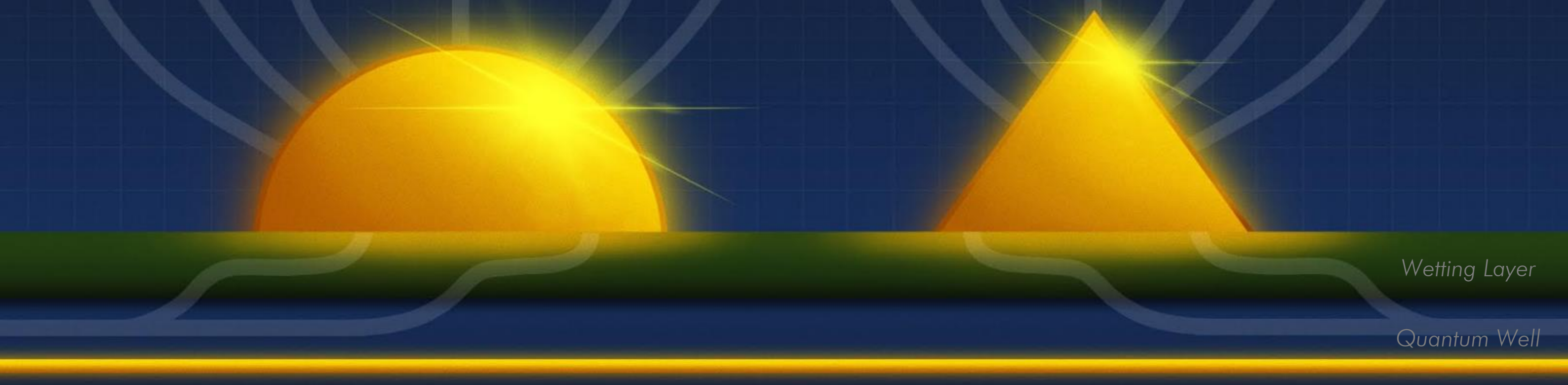
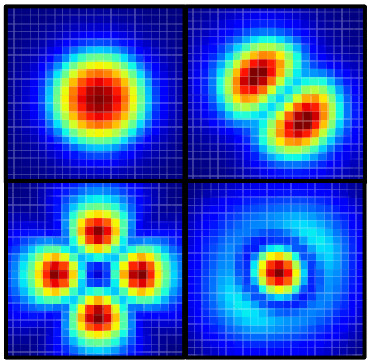
Quantum Dots

Simulate Gain and Absorption Spectra

- Lens and Pyramid shapes with distribution of sizes
- Full 3D Stress Strain Calculations
- 8x8 3D K.P Model

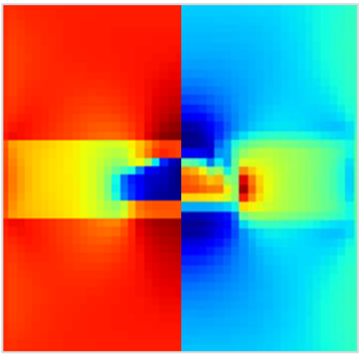


Available in Harold Early 2025 | Photon Design



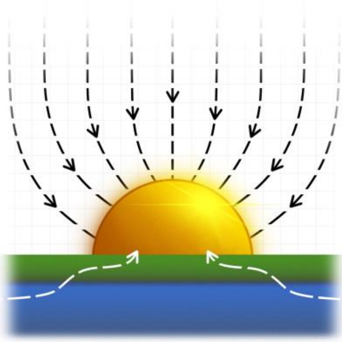
8x8 3D k.p Model

Schrödinger solution provides the probability densities of multiple states of a confined electron in lens shaped dot.



Full 3D Strain Model

The ε_{xx} (left) and ε_{zz} (right) strain component profiles due to lens shaped quantum dot.



Established Laser Simulator

Including current flows, 2D optical modes, LI-Curves, and more…

In early 2025 we're bringing the *Nobel Prize* winning topic of ***Quantum Dots*** to our software Harold. The quantum dot model will allow users to ***compute absorption and gain spectra*** for quantum-dot based lasers and SOAs thanks to its 3D strain model and 3D band structure calculator.

Test your dot designs are delivering the high-temperature performance that quantum-dot materials are promising the World.

Start your 30 day trial on release day

Photon Design

Photon Design have been serving the photonics community for over **30 Years** with market leading software for designing passive components, active components, and entire PICs. All of our tools are under continuous development driven by the feedback of our users and their cutting edge research.

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Key Features

8x8 3D k.p Model

Identify the available energy states in the conduction and valence band with our ***spurious free 8-band model*** for an individual quantum dot.

The band gap energy is perturbed by coupling to the light hole, heavy hole, and spin orbital bands. By simulating these further bands, our 8-band K.P model will ***more accurately*** describe the band gap and the gain spectra results.

3D Full Stress-Strain Model

The strain due to lattice mismatch between materials can have a *significant* effect on a quantum dot's energy levels. Our continuous mechanical strain model rises to the challenge of calculating the ***full 3D strain tensor*** necessary to describe a 3D quantum dot's geometry (*apposed to the 1D stain from a quantum well*). This allows for a detailed description of confining potential and a more accurate description of the system.

Distribution of Dot Sizes

When fabricated, quantum dots don't have the intended singular size but a *distribution of sizes* to detrimental effect to properties such as linewidth. To account for this, Harold will simulate a ***Gaussian distribution of dot sizes*** and combine the results in its final output. This gives a more accurate reflection of the results that can be expected at fabrication.

By tuning the size distribution to match experimental results, the Harold quantum dot model can ***inform the size and deviation of the dots being fabricated***.

Multi-Level Capture – Escape Model

On a macroscopic level current flow is modelled classically in Harold, but at the scale of quantum dots the evolution of charge carriers is described by a capture/escape model.

Harold will calculate the ***occupation probability*** of the conduction and valence bands within the dot as a function of contact voltage and substrate temperature with a sophisticated model that allows for ***non-equilibrium populations*** (*apposed to a simple fermi-level model)*. With this, Harold can simulate capture and escape between the multiple energy levels that have been simulated.

Integration with Harold

Our quantum dot module is integrated with our established hetero-structure simulator Harold which has provided research and industry.

…laser simulations for over 20 years
while under continuous development.

Harold provides a ***2D drift/diffusion model*** to compute the current paths from the electrical contacts to the quantum dot layer, coupling to the dots themselves through the capture-escape model
From this, a gain spectrum can be computed.

Results

- Energy levels and Wave functions
- Modal Gain Spectra
- Absorption spectra (unbiased device)
- Laser PI curves
- IV Curves
- Temperature dependence (for all results listed)

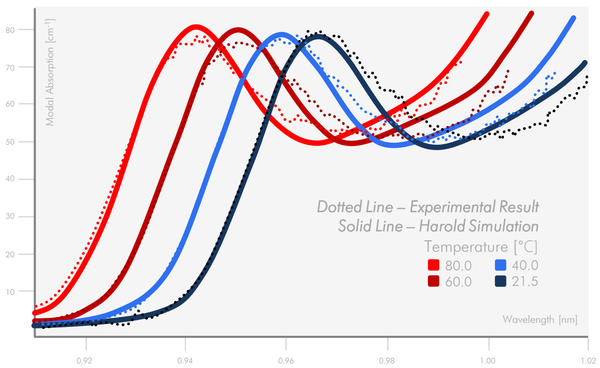
Applications

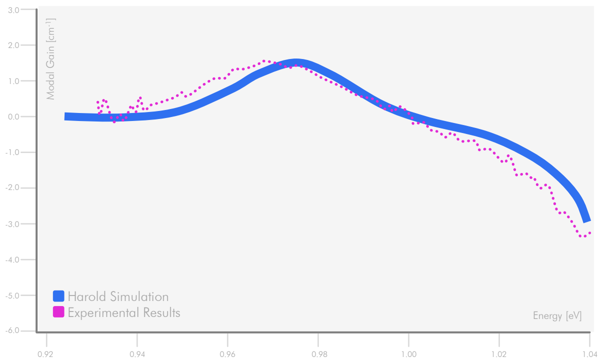
- Edge Emitting Laser Diodes
- VCSELs
- SOAs

Start your 30 day trial on release day

Validated with Cutting Edge Research Groups

The Harold Quantum Dot Model has been developed in collaboration with ***Cardiff University*** - one of the UK's leading centres for compound semiconductor photonics research. In the figures shown we demonstrate the excellent agreement between the results of the model and experimental data measured by Cardiff. The devices were fabricated by the ***University College of London***.





Comparing simulation to measured results obtained by Cardiff University where dot distribution has been used as a fitting parameter.
Left: *Modal Absorption spectra at multiple temperatures.* ***Right***: *Modal Gain Spectra.*