White Paper

Choosing the Right Photonic Design Software

September 2016

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Introduction

There are many factors to consider before deciding which photonic design software to use. To narrow the field, it can be helpful to ask these key questions as you investigate and compare software functionality.

- Does the software provide enough flexibility to model and analyze products that offer the best solution to likely and possible design goals?
- Is the simulation capable of producing results that are not only theoretically feasible, but also practically possible?
- Does the software provide a range of simulation solutions that allows you to design specific devices, as well as the larger photonic systems in which they are used?
- Does the software include a reliable infrastructure that supports both initial and long-term use, such as training, technical support, documentation, development resources, and technological leadership?

The answers could reveal which software will maximize engineering efficiency and result in the best competitive product.

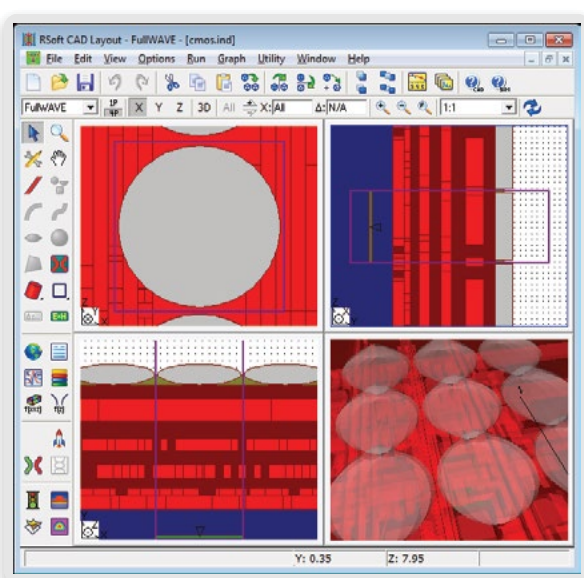

Figure 1. The RSoft CAD graphical user interface (GUI)

Modeling and Analysis

Photonics systems are rapidly evolving. Technical requirements and technical approaches for these systems are increasing in complexity and performance to such an extent that the limiting factor on the final product may be the capabilities of the photonic design software. Therefore, choosing a software product that supports the largest array of modeling and simulation features is the best way to ensure that your photonic products are differentiated in the market.

The first step for any design is modeling the system geometry. Given a design tool with maximum flexibility, a designer can experiment with multiple design forms to meet a design specification or goal; the more configurations you're able to consider, the more likely you are to achieve an optimal solution.

It's essential to have a design environment that can be used to draw both simple and arbitrary geometries. The RSoft™ CAD environment is fully parametric: any parameter can be expressed as a user-defined symbol that can be defined as an arithmetic function of any other parameter. In this way, complicated designs can easily be created and parameter scans can easily be used to determine optimal device performance.

Another modeling challenge you might encounter is including fabrication defects. Although it is useful to simulate ideal structures, the reality is that no device can be perfectly fabricated. RSoft provides the tools needed to study the effects of misalignment, fabrication defects such as sidewall roughness, and other manufacturing defects to ensure device performance. While these may seem like straightforward capabilities, they are not universally found in photonic design products.

Photonic design software should also be able to simulate a wide variety of system types. One type of system that can be difficult to simulate is photonic crystals. RSoft's Plane Wave Expansion (PWE) algorithm accurately models these devices. Without PWE, it can be impossible to fine-tune the bandgap of photonic crystals. While other methods such as Finite-Difference Time-Domain (FDTD) can be used, they can be inefficient and far from optimal.

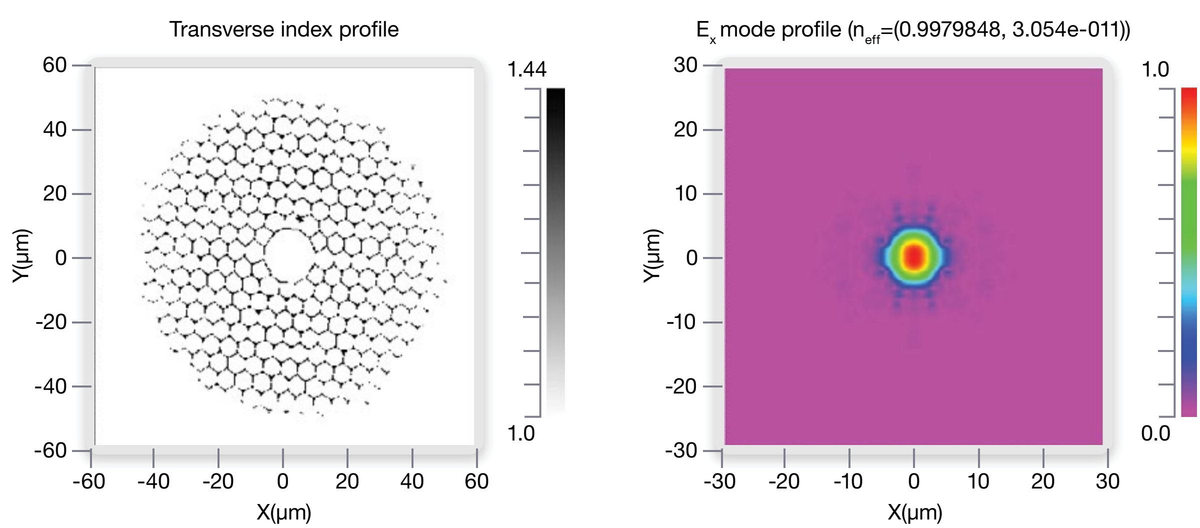

Figure 2. a) Converted index profile of a photonic crystal fiber (PCF) cross-section that shows geometry variations introduced during fabrication, and b) Calculated modes of exact PCF fiber found with FemSIM

Simulation Efficiency

One of the biggest challenges of designing photonic systems is the amount of time required to perform the simulation. In practice, a simulation can take hours, days, or even weeks. Furthermore, there are many systems that could take months or years to simulate, which makes them impractical for designers to attempt. Selecting design software that can not only theoretically design your system, but can also do so in a practical, efficient timeframe, can be the most important criteria when choosing software for designing photonic components.

The Finite Difference Time Domain (FDTD) algorithm directly solves Maxwell's equations, but does so in a "brute force" manner that is computationally extremely demanding. Because of the flexibility of the FDTD method to design any system, selecting software with a robust FDTD implementation should be a key decision criteria, particularly if your design goals do not meet criteria supported by one of the much more efficient and practical algorithms. If your design goals do not require an FDTD solution, then you should ensure that your software supports other approaches like the Beam Propagation Method (BPM), Plane Wave Expansion (PWE) algorithm, Rigorous Coupled Wave Analysis (RCWA), or the Coupled Wave Mode Theory (CMT) algorithm.

There are many examples of systems or device geometries that are not feasible using FDTD software.

- Large (> 10 wavelength) waveguide-based devices such as couplers, splitters, DWDM, and mode converters can easily be modeled with BPM many orders of magnitude faster than FDTD. The BPM method, for applicable problems, is almost universally faster than FDTD. Consider the star coupler of a Si-based AWG (Arrayed Waveguide Grating): a 3D BPM simulation of such a device is at least 100 times faster than 3D FDTD. So-called 2.5D FDTD methods may work in some limited cases, but not for all structure types.
- The band structures of photonic crystals are more efficiently modeled with PWE than FDTD. PWE solves for the eigenstates of a photonic crystal in the frequency domain directly, which gives faster and more accurate results when compared to time-domain based FDTD.
- Periodic surface gratings can easily be modeled by RCWA. For many structures, the RCWA method is faster than FDTD. Consider a simple Si-based checkerboard grating: a 3D RCWA simulation of this device will be at least 50 times faster than 3D FDTD
- Periodic structures like fiber-Bragg gratings can quickly and efficiently be modeled with CMT. It is not possible to use FDTD for these structures.

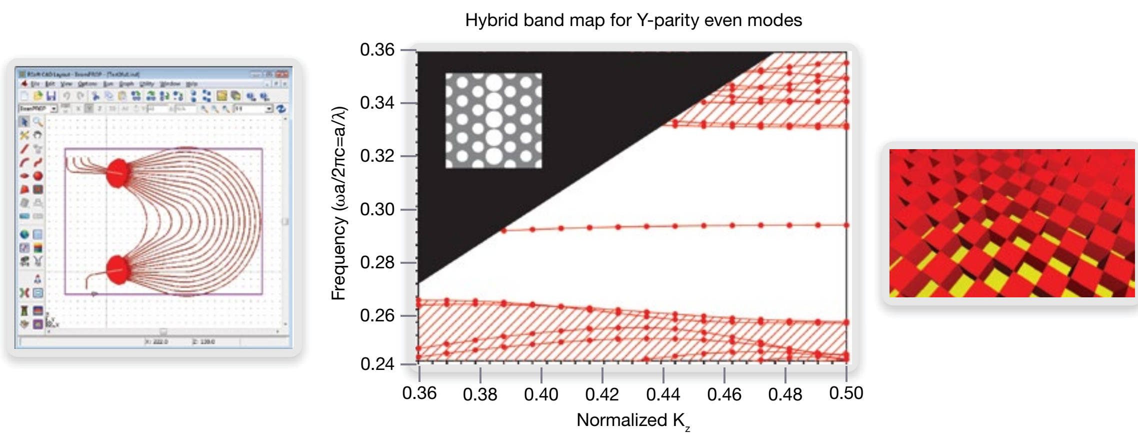

Figure 3. a) AWG device, b) Defect mode of a PBG, and c) Checkerboard structure

There are some devices that require an FDTD-based solution. Selecting software that maximizes practical usage of the FDTD software is critical. For example, the software should ensure that the best computational techniques are fully employed to minimize the required simulation time. For instance, RSoft products fully support multicore CPU clustering, optimal index averaging (sometimes called conformal meshing), and non-uniform grids to help make FDTD simulations practical in many cases where they would not otherwise be. In addition, features such as dynamic field display during simulation (useful when first working on a design) and the ability to run multiple, simultaneous simulations are very useful.

Broad Range of Photonic Simulations

The first step in designing a photonic device might be drawing the overall system, designing a groundbreaking active device that the system will leverage for competitive advantage, or designing a series of photonic devices that will work together in a larger system. This first step and each design step that follows should be factored into the decision about which photonic design software is the best to use for your project. The most efficient approach for minimizing time to market for the final product dictates using design software that supports both passive and active photonic devices and supports simulation of the system in which all these devices will operate.

RSoft products offer many tools for designing both passive and active photonic devices, as well as system design tools. The passive design tools support the design of a broad range of devices, including waveguides, fibers, gratings, sensors, and LEDs. Active design tools allow you to model and simulate devices such as modulators, semiconductor lasers (FP, DFB, and VCSEL), detectors, and solar cells. All these devices can be combined with other devices in a system-level simulation to determine system performance. This range of photonic simulation capabilities, unique to the RSoft products, can be a compelling reason for selecting a software design tool. In addition, RSoft products support common interchange formats with CODE V® and LightTools® optical design software to extend the modeling capabilities to a wide range of illumination and imaging applications.

Reliable Infrastructure

The strength and range of photonic software capabilities are relevant only to the degree that any given user or company is able to leverage those capabilities. Important tools that help ensure productive usage of a software tool include documentation, training, examples, and technical support.

Documentation, training, and application examples help users understand how to use the software, as well as the software's benefits, strengths, and the limitations of design approaches or algorithms. Without an in-depth understanding of the algorithms, users can unknowingly end up with wrong results. Clear and detailed documentation can help prevent this from occurring. Technical support staff, trained in photonics engineering and knowledgeable about the software, can help overcome specific issues that arise in a given design as well as help users head in the right direction at the beginning of project, thereby maximizing efficiency and the likelihood of success.

With more than 40 years of combined photonics experience, RSoft's team of technical support staff has published numerous, over 250 technical papers and has contributed to the development of the simulation algorithms (BPM). The staff has a close working relationship with the RSoft development team, which allows the product developers to be directly involved with customer issues whenever necessary. Customer success is the overriding objective of the RSoft team, and it determines staff priorities and objectives.

In addition to the support infrastructure for the current product, it is critical to have a developer-vendor that can be counted on in the future. The criteria for this includes a capable, committed development team, resources for future investment and development, and a range of photonic and algorithmic backgrounds among the technical staff to ensure that future innovation opportunities are addressed by the software. RSoft products are a part of the Optical Solutions Group at Synopsys, which includes CODE V, LightTools, and LucidShape®. There is much synergy between these products, as well as the broader Synopsys products.

Synopsys, Inc. provides products and services that accelerate innovation in the global electronics market. As a leader in electronic design automation (EDA) and semiconductor intellectual property (IP), Synopsys' comprehensive, integrated portfolio of system-level, IP, implementation, verification, manufacturing, optical and field-programmable gate array (FPGA) solutions help address the key challenges designers face such as power and yield management, system-to-silicon verification and time-to-results. These technology-leading solutions help give Synopsys customers the competitive edge needed to quickly bring the best products to market while reducing costs and schedule risk.

For more than 25 years, Synopsys has been at the heart of accelerating electronics innovation, with engineers around the world having used Synopsys technology to successfully design and create billions of chips and systems found in the electronics that people rely on every day. Today's designers face tremendous pressure to develop differentiated products more quickly and cost effectively than ever before. At Synopsys, helping companies accelerate innovation is in our DNA.

Integrated Solutions to Accelerate Optical Systems Innovation

In addition to the RSoft products, Synopsys' industry-leading optical design solutions include CODE V for imaging optics design, LightTools for illumination design, and LucidShape for automotive lighting design. Together, these products provide a full spectrum of photonic and optical design solutions.

Summary

The decision about which photonic design software to invest in should not be taken lightly. The quality of new products is often incumbent upon the capabilities of the design tool, which can either encourage innovation or limit it. There are many practical technical issues that can maximize the success of photonic design software at a given company, and some of these have been outlined above. The decision should not be based on a cursory technical specification or a single feature; rather, the decision should be based on the overriding goal of reducing costs through engineering efficiency, and maximizing revenue through innovation and competitive advantage in the marketplace. RSoft products continue to deliver capabilities that enable the complex photonic designs of today and accelerate innovation in the global photonics market.

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