Chapter 1
Introduction

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In recent years, laser based technologies became important or even dominant in industrial applications such as welding or cutting. Further possibilities of processing, innovation, and advancement of laser material treatments are still in progress and very challenging. Laser-based analysis [1], spectroscopy [2], or metrology [3] are well known and established methods. For this field of research, a number of reviews, books, and other literature were published in order to give detailed descriptions of laser based physics [4]. The very broad field of laser materials processing [5, 6] is still very fast developing.

The primary goal of this book is to give a detailed insight into current research topics of this part of laser technology, especially in the field of laser processing of materials in high-tech applications.

The basics of lasers and laser optics, the fundamentals of laser material interactions, and their application for demanding applications are described. The first part of the book gives an introduction to the physics of lasers and laser optics, laser radiation interaction with materials and the effects occurring as a result of such irradiations. Chapter 2 will explain the basics of lasers, its spatial and temporal shaping, and of course the optical transport. New requirements and demands of light sources, their possibilities, and the status quo of laser based research will be instructed. In Chap. 3, a detailed description of laser-material interaction is given. Basics of electromagnetic wave propagation, absorption, etc., will be discussed. Different interaction time regimes will be explained according to the actual state of theory. Effects like vaporization, transfer of heat, and material will be considered as a result of irradiation. Then Chap. 4 deals with the interaction of laser light with plasmas. Fundamentals of plasma physics and their relationship to laser radiation will be explained. Laser induced breakdown will be given the main attention. Plasma

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effects will be related to different time regimes and an insight into their applications for technology is given.

The next part of the book will give an overview about current research topics and the state-of-the-art in materials processing. Achievements in nanostructuring or in film depositing will be shown, including current trends and developments of methods. Further, future applications and their importance for medicine, biotechnology and nanotechnology will be discussed.

A huge field of interest is Pulsed Laser Deposition and its possibilities [7]. Chapter 5 gives an insight into the method and its involved physics. Basics of ablation will be discussed and the resulting plasma plume expansion into different ambients, too. Energy balances will be related to thin film growth and their properties. The growth behavior gets widely discussed for different materials like metals or polymers. In Chap. 6, a detailed instruction into processing with ultrashort laser pulses is given. Actual developments in this field are, for example, treatment of transparent materials [8]. On the femtosecond timescale, nonlinear and non-thermal effects determine the processing. This offers new possibilities in research and for industrial applications.

Typically, surface structuring is one of the most famous application fields in laser based technology. Chapter 7 shows the scope of creating nanostructures by means of laser irradiation. Nanoparticle generation and its limitations will be explained and related to selforganizing processes. Typical examples for structuring of glass are discussed in [9, 10]. Established techniques like direct writing (nice example [11]) or laser etching will be discussed extensively.

Laser microprocessing will be discussed in Chap. 8. In the literature, this subject has been widely discussed [12, 13]. The miniaturization in every kind of application field is still in progress. Here, a discussion of laser treatment of several materials will be given. Process limits in microstructuring of, for example, glasses and ceramics will be explained. A nice example for structuring polymers is shown in [14]. Another area of interest is the micro optic. In [15, 16], the developments in this technique are explained. Further, classical applications like drilling will be reviewed in relation to scaling and efficiency.

For the improvement of several laser based methods, sometimes, new beam parameters are necessary. Chapter 9 tries to depict the trends and the aim of shaping laser radiation. In recent works [17, 18], tailoring of laser pulses in spatial and temporal distribution is shown. The chapter discusses the problem of modulation and of controlling the process. At last, first applications will be shown, followed by future ideas.

Altogether, the book contains the state-of-the art in laser materials microprocessing. The authors of the chapters are specialists in their fields and have tried to explain the achievements in their subject on an up-to-date scientific level. Therefore, the book can be assumed to be a reference work for advanced laser materials processing for a long time.

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