such as band energies, recombination rates, current density, temperature and more...



Cross-section of an InP/SOI hybrid laser showing optical mode



Current density plot showing current spreading in a ridge waveguide laser

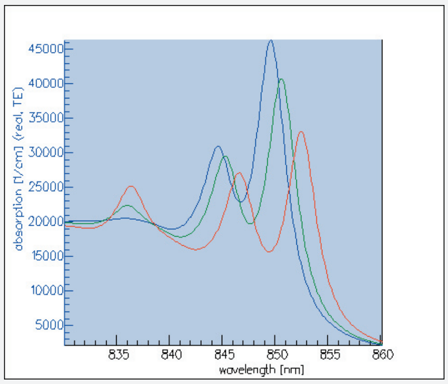
Electro-Absorption Modulator module

(Quantum-Confined Stark Effect)

The EAM (Electro-Absorption Modulator) Simulator calculates spectral and dynamic properties of modulators for a specified epitaxial layer structure and bias range. The underlying model is based on fundamental physical principles, providing a unique level of versatility.

Main features

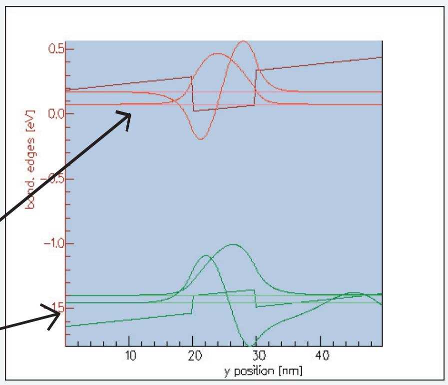
- Poisson and drift-diffusion model calculates band-edge spatial profile as a function of bias
- Quantum-Confined Stark Effect model features:
  - Schrödinger solver for quasi-confined modes
  - Exciton energy solver
- Carrier escape dynamics based on the analysis of thermionic emission and tunnelling.
- Export to PICWave for incorporation into a full device model with travelling wave efects and circuit level simulation.



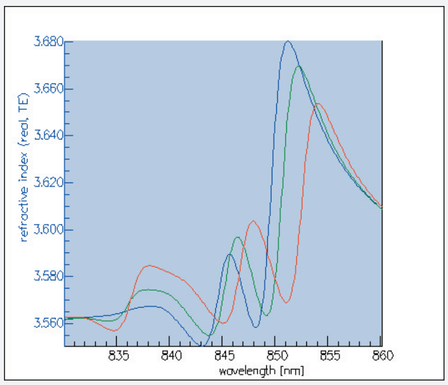
Absorption spectra of the EAM for different values of bias voltage

conduction band

valence band



Solution of the Schrödinger equation along the epitaxial structure



Refractive index spectra for different values of bias voltage