Optical Lithography
Here Is Why
Optical Lithography
Here Is Why

Burn J. Lin
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Preface

Optical lithography is a fascinating field. It requires knowledge of geometrical and wave optics, optical and mechanical systems, diffraction imaging, Fourier optics, resist systems and processing, quantification of imaging performance, and the control of imaging performance. Even the history of its development helps to stimulate new ideas and weed out less promising ones. Practitioners of optical lithography may only have a vague idea of its theory, and likewise, theoreticians may not have the opportunity to practice the technology on the manufacturing floor. Although optical lithography seems to be easy to grasp on the surface, many executives or decision makers often muddle about in this important field without paying due respect to the experts. When it comes to lithography, everybody has an opinion. This book intends to cover the above fields in theory and practice to sufficiently bridge these gaps. Optical lithography need not remain “black magic.” It is a multidisciplinary science and treated as such in this book.

In the late 1980s I began teaching a course called “Here is Why in Optical Lithography” at the SPIE Microlithography Symposium. It was an overwhelming success. The course continued until 2005, when I could no longer afford to spend eight hours of my time at the symposium teaching the course. However, many people told me they missed it, especially those companies that routinely sent their new engineers to the course. Fortunately, Bruce Smith and his students, who audited in my course, eagerly asked me for the course notes, explaining that they could use it in a training course they planned to offer. So, there is a good chance the course material has been put to good use. Quite a few people also asked me whether I had written a book based on the course; however, even though I planned for such a book long ago, my work schedule prevented me from spending the time its development deserved. At one time SPIE even filmed an abbreviated version of the course, but these video tapes only reflect a part of the course, not a complete documentation. In the last two years I expanded the course into a one-semester three-credit course at the National Taiwan University. There, I also felt the need of a book for the course.

Yet, as soon as I started writing, I realized that the book could not be just course notes. It had to stand by itself: The content had to be broadened, so that much more depth could be provided. Since time restrictions (as in a short course) and space constraints (as in a journal article) were no longer limiting conditions, I could cover the entire field of optical lithography and provide as much information as a lithographer ought to know.
This book spans from the early days of the technology up to this very moment, when the lithographic technique for 32-nm half pitch is still a looming question worldwide. This text should be useful for both academics and industry practitioners alike.

Even though the subject has broadened and deepened, I am maintaining the original spirit of my short course, i.e., explaining the reasons and principles behind the techniques we use, so that even novices to the technology can gain insights from it. In addition, students in the field can use this text to delve to great depths. Veterans in the field might enjoy reviewing all phases of the technology that they spent their lives practicing and recalling how innovations have sprung up at the different phases of the technology’s development.

I am indebted to my colleagues at TSMC who contributed figures and texts. Among them, Shinn Sheng Yu contributed Section 3.1.4.2, part of Section 3.4.2, Sections 5.7, 6.1.4.2, and 6.4. Ru-Gun Liu contributed Figs. 6.79, 6.87–6.90, 6.94–6.105, and 6.111; Ching-Yu Chang, Figs. 6.39, 6.40, and 7.56; Tsai-Sheng Gau, Figs. 7.45 and 7.69–7.70; Chun-Kuang Chen, Fig. 7.46; Shih-Che Wang, Fig. 7.58; Fu-Jye Liang, Figs. 7.59–7.66; Kuei-Shun Chen, Figs. 7.71 and 7.77; John Chin-Hsiang Lin, Fig. 7.74; and Da-Chung Owe-Yang, Fig. 7.78. Some other SEM pictures are the result of engineering studies in the Nanopatterning Division at TSMC. Figure credit from authors outside of TSMC is acknowledged where the figures appear.

Finally who writes a book without thanking their family for patience and understanding? Here, my wife Sue stands out as a great partner in my life to share my family responsibilities and even take them over in times of need. She is a brilliant professional who managed to have successful careers at IBM and AT&T, and yet has not shortchanged her support to my career and the upbringing of our children, Christiana and John.

Burn Lin
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