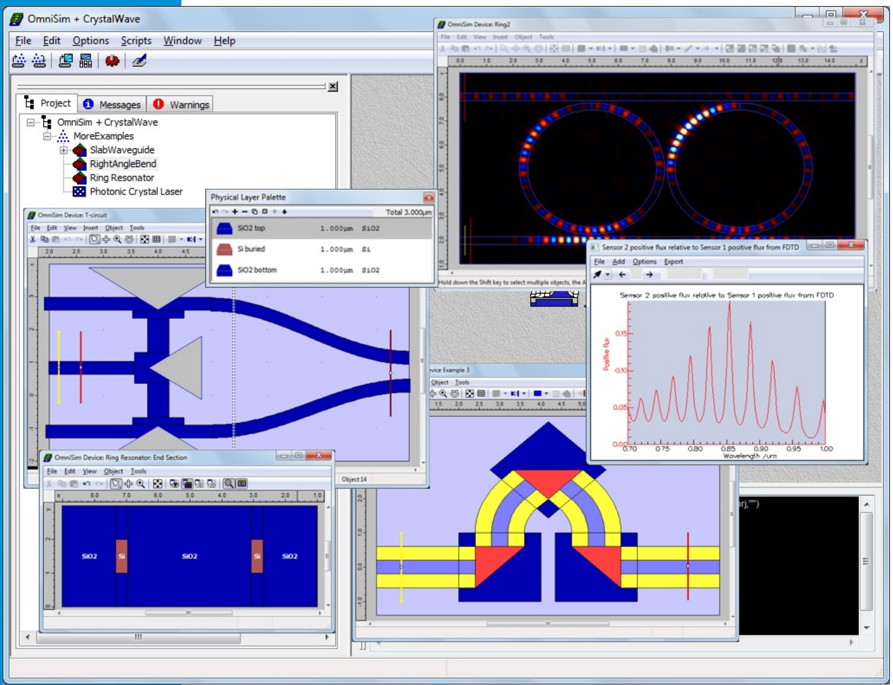
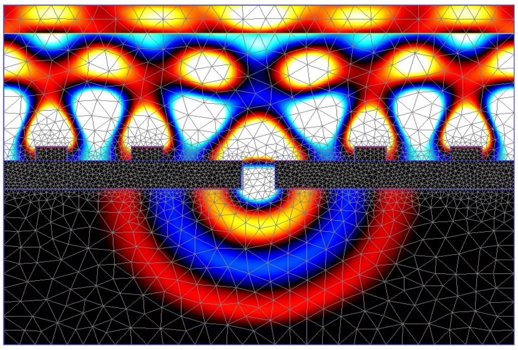
OmniSim

FDTD, FETD and RCWA for nanophotonics



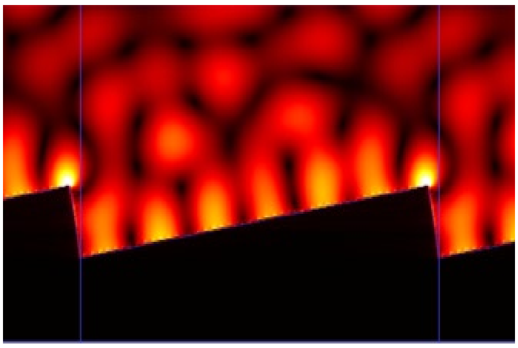
- ☑ Unique combination of FDTD and FETD engines
- ☑ State-of-the-art FDTD with advanced averaging methods
- ☑ Unparalleled convergence for nano-plasmonics with FETD
- ☑ Innovative RCWA for metamaterials and DOEs
- ☑ Linux and Windows cluster support for FDTD
- ☑ Mask export to GDS-II
- ☑ Python & MATLAB scripting

- ☑ Support for dispersive and nonlinear materials with arbitrary tensors
- ☑ Support for negative index materials using dispersive permeability model
- ☑ Automatic wide-band fitting of dispersive materials to time-domain models



The only tool you will ever need for the modelling of your nanoplasmonics and metamaterials!

- ☑ Automatic optimisation with Kallistos
- ☑ Active FDTD for modelling nano-lasers with carrier rate dynamics
- ☑ Extensive example library
- ☑ Scripting tools for automated design of surface grating couplers



Photon Design®

Photon Design Ltd
34 Leopold St.
Oxford, OX4 1TW
United Kingdom

Tel: +44 1865 324990
Fax: +44 1865 324991
Email: info@photond.com
Web: https://www.photond.com

What is OmniSim?

OmniSim is a powerful and flexible simulation package for the design and optimisation of nano-photonic, plasmonic and metamaterial devices.

It features a **very flexible layout editor** which allows you to design virtually any photonic device you want, and it is packed with a **complete suite of high-performance 3D and 2D Maxwell solvers**, including FDTD, FETD, RCWA and FEFD, as well as our Kallistos optimiser.

OmniSim is the only software package to include both FDTD and FETD. This combination allows you to get the best of both worlds: FDTD for quick approximate simulations and FETD for higher accuracy. These two methods are truly complementary, and can be used to model structures of similar size and complexity.

FETD is particularly useful for modelling plasmonics and metallic structures, for which high resolution is routinely required, and FDTD is often very slow.

FDTD is ideal for dielectric structures, where its rectangular mesh works efficiently. RCWA is ideal for gratings or other periodic devices.

With its complete suite of engines and multi-core and 64-bit support included as standard, OmniSim is the ultimate toolkit for the modelling of nanophotonics!

Requirements

PC: x86 or x64; Win Vista/7/8/10, 1GB RAM, 2 GHz or better recommended.

A complete suite of propagation models

☑ A unique combination of FDTD and FETD

Start your simulations with our fast state-of-the-art FDTD, then switch to our powerful FETD when you need high precision

Our highly efficient FDTD Engine (Finite Difference Time Domain) can simulate the propagation of light through any design.

Our FETD Engine (Finite Element Time Domain) is a great complement to FDTD and can take over whenever you need high accuracy for structures on which FDTD would be slow (e.g. plasmonics).

Features of our Time Domain Engines:

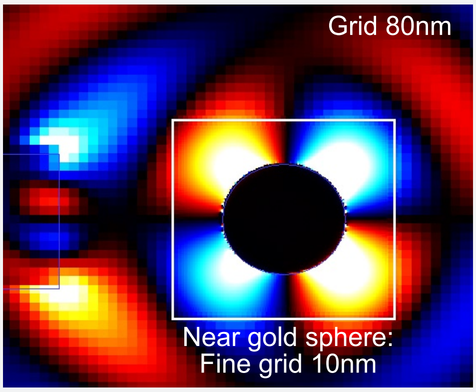
- ☑ Very fast, speed-optimised engines
- ☑ 2D and 3D simulations on the same design
- ☑ Full support for multi-core, multi-CPU computers
- ☑ 64-bit: **no memory limitation**
- ☑ Switch between FDTD and FETD in one click
- ☑ Wide range of optical sources - plane wave, Gaussian beam, dipole, waveguide mode; all available as CW, pulse or user-defined temporal envelope
- ☑ Can launch mode profiles calculated with FIMMWAVE
- ☑ PML, metal, magnetic, periodic or Bloch periodic boundaries
- ☑ Extensive material database including metals
- ☑ Anisotropic materials (general symmetric tensor), magnetic permeability, chi2 and chi3 non-linearity, negative index materials
- ☑ Automatic wide-band fitting of dispersive materials to Drude, Lorentz, Drude-Lorentz or Debye models
- ☑ Variety of sensors for measuring spatial, time-evolving and spectral responses
- ☑ Time-domain results and frequency-domain results through Fourier analysis
- ☑ Farfield calculator
- ☑ Directional flux and mode power vs time or wavelength
- ☑ Full integration with the OmniSim framework
- ☑ Intuitive **live** field visualisation during the simulations
- ☑ Video recording

FDTD Features:

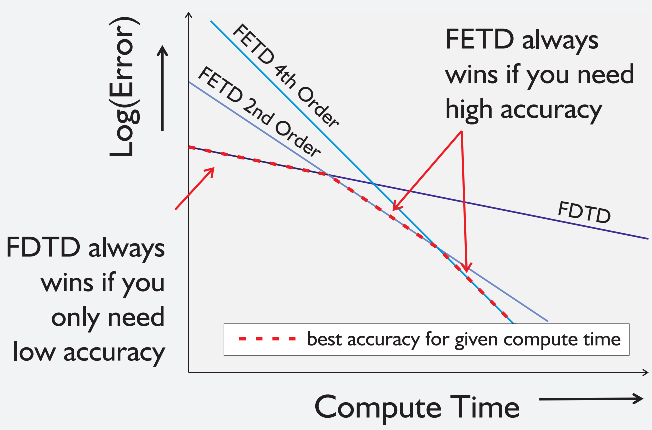
- ☑ Supports **clustering** on Windows and Linux clusters
- ☑ Unique **subgridding** tool to add resolution locally
- ☑ Unique **Active FDTD** with carrier dynamics
- ☑ Advanced averaging techniques for high accuracy
- ☑ Q-Factor calculator with resonance fitting
- ☑ Mode volume calculator
- ☑ Batch manager and parameter scanner

FETD Features:

- ☑ Finite element time domain calculation engine based on a new super-efficient method - much faster than conventional finite element time domain methods!
- ☑ Automatic conformal tetrahedral (3D) or triangular (2D) meshing: no staircasing or averaging of surfaces
- ☑ Finite element orders from 1 to 5, allowing large efficient elements
- ☑ Variable mesh refinement according to local refractive index – automatically uses a finer mesh where required
- ☑ TF/SF analysis for modelling low-level scattering



FDTD subgridding on a gold nanoparticle: accelerate your simulation by up to 64x!



Comparison of the speed of convergence of FDTD and FETD

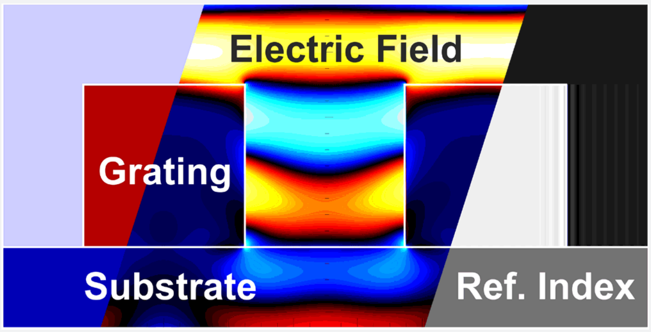
☑ RCWA: Rigorous Coupled Wave Analysis

For the modelling of periodic metamaterials, diffractive gratings and DOEs

OmniSim's RCWA Engine can be used to simulate light incident on structures periodic in 1 or 2 dimensions, such as diffraction gratings, periodic metamaterial or diffractive optical elements. It features many sophisticated improvements in accuracy compared with standard RCWA tools.

Features:

- ☑ Model for 1D-periodic and 2D-periodic gratings
- ☑ Arbitrary angle of illumination with two degrees of freedom for both 2D and 3D simulations
- ☑ Arbitrary polarisation: linear, circular, elliptical
- ☑ Support for metal and dielectric materials
- ☑ Support for slanted walls
- ☑ Innovative formulation for the modelling of the electric near-field, eliminates usual RCWA artefacts.
- ☑ Improved formulation for 1D-periodic slanted gratings
- ☑ Inspect modes and discretised refractive index profiles
- ☑ Built-in scanner to generate spectra, parameter scans or convergence tests
- ☑ Plot near-field and calculate power in the different diffraction orders for the far-field (both R and T)



Near-field and discretised profile

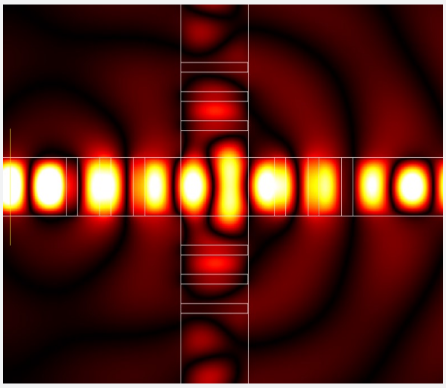
☑ FEFD: Finite Element Frequency Domain (2D)

Ultrafast engine for quick prototyping and optimisation

OmniSim's FEFD Engine is a powerful state-of-the-art 2D Maxwell solver for propagating electro-magnetic fields within an arbitrary photonic structure. The FEFD Engine is blazingly fast, performing calculations of complex 2D layouts an order of magnitude faster than competing tools; ideal for optimisation.

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 and FETD Engines
- ☑ Wide range of sources and sensors
- ☑ Parameter scanning
- ☑ Its speed and low numerical noise make it ideal for **automatic optimisation**



Cross-talk in a 90-degree junction

Tackle any problem with the OmniSim toolbox

☑ Surface Grating Coupler Design Utility

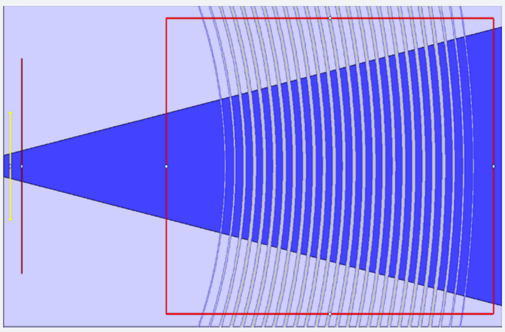
Automatic design of surface grating couplers

OmniSim's Surface Grating Coupler Design Utility allows you to design and optimise surface grating couplers automatically. It supports both 2D (optimising the YZ grating profile) and 3D simulations (including the design of the curved waveguides).

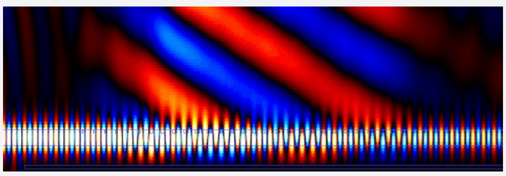
You only need to specify your epitaxial structure, your wavelength and the properties of your output beam and OmniSim will automatically generate 2D grating profiles with routines for finding the best effiency, with a choice of periodic or apodised geometry.

The Surface Grating Coupler Design Utility can also generate the 3D layout of the grating and calculate their efficiency. For tapered gratings it will automatically generate the optimal curvature of the grating lines based on the taper geometry.

The designs can be simulated with all three of OmniSim's FDTD, FETD and FEFD engines, allowing you to calculate the efficiency with confidence and high precision. The utility can automatically calculate the 2D and 3D coupling efficiency to the fibre by performing an overlap with tilted Gaussian beam profiles.



A 3D tapered apodized grating



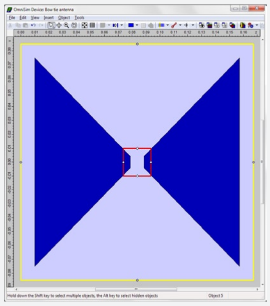
Emitted field in an apodised grating

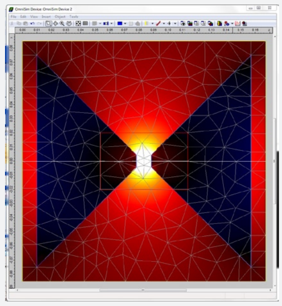
☑ Modelling plasmonics and metamaterials

Using OmniSim's FETD and RCWA engines

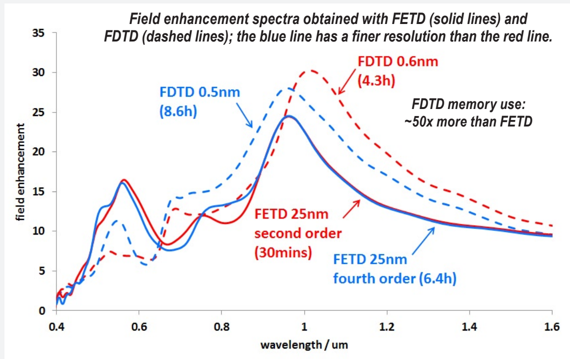
Modelling nano-plasmonics is challenging: it involves extremely high resolution, complex geometries with dispersive nonlinear materials for periodic and aperiodic devices. FDTD will allow you to obtain initial results quickly, but it will often be too slow to handle the resolution routinely required when modelling surface plasmons in metallic structures. This is where our FETD Engine steps in, allowing you to obtain highly accurate results in a fraction of the time and memory needed for FDTD.

With FETD+Bloch boundaries and RCWA, OmniSim offers two different methods to model periodic metamaterials; you can switch between the two in just one click and take advantage of the one which will be better suited to your geometry.





Field enhancement in a bow tie antenna: (top) design and E-field, (bottom) field enhancement spectra for FDTD and FETD



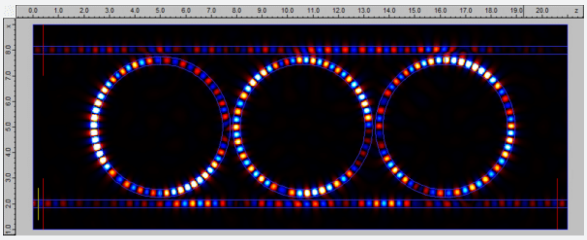
Find out more in our brochure "OmniSim for Nano-Photonics"

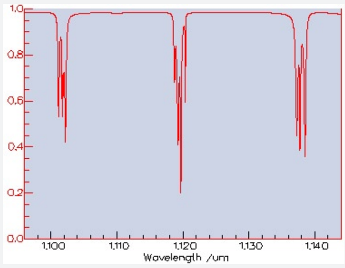
☑ Designing ring and disk resonators with FDTD and FETD

FDTD and FETD are ideal tools to model optical ring resonator filters and optical disk resonator filters of modest dimensions. OmniSim's user-friendly layout editor allows you to design optical ring resonators and optical disk resonators in just a few clicks, ready to simulate in 2D or 3D with FDTD, FETD or FEFD.

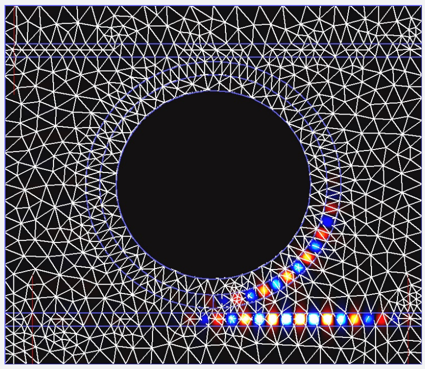
An example of FDTD simulation is given here, with a 3-ring resonator. The resonances show degenerate peaks, due to the coupling between the rings. Although FDTD will be able to generate results with reasonable accuracy in a small amount of time, you can switch to FETD when you need high precision as FETD offers faster convergence.

Another benefit of FETD is that it allows you to exclude parts of the structure from the simulation by defining void regions, in order to speed up the simulations. You can see this here applied to a ring resonator; we have specified a void region in the centre of the ring, where the fields will not be computed. This feature is particularly useful for large ring and disk resonators.





Coupled ring resonators: field and spectrum

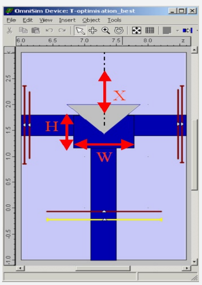


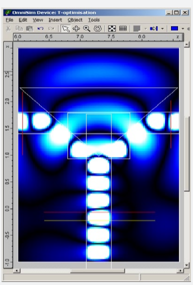
FETD Voids: exclude the centre of the ring to speed up your calculation!

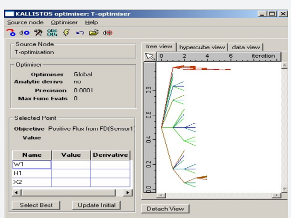
☑ Optimising a silicon nano-wire T-junction with Kallistos

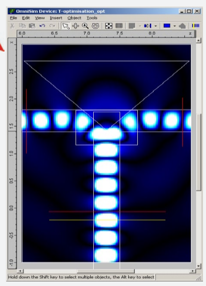
To optimise this silicon nanowire T-junction, we first used the 2D FEFD Engine and our automatic optimiser Kallistos to optimise the 2D performance with respect to three design parameters. We used a global optimiser to explore the full parameter space, which also allowed us to test the tolerance to design parameters, with a multi-wavelength objective to ensure a broad band optimum. Once satisfied with the 2D design, we moved on to a local optimisation with 3D FDTD for verification and fine tuning. The initial structure had a transmission of approx. 20%/arm. In the first stage of the optimisation (FEFD), after 200 iterations (a few minutes), we were able to obtain a transmission of over 40%/arm. After the second stage (FDTD), we found a 3D device with a transmission of approx. 40%/arm at the working wavelength of 1.55um, with broadband performance.

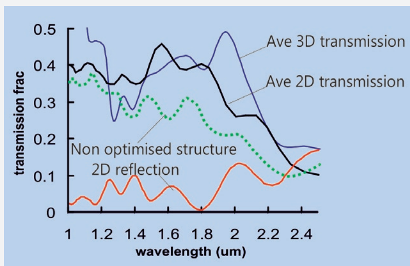
From this... to this... in just a few minutes!!











transmission spectra