

Edited by
Koji Sugioka
Ya Cheng

ULTRAFAST LASER PROCESSING

From Micro- to Nanoscale



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Preface

The rapid development of ultrafast lasers (i.e., picosecond and femtosecond lasers) over the past few decades has opened up new avenues for materials processing that exploit the many advantages that such lasers have over conventional pulsed lasers (i.e., nanosecond lasers). The extremely short pulses of ultrafast lasers reduce the size of the heat-affected zone (HAZ) in processed regions, resulting in high-quality microfabrication of both soft materials and hard or brittle materials. The negligible HAZ can also give nanoscale spatial resolutions in fabrication. Another important advantage of ultrafast lasers is that they can generate extremely high peak powers. Focusing the laser beam produces sufficiently high peak intensities to induce efficient multiphoton absorption, even in transparent materials such as glass. This permits surface microstructuring and micromachining of transparent materials. Furthermore, by shifting the position of a tightly focused laser beam with a moderate pulse energy in a transparent material, multiphoton absorption can be confined to a region near the focus position, allowing internal modification and microfabrication of transparent materials. Ultrafast lasers have become common tools for micro- and nanoprocessing, and they are currently widely used in both fundamental research and practical applications. In fact, ultrafast lasers were used in over 60% of the studies presented at the 11th International Symposium on Laser Precision Microfabrication (LPM 2011, June 7–10, 2011, Takamatsu, Japan), one of the biggest and most important international conferences in the field of laser micro- and nanoprocessing.

Despite the rapid growth in this field, there are only a limited number of books that review ultrafast laser processing. We, thus, decided to edit a book that covers a broad range from fundamentals to scientific and industrial applications to provide comprehensive information on ultrafast laser processing. This book consists of 12 chapters that cover relevant topics in ultrafast laser processing, which have been reviewed by internationally recognized experts in the field. It includes an overview of ultrafast laser processing (Chapter 1), ultrafast laser systems and optics for materials processing (Chapter 2), fundamental mechanisms in the interaction of ultrafast

laser beams with matter (Chapter 3), beam-shaping techniques for micro- and nanoprocessing (Chapter 4), surface patterning, drilling, cutting, micro- and nanostructuring, and nanoablation (Chapters 5–7), ultrafast laser-induced phenomena in transparent materials and internal modification (Chapter 8), applications of internal modification and microfabrication for fabricating three-dimensional (3D) photonic devices and biochips (Chapters 9 and 10), two-photon photopolymerization and 3D lithography and their applications (Chapter 11), and industrial applications (Chapter 12). Each chapter clearly presents the background, state-of-the-art techniques, and future prospects of the topic.

We believe that this book provides a realistic and comprehensive review of ultrafast laser processing and will be beneficial for students and young scientists who either are considering to work or have just started working in this area, as well as for researchers and engineers who are already working in this field.

Finally yet importantly, we would like to thank all the chapter authors for their great effort and wonderful work in writing informative chapters.

Koji Sugioka

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