Preface

This book deals with the exciting field of biomimetics in combination with laser technology. Biomimetics, the translation from nature-inspired principles to technical applications, is strongly multidisciplinary. Since its invention, the laser has proven many times its versatility. Therefore it is not astonishing that the wide scientific interest entangled with biomimetics has discovered the laser as a fast and reliable processing tool for its purpose. This field offers intrinsically a wide scope of applications for laser-based methods regarding structuring and modification of materials. Plus, the development for novel laser-based processing methods is permanently under development.

This book attempts to give a survey over state-of-the-art laser technology and materials that are used for diverse biomimetic applications. It covers the most important laser lithographic methods and various biomimetics application scenarios ranging from coatings and biotechnology to construction, medical applications and photonics. The term biomimetics is hereby expanded to cover also the field of biotechnology and biomedical applications. Due to the availability of a large spectrum of different laser sources regarding their characteristics such as laser power, wavelength, operation mode, the laser serves as tool and light source for widespread applications.

The book introduces both a laser technology focused approach as well as an application focused approach. It is dedicated to the advanced reader that is already familiar with laser basics and laser technology and to scientists, who may discover a possibility or inspiration to use a laser for their own specific works.

Chapter 1 is dedicated to a short introduction and motivation of the laser application for biomimetics.

Chapter 2 represents a comprehensive review of direct laser writing methods, especially focusing on laser-induced two-photon-based photochemical effects. This method has evolved in recent years as a powerful technology for the realization of micron-, to sub-micrometer resolution structures and gains more and more interest in the field of biomedicine. In this chapter, the basic principles of direct laser writing, a short survey of available techniques, and finally technologies for enhanced performance are described. The review is completed with some examples of direct laser writing in the field of 3D cell culture and tissue engineering.

Chapter 3 deals with direct 3D laser writing of bio-inspired materials related to optical phenomena. This chapter introduces direct laser writing as a flexible technology for the development of 3D microstructures for applications in photonics. The structural designs found in nature often exhibit useful physical phenomena such as photonic bandgaps and circular polarisation stop bands. The investigated biological nanostructures will certainly inspire novel biomimetic materials for photonics applications.

Chapter 4 focuses on selective laser sintering, which is another mature and versatile rapid prototyping method. After the introduction of major rapid prototyping technologies suitable for biomedical applications, a review on laser sintering is made, which includes its working principle and technical benefits as well as materials. A biomimetic application, namely tissue engineering scaffolds and drug or biomolecule delivery vehicles is discussed, showing the great potential also for many other biomimetic and biomedical applications.

Chapter 5 reviews matrix-assisted pulsed laser evaporation for biomimetic applications in drug delivery systems, biosensors and advanced implant coatings. This method emerged more than a decade ago and is dedicated to the transfer of organic materials onto solid substrates, because it represents a minimal harmful approach for transporting and depositing thin films of delicate, heat sensitive molecules, such as organic biomaterials on largely extended active areas. Such films are considered to play an important role in biology, pharmaceutics or sensing applications.

Chapter 6 gives an overview over the process basics, its parameters and the major influences on the quality of complex three-dimensional parts manufactured by Laser additive manufacturing. Its preferred field of application is the one-step manufacturing of complex geometries in low lot sizes, where conventional machining would require a longer overall production time due to a high number of processing steps. In addition, the chapter deals with design guidelines, current applications of laser additive manufacturing and future developments.

Chapter 7 reviews important applications of pulsed laser deposition and recent work in the field of biomimetic coatings. Furthermore, technical limitations and possible solutions are outlined. The general characteristics of pulsed laser deposition relevant to solid-state physics, e.g. the initial ablation processes, plume formation and plume characteristics are discussed as well.

In Chap. 8, laser-assisted bio-printing based on the laser-induced forward transfer is discussed as an emerging and complementary technology in the field of tissue engineering envisaging biomimetics applications. The method allows to print cells and liquid materials with a cell-level resolution, which is comparable to the complex histology of living tissues. Experimental requirements are described and typical multi-component printing, 3D printing approaches and in vivo bio-printing are presented.

Chapter 9 Laser-based biomimetic tissue engineering relies on the controlled and reproducible structuring of biomaterials at micro- and nanoscales by means of laser radiation. Tissue Engineering is defined as the technology aiming to apply the principles of engineering and life sciences towards the development of biological

substitutes that restore, maintain or improve tissue function or a whole organ. This chapter reviews current approaches for laser-based fabrication of biomimetic tissue engineering scaffolds. These include laser processing of natural biomaterials synthesized to achieve certain compositions or properties similar to those of the extracellular matrix as well as novel laser fabrication technologies to achieve structural features on artificial materials mimicking the extracellular matrix morphology on various levels. The chapter concludes with the wealth of arising possibilities, demonstrating the excitement and significance of the laser-based biomimetic materials processing for tissue engineering and regeneration.

Chapter 10 reviews material aspects with respect to laser processing of natural materials. The laser is known as a versatile tool and its application is successfully expanded to the processing of natural biomaterials. Various natural biomaterials, such as collagen, agarose, hyaluronic acid and Matrigel, have been treated through laser-induced polymerization, ablation or activation. The presented developments expand and will continue to expand the potential applications of natural biomaterials in biomimetic approaches.

Last but not least, the book ends with Chap. 11 about future perspectives of laser-based research in the wide field of biomimetic applications.

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Weiz, Austria

Maria R. Belegratis
Volker Schmidt

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