Preface

Fabrication of two and three dimensional structures in the micro- and nanorange allows a new degree of freedom to the design of materials by tailoring desired material properties and in this way obtaining a superior functionality. Such complex designs are only possible by using novel fabrication techniques with high resolution, even in the nanoscale range. During the last years, different methods have emerged, allowing local modification of materials properties in two or three-dimensions as well as the rational design of complex three dimensional architectures. In this way, it has been possible to improve physical, chemical and biological properties of all classes of materials including ceramics, metals and polymers. Moreover, it was observed that even internal microstructural inhomogenities such as grain boundaries and porosity can further enhance their performance.

However, the future progress for the development of new advanced materials depends not only on the ability to fabricate them, but also on understanding underlying nanoscale and interface effects as well as through a truly three dimensional characterization of their structure. In consequence, adequate and high detail characterization of these structures is necessary. This is nowadays possible due to new developments in tomography techniques which allow their complete three-dimensional reconstruction in all ordering scales. These tools have been also applied recently to investigate time-dependent properties such deformation mechanisms of structural materials.

This book comprises a series of monographs elaborated by contemporary experts. It outlines the underlying of scientific principles for a broad sample of both fabrication and characterization techniques from the micro to the nanoscale. The book is divided into two sections, a first part describing two and three dimensional fabrication techniques, and a second one for the latest characterization technique at the same resolution scales.

The first part of the book consists of five chapters. Chapter 1 discusses the possibilities of Laser Interference Patterning for the rapid fabrication of periodic patterns, with a well-defined long range order from the submicrometer level up to micrometers, on macroscopic areas. Chapter 2 describes different laser assisted

microfabrication techniques as well as typical applications of laser micro machining including drilling, cutting, and marking. Chapter 3 deals with the fabrication of nanostructured materials with enhanced optical properties using different methods such as nanoimprint lithography and nanosphere self-assembly. In addition, also the characterization of the optical properties is introduced. Chapter 4 focuses on self-organized pattern formation by ion beam sputtering technique. A general description of the method and experimental observations are presented, showing the complexity of the processes involved. The great potential of the technique is presented as well. Finally, Chap. 5 describes the use of Additive Manufacturing Technologies for fabrication of cellular architectures with enhanced mechanical properties. In particular, an overview on two-photon polymerization method is given.

The second section of the book has four chapters. Chapters 6 and 7 deal with different X-ray tomographic methods including micro-focus X-ray computed tomography as well as submicron tomography using high energy synchrotron radiation. In the last case, the application of the optical X-ray phase of the transmitted beam for increasing the sensitivity of the method is also described. Different examples for the 3D characterization of structures as well as defect analysis are given. Chapter 8 introduces the method of Focused Ion Beam Tomography, which allows the nano-characterization of three-dimensional geometries by reconstructing the information provided from two-dimensional cuts (slices) imaged either with electrons, X-rays or ions detectors. Finally, Chap. 9 describes the method of Atom Probe Tomography, which is able to map out the 3D distribution of chemical species in a material at the atomic scale. In addition, new alternatives that permit the analysis of semi-conductors or oxides are introduced.

The methods here described illustrate that there are often various approaches for both fabrication and characterization of micro and nanostructures using in many cases equipment that is commercially available or can be readily assembled. The book is indented to serve as a resource text for undergraduate and graduate students, as well as for researchers from materials science and engineering.

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