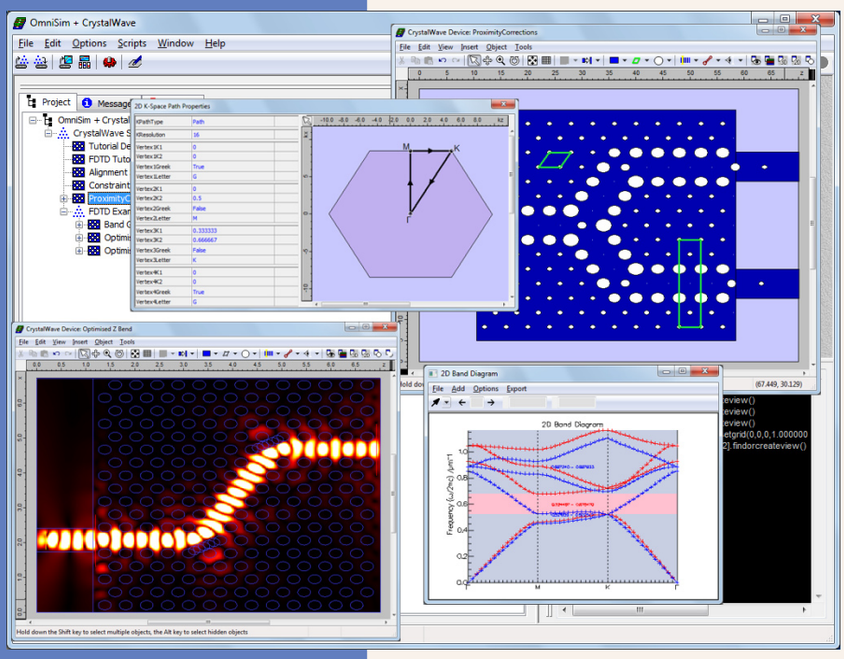
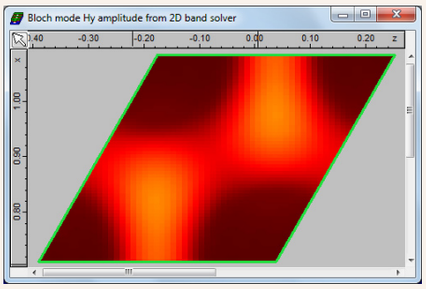
CrystalWave

a design tool for photonic crystals

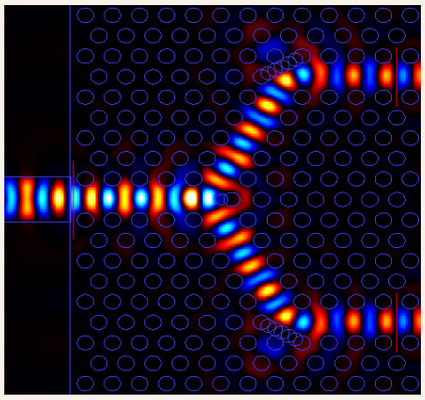


- ☑ Professional photonic crystal lattice editor for 2D and 3D lattices
- ☑ 2D and 3D FDTD Engine
  Finite Difference Time Domain
- ☑ High speed FEFD Engine
  Finite Element Frequency Domain
- ☑ 32-bit and 64-bit versions available
- ☑ True SMP to run the fastest FDTD calculations on your multi-core computers
- ☑ FDTD Cluster for Windows and Linux
- ☑ Unique Active FDTD capability for the modelling of photonic crystal lasers

- ☑ Create lattice defects in one click and efficiently edit >100000 holes
- ☑ Calculate band diagrams and Bloch modes with PWE-based solver
- ☑ Material dispersion modelled with Drude, Lorentz and Debye models, accurate even for metals



- ☑ Fourier analysis of FDTD output: get spectral responses in one run
- ☑ Output to GDS-II with hierarchy
- ☑ Automatic optimisation with Kallistos
- ☑ Constraint system
- ☑ Script automation



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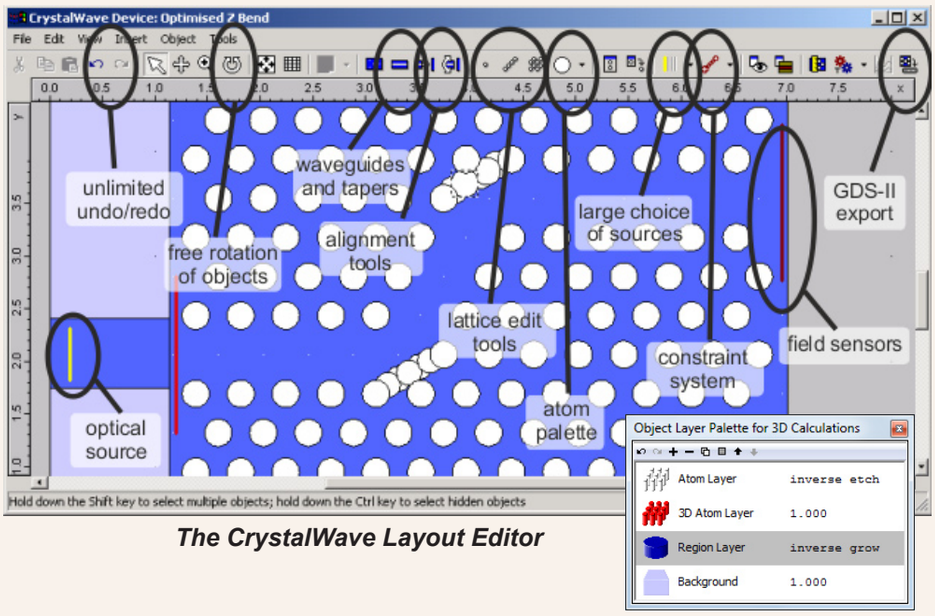
What is CrystalWave?

CrystalWave has been developed from the ground up for the design and simulation of 2D-lattice and 3D-lattice photonic crystal structures. It includes a lattice-aware layout editor, powerful simulation tools and a mask-file generator.

You may have tried to specify photonic crystal circuits with a general purpose mask layout tool, in which case you will probably have found that this takes hours to do and also hours to modify anything. On this layout time alone, CrystalWave will save you hours, for example the construction of a lattice with 500+ holes and a line defect is just 4 simple operations.

A photonic crystal circuit is typically a structure consisting of a series of holes on a hexagonal lattice, etched vertically in an SOI or GaAs/AlGaAs or other substrate. CrystalWave makes it trivial to specify such structures with holes of near arbitrary shape, on a hexagonal, rectangular or any other regular lattice, adding single and line defects to the lattice, adding individual holes with non-standard shape or radius and many other features.

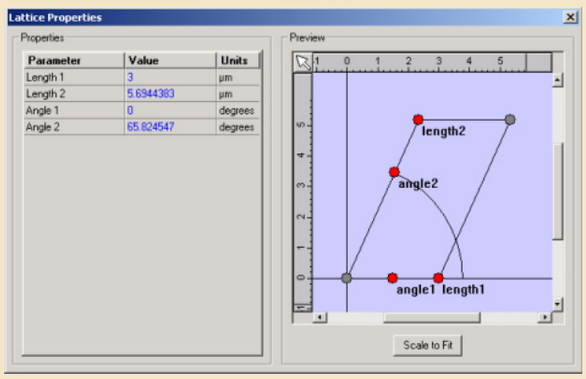


The CrystalWave Layout Editor

Layout and Photonic Crystal Lattice Editor Features

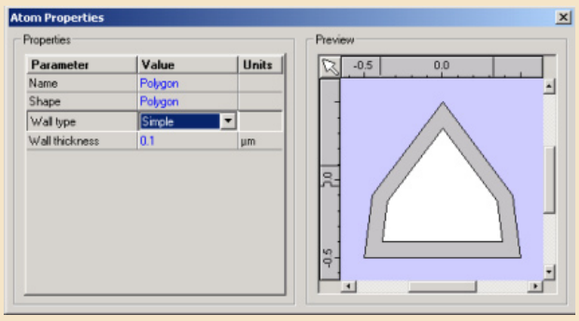
- Hexagonal, rectangular or arbitrary 2D lattice shape; user may specify both lattice vector directions and both lattice spacings.
- 2D atoms may be circular, elliptical, rectangular, regular or irregular polygons.
- Diamond, cubic, BCC and FCC 3D lattices with spherical atoms.
- 2D atom vertical profiles of arbitrary shape, e.g. round bottom, tapered walls.
- Easy placement of single and line defects.
- Easily alter the shape of groups of atoms as well as add and edit "special" atoms.
- Free rotation of any object
- Randomisation of atoms for tolerance analysis.
- Efficient editor design; can edit even the largest structures with tens of thousands of atoms quickly.
- Output to GDS-II with use of hierarchy (GDS-II cells) to dramatically reduce file size.
- Multiple crystals - e.g. could have one region with lattice vectors at 0° and 60° and another with vectors at 5° and 65°.
- Addition of other features for e.g. defining conventional waveguides and tapers into the lattice.
- Extensive multi-mask etch/regrow system with non-vertical etching and anisotropic etching.
- Multiple undo/redo.
- Define your structure in terms of expressions and named parameters.
- Automatic parameter scanner for easy generation of design graphs.
- Constraint system to build more complex structures by joining elements together.
- Script system allows you to programmatically construct even the most complex structures in an automated manner.

Arbitrary atoms and lattices



The 2D Lattice Grid Editor

It is trivial to set up a lattice with any lattice vector directions and lattice spacing using this graphical editor.



The 2D Atom Editor

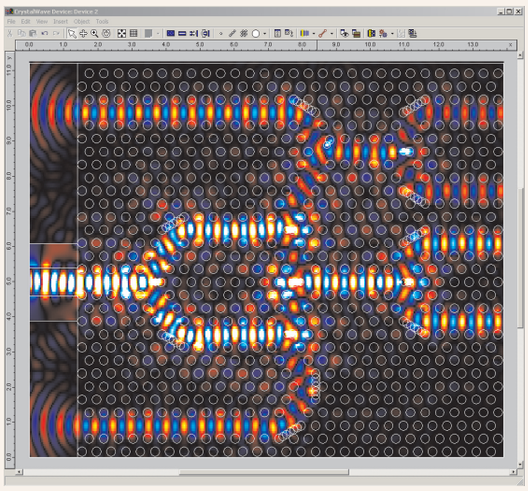
Here we define a 2D atom as an irregular polygon and also specify a 0.1um-thick oxide layer on the inside wall of the hole.

Finite Difference Time Domain Engine

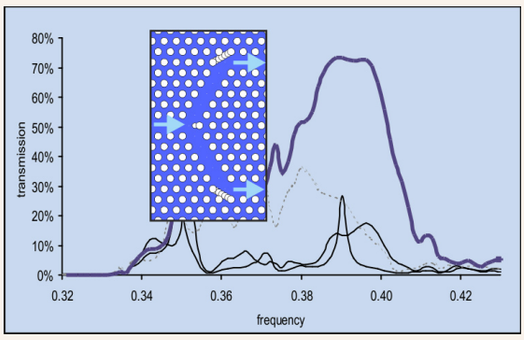
The CrystalWave framework includes an advanced highly efficient FDTD (finite difference time domain) engine to simulate the propagation of light through your designs. This has been written specifically for photonic crystal simulations, taking best advantage of the lattice structure. It is therefore more efficient for this application than a general-purpose FDTD tool.

Features:

- Full integration with the CrystalWave framework
- 2D and 3D simulations supported - either can be done on the same design
- Very fast, speed-optimised engine
- Uses **symmetric multi-processing (SMP)** on multi-core/multi-CPU computers
- Supports **clustering** on Windows and Linux clusters
- Unique **subgridding** tool: add resolution where needed, ideal for plasmonics modelling
- Unique **Active FDTD** (optional module)
- 64-bit: **no memory limitation**
- Special techniques substantially reduce memory use
- Wide range of optical sources - plane wave, Gaussian beam, dipole, waveguide mode; all available as CW, pulse or user-defined temporal envelope
- Can launch mode profiles calculated with FIMMWAVE, our flagship full vector mode solver
- PML, metal, magnetic or periodic boundaries
- Material database including lossy and dispersive materials, even metals. Dispersion spectra accurately fitted with Drude, Lorentz and Debye models.
- Anisotropic materials, magnetic permeability, non-linearity
- Batch manager and parameter scanner
- Video recording



Above: a photonic crystal circuit of Y-junctions and bends simulated with the FDTD Engine.



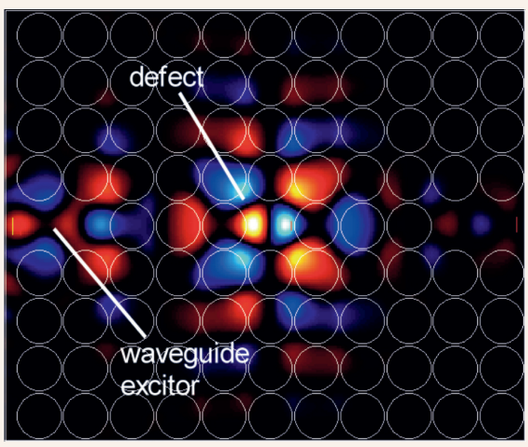
Above: transmission spectrum (blue line) of a Y-junction (inset) simulated in 3D FDTD. The device was designed using automatic optimisation (Kallistos - see over) for both high efficiency and wide bandwidth. Lab measurements of the manufactured design yielded World record bandwidths (ref. Uni. St. Andrews, UK).

Finite Element Frequency Domain Engine

The FEFD Engine (Finite Element Frequency Domain) provides a powerful full-vector 2D Maxwell Solver and is the ideal compliment to FDTD. Using techniques developed at Photon Design, this enables you to simulate your structure at a given wavelength often in just a few seconds. It works as well with high as with low delta-n structures and is fully omni-directional. Applications include rapid prototyping and highly resonant structures - the latter requiring very long simulation times in FDTD. Combined with Kallistos, it is able to evolve new photonic crystal designs in hours that have previously taken months to do.

Features:

- Based on new efficient numerical techniques
- Fast fast fast! Unparalleled speed
- Uses symmetric multi-processing (SMP) on multi-core/multi-CPU computers
- High delta-n capability
- Integrated with our FDTD Engine
- Wide range of sources and sensors
- Parameter scanner relying on named variable system
- Its speed and low numerical noise make it ideal for **automatic optimisation**



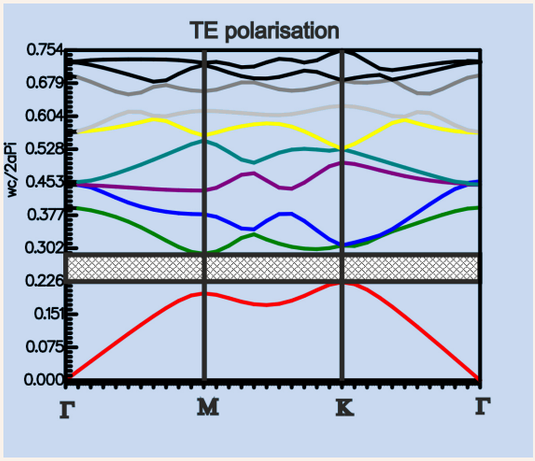
Above: simulation of defect mode in a PBG lattice using FEFD Engine. This simulation takes just a few seconds compared to several minutes in FDTD.

Band Structure Analyser

The analysis of the band structure of a periodic lattice is a very useful starting point for a photonic crystal circuit design. In essence it computes the solutions of a structure with infinite periodicity. This can be a "bulk" lattice but could also be a line defect, telling you when the lattice is opaque, when a line defect is single moded and so on.

The Analyser will compute the Bloch (periodic) modes of a photonic crystal lattice with 2 or 3 dimensional periodicity. It will automatically identify the band gaps of your structure and evaluate the Bloch mode profiles at any point.

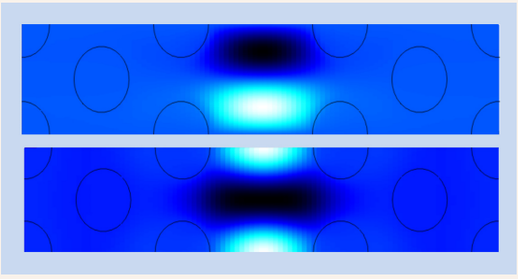
The extensively flexible design interface allows you to control the dimensions of the computational cell in the first Brillouin zone, allowing you to perform calculations along a specific K-path.



Band Diagram of a 2D lattice

Features:

- PWE (plane wave expansion) based engine for best computation in the frequency domain.
- 2D and 3D simulation modes.
- Generates w/k band diagrams for TE-like and TM-like polarisations.
- Easily plot the Bloch modes from any point on the w/k band diagram.
- Full integration with the CrystalWave framework
- Simple graphical specification of Cartesian and non-Cartesian unit cells.
- Supports all lattices defineable in the CrystalWave layout editor - rectangular, hexagonal lattices, with square, elliptical or arbitrary shaped "atoms".
- Automatic detection of band gaps.
- Real and lossy materials.
- Calculate effective index, group index and dispersion of the Bloch mode.
- Automatic scanners for generation of "band maps" e.g. against lattice period or hole size.
- Speed optimised calculation engine takes advantage of any symmetries.



Bloch modes of a line defect. The lower figure is the same mode half a period later.

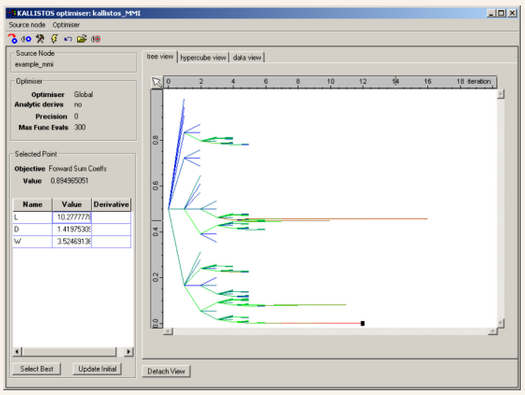
Kallistos automatic optimisation (option)

The Kallistos module adds powerful automatic optimisation to your CrystalWave design suite. It will save you many hours of design time if not days and will often locate new designs that you are unlikely to obtain manually by trial and error.

You can readily find global optima for 3 or 4 parameters of your choice or local optima for 10 or more. Photon Design has used this internally to develop photonic crystal components with World record efficiencies.

The module provides several optimisation algorithms for you to choose from including both global and local. It also permits you to define your design goal (objective function) in a near-arbitrary manner, including use of multi-wavelength optimisation to locate wide bandwidth designs.

The tool includes advanced visualisation and interaction tools to communicate the large amounts of data generated to you and ensure that your insights as a designer can be enhanced rather than replaced by the automation process.



The tree view is one of the monitoring interfaces in Kallistos for viewing the progress of a global optimization algorithm of any multidimensional problem. The longest branches tend to correspond to potentially good designs. Just click on any of these to view the corresponding design.

Platforms

PC: XP/Vista/Win7, 2GB RAM, Core2Duo 1GHz or better

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