

APPLIED DIGITAL OPTICS

FROM MICRO-OPTICS TO NANOPHOTONICS

Bernard C. Kress

Photonics Systems Laboratory, Université de Strasbourg, France

Patrick Meyrueis

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To my lovely wife Mei-Mei, whose unconditional love and support made this book possible. I even learned to appreciate her constant nagging, which drove me up the wall but helped me finish this project.

Bernard

I would like to dedicate this book to all my university colleagues, students, Photonics Systems Laboratory staff, my assistant Anne and members of institutions and companies all over the world that allowed us, by contributing to or supporting our microphotonics and nanophotonics activities in research and education, to gather the information that made this book possible.

Patrick

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About the Authors

Bernard Kress has been involved in the field of digital optics since the late 1980s. He is an associate professor at the University of Strasbourg, France, teaching digital optics. For the last 15 years Dr Kress has been developing technologies and products related to digital optics. He has been working with established industries around the world and with start-ups in the Silicon Valley, California, with applications ranging from optical data storage, optical telecom, military and homeland security applications, LED and laser displays, industrial and medical sensors, biotechnology systems, optical security devices, high power laser material processing, to consumer electronics. He is on the advisory boards of various photonics companies in the US and has also been advising venture capital firms in the Silicon Valley for *due diligence* reviews in photonics, especially in micro- and nano-optics.

He holds more than 25 patents based on digital optics technology and applications, and is the author of more than 100 papers on this subject. He has taught several short courses given at SPIE conferences. His first book on digital optics, *Digital Diffractive Optics* (2000), was published by John Wiley & Sons, Ltd and has been translated into Japanese in 2005 (published by Wiley-Maruzen). He is also the author of a chapter in the best seller *Optical System Design* (2007), edited by R. Fisher and published by McGraw-Hill. Bernard Kress can be contacted at bernard@applieddigitaloptics.com.

Patrick Meyrueis is full professor at the University of Strasbourg since 1986 (formerly Louis Pasteur University). He is the founder of the Photonics Systems Laboratory which is now one of the most advanced labs in the field of planar digital optics. He is the author of more than 200 publications and was the chairman of more than 20 international conferences in photonics. He was the representative of the Rhenaphotonics cluster and one of the founders of the CNOP in 2001 (national French committee of optics and photonics). He is now acting as the scientific director of the Photonics Systems Lab and the head of the PhD and undergraduate program in the ENSPS National School of Physics in Strasbourg.

Foreword by Professor Joseph Goodman

The field of digital optics is relatively new, especially when compared with the centuries-long life of the more general field of optics. While it would perhaps have been possible to imagine this field a century or more ago, the concept would not have been of great interest, due to the lack of suitable sources, computing power and fabrication tools. But digital optics has now come of age, aided by the extraordinary advances in lasers, processor speed and the remarkable development of tools for fabricating such optics, driven in part by the tools of the semiconductor industry.

It was perhaps in the seminal work of Lohmann on computer-generated holograms that interest in the field of digital optics was launched. Lohmann based his experimental work on the use of binary plotters and photo-reduction, but today the plotting tools have reached a level of sophistication not even imagined at the time of Lohmann's invention, allowing elements with even sub-wavelength structure to be directly fabricated on a broad range of materials.

Applied Digital Optics is a remarkable compendium of concepts, techniques and applications of digital optics. The book includes in-depth discussions of guided-wave optics, refractive optics, diffractive optics and hybrid (diffractive/refractive) optics. Also included is the important area of 'dynamic optics', which covers devices with diffractive properties that can be changed at will. The optics of sub-wavelength structures is also covered, adding an especially timely subject to the book.

Most interesting to me is the extremely detailed discussion of fabrication and replication techniques, which are of great importance in bringing diffractive optics to the commercial marketplace. Finally, the wide-ranging discussion of applications of digital optics is almost breathtaking in its range and coverage.

Professors Kress and Meyrueis provide therefore a comprehensive overview of the current state of research in the field of digital optics, as well as an excellent analysis of how this technology is implemented today in industry, and how it might evolve in the next decade, especially in consumer electronics applications.

In summary, this book will surely set the standard for a complete treatment of the subject of digital optics, and will hopefully inspire even more innovation and progress in this important field.

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Applied Optics is a peer-reviewed scientific journal published by The Optical Society three times a month. It was established in 1962 with John N. Howard as founding editor-in-chief. The journal covers all aspects of optics, photonics, imaging, and sensing. According to the Journal Citation Reports, the journal has a 2018 impact factor of 1.791. Kress Bernard C. (EN). Miniaturization and mass replications have begun to lead the optical industry in the transition from traditional analog to novel digital optics. As digital optics enter the realm of mainstream technology through the worldwide sale of consumer electronic devices, this timely book aims to present the topic of digital optics in a unified way.