

Preface

Soon after its experimental realization, the laser was used in several practical applications. One of the most important applications of lasers are related to the laser ablation of solids because they offer very important advantages over the classical tools, including choice of wavelength and pulse width to match the target material properties as well as one-step direct and locally confined structural modification. Also, using lasers it is possible to reduce the thermo-mechanical damage and to facilitate heterogeneous integration of the components into functional devices. The above mentioned advantages are very important in cases where conventional thermo-chemo-mechanical treatment processes are ineffective.

The microfabrication of several components with basic dimensions in the few-microns range via laser irradiation has been implemented successfully in the industrial environment. Beyond this, there is an increasing need to advance the science and technology of laser processing to the nanoscale regime.

This book aims at providing young researchers and graduate students with a comprehensive review of progress and the state of the art in the pulsed laser ablation (PLA) field linking fundamental phenomena with recent applications. The book introduces the researchers into the field of *Pulsed Laser Ablation of Solids* by synthesizing the state-of-the-art of the pulsed laser ablation processes and its applications. The understanding of the evolution of the energy coupling with the target and the induced phase-change transformations plays an important role for improving the quality of the material processing.

The content of the book is based on recent research studies of different groups and includes the authors' contribution on pulsed laser ablation. In the introductory chapter, several considerations concerning the tools, which are used for laser ablation of solid materials (metals, semiconductors, dielectrics) are presented, pointing out the major role of the material processing using lasers as compared to classical tools. Also, some practical applications of PLA and general aims are emphasized.

In **Chap. 2** several lasers for pulsed laser ablation like: Nd-YAG laser, Ti-sapphire laser, excimer laser, CO₂ laser are analyzed concerning the mode operation (pulsed, CW, tunable), pulse duration (nano, pico, femtosecond range), power and operation wavelength (from near UV to far IR range), emphasizing their best capabilities. Also, the Q-switched and mode locked lasers are analyzed

together with the most used methods for their practical operation: mechanical, electro-optical, acousto-optical, methods with saturable absorbers and thin films, etc. The knowledge of the laser operation and the parameters is used to control PLA process for different types of solid materials in different ambient conditions. At the end of this chapter several combined irradiation methods in the far and near field (i.e., direct irradiation and projection through masks and microlens array, laser trepanning, and laser lithography), and some effects of pulse duration on the ablation rate are discussed.

The [Chap. 3](#) is devoted to the laser-matter interaction below the plasma ignition threshold intensity. The basic linear and non-linear phenomena involved in laser-matter interaction at high intensities: harmonic generation, self focusing, self guiding, absorption and ionization, two-photon absorption, stimulated Raman Effect are characterized from theoretical and experimental point of view. Also, the most important experimental methods for analyzing the main phenomena involved in laser-matter interaction during PLA below the plasma ignition threshold such as reflectometry and analysis of thermal radiation are discussed. The physics of the ablation process is complex, given that it involves laser-solid interactions, the vapor/plasma formation and expansion, and the laser-vapor interaction. The phase and/or structural changes induced on the target by the laser radiation can be detected by means of the time-resolved reflectivity (TRR) method, while the thermal changes can be detected by rapid infrared pyrometry (RIP) systems. The coupling of the two methods (RIP and TRR) allows the study of the melting kinetics induced by laser radiation in a large number of bulk metallic, dielectric, and semi-conductor materials. The plasma spectroscopy methods were developed over the past decades and they provide basic data which are needed for the implementation of many of the experimental methods, and to descriptions of instrumentation. A detailed study of the basic mechanisms involved in laser ablation below the plasma ignition threshold is performed at the end of this chapter.

The laser-matter interaction above the plasma ignition threshold intensity is presented in the [Chap. 4](#) of this book. At the beginning of this chapter the main phenomena involved in production of the ablation plasma and in laser-plasma interaction during PLA are analysed: plasma heating, critical density, plasma shielding, ablation plume expansion, several types of collisions, etc. Also, in this chapter several experimental methods for analyzing the main phenomena involved in laser-plasma interaction are presented in detail: optical methods (interferometric, Thomson-scattering, spectrometric methods, laser induced fluorescence (LIF) spectroscopy), mass spectroscopy, high speed imaging, etc.

The [Chap. 5](#) of the book is devoted to the material removal and deposition by PLA and associated phenomena: micro and nano-processing (patterning) of materials by PLA, material removal in gaseous and liquid etchants, nanoparticle production, pulsed laser deposition and ablation, plume filtering, etc.

In [Chap. 6](#), we present several experimental techniques for analyzing the material removal and deposition rates in real time: opto-acoustics and

interferometric methods, emission spectroscopy of the ablation plasma and quartz microbalances.

The conclusions of the work are outlined in the last chapter of this book.

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Basics, Theory and Applications

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