4-1995

Review: 'Integrated Optics: Design and Modeling,' by Reinhard Marz

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DEPARTMENTS

BOOK REVIEWS

Integrated Optics: Design and Modeling

Reinhard Marz, 336 pages, illus., index, references, and four appendices. ISBN 0-89006-668-X. Artech House, 685 Canton Street, Norwood, MA 02062 (1995) $79.00 hardbound.

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My overall impression is that *Integrated Optics: Design and Modeling* will make a fine addition to almost anyone's collection of books on integrated optics. It will, however, serve its readers better as a reference book rather than as a text from which to first learn the basic concepts of integrated optics. I say this because the book is written at a fairly sophisticated technical level, though the author often moves rather quickly to the "bottom line" without providing material much beyond what is first necessary to introduce a problem or concept, and then a statement of the results and/or implications. It seems that the reader is assumed to have the necessary background in mathematics, quantum mechanics, and waveguide electromagnetics to fill in the blanks. An uninitiated reader will likely find this book both disappointing and frustrating. Nevertheless, *Integrated Optics* contains lots of useful and interesting information for the skilled engineer interested in designing and/or modeling integrated waveguide devices and structures.

On initially surveying the book, my first impression was that there are lots of nice figures and fairly current references. In all I counted 96 references, most of which were published within the past five to six years. After reviewing the book further, I developed the following impressions which I shall, for the most part, present on a chapter-by-chapter basis.

Chapter 1, of course, provides a general introduction to the history of integrated optics and to the book as a whole. The author also provides a discussion and nice comparison of common optical waveguide materials, though I feel his mathematical discussion of the evolution of the dielectric constant in InGaAsP is out of place and would find a better home in an appendix. On the other hand, I feel that the material in Appendix A, "Application of photonics," should have been included in the introduction. Enough said.

Chapter 2, "Foundations," provides a review of the basic electromagnetic principles needed for further study of integrated optics. Concepts such as the vector and scalar Helmholtz equations, polarization, dielectric boundary conditions, reflection and refraction at dielectric interfaces, and the eikonal and ray equations are presented. This chapter is included mostly for completeness and it's likely that most readers will skip this chapter initially and use it only for review when necessary. Anyone not already familiar with these concepts will find the rest of the book hopelessly confusing. As I've said this is not really a book for beginners.

Chapter 3, "Waveguide theory," though anything but an all-encompassing treatise on waveguide theory, presents several useful concepts relating to the theory of dielectric optical waveguides. For the most part, this chapter looks at various formulations and approximate solutions to the eigenvalue problem. I would have personally liked to have seen a more detailed physical discussion of modal field solutions in a few simple waveguiding structures (e.g., slab and rectangular waveguides), as well as a much more detailed discussion on dispersion. As it is, the author presents dispersion in only one page and offers only the results for material dispersion, with no discussion of dispersion compensation or control. On the other hand, probably the nicest parts of Chap. 3 are the author's discussions of geometric waveguide optics and the effective index method (a mathematical technique that provides approximate solutions to the eigenvalue problem for weakly guiding waveguides).

In my opinion, the real value of this book lies in the material covered in Chaps. 4 through 8. Chapter 4, "Beam propagation," develops in detail the beam propagation method as a means for numerically tracking the propagation of optical beams in complex waveguide structures (e.g., tapers), which may be difficult to describe quantitatively in closed form. Chapter 5, "Mode conversion," then discusses the efficient interfacing of optical waveguides. Specifically, butt coupling, imaging by optical systems, and adiabatic mode conversion via optical tapers are discussed in detail. Next, Chaps. 6 and 7, entitled "Codirectional coupling" and "Contradirectional coupling," respectively, though presented as separate chapters, are very complementary to one another. Both chapters develop nicely from the author's discussion of coupled mode theory presented in the early sections of Chap. 6. Though the author presents a fairly rigorous treatment of the underlying theory, the real focus of each of these chapters is on the descriptions of several integrated optical devices that rely on wave coupling. Of special interest, in my opinion, are the discussions of symmetric evanescent wave couplers, asymmetric coupler/filters, and Mach-Zehnder devices in Chap. 6, and in-line Bragg grating filters in Chap. 7.

The main text of the book then concludes with Chap. 8, "Planar spectrographs." This chapter takes a detailed look at focusing planar spectrographs, which are in essence diffracting elements having a fixed point of incidence. Such devices will find applications as multichannel filters for wavelength division multiplexing (WDM) optical communication systems, for example. Frankly, this was a new topic of study for me and thus gave me the opportunity to evaluate the author's technical writing ability without already knowing what ought to be included. I'm happy to say that the sections of this chapter that I read in detail were presented clearly and at a level understandable by anyone already somewhat familiar with general waveguidance principles. Though I still feel that this is not suitable as a text book *per se*, I was indeed able to learn something new.

The author then rounds out his work with four appendices. As I mentioned earlier, you ought to read Appendix A, "Application of photonics," along with the introduction. Among other details, Appendix B, "Computer-aided engineering," includes the source code for several Matlab and Mathematica programs (I did not try them), which will likely help in paving the way for numerically simulating the concepts presented in the main text. I honestly did not read Appendix C, "Component cost modeling," though I'm sure it contains useful information for the practicing design engineer, and finally, Appendix D, "Mathematical background," provides a vector algebra review for those who want it and/or have trouble with the math in Chaps. 2 and 3.

In all this is a pretty good book. It does not provide a full treatment of integrated optical concepts and seems to assume at least some prior knowledge of guided wave optics. It does, however, contain a wealth of timely information for practicing optical design engineers wishing to further their knowledge of integrated optical devices. It will make a fine addition to my technical library. If I were to give this book a grade, I'd give it an A-.

Dr. Duncan would like to gratefully acknowledge the assistance of University of Dayton PhD student Robert J. Feldmann, whose comments have been incorporated into this review.