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Optical thin films and coatings

From materials to applications

Edited by Angela Piegari and François Flory

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Preface

The field of optical coatings was thoroughly investigated in the last century and the optical effects of thin films were known even before then, as described by Newton and other scientists in the eighteenth century. The antireflection effect of a single layer on glass was first discovered by Fraunhofer in 1817 but the real development of simple antireflection coatings using vacuum deposition techniques was made in the 1930s, both in Europe and the United States. The understanding of optical interference in thin films and the development of the formalism for the propagation of electromagnetic waves through a layered medium paved the way for designing and producing multilayer coatings in the years following. The deposition under vacuum of metal films for obtaining high-reflectance mirrors was also developed at the industrial level in the first half of the twentieth century, even though mirrors were known long before that, and metal-dielectric filters started to be produced at that time as well.

Since then, much progress has been made in coating design, owing to both the fast development of computers and the implementation of dedicated software. At the same time, the improvements in the technologies for deposition of thin films have allowed ever more reliable coating manufacturing.

Nowadays optical coatings are considered an important sector of optical components and often they represent the critical part of entire optical systems, therefore significant efforts are dedicated to improve their performance. Applications can be found in many areas: lasers, smart windows, clean energy, environmental monitoring, telecommunications, astronomy, aerospace, displays and lighting, and anti-counterfeiting devices are only some examples of a long list. As there is an increasing demand for optics in many fields, the range of applications for optical thin films and coatings is widening more and more.

Thin-film optical coatings is an active field of research and innovative breakthroughs are continuously being made, especially in investigations on new materials and structuring of the coating morphology. The development of heterogeneous nanostructures is enlarging the use of thin films and this area is now part of nanophotonics.

A number of books have already been published on both optical coating design and thin-film deposition techniques, as well as on characterization methods, and there is a vast literature on these topics. Thus we decided to dedicate this book mainly to developments on thin-film materials and applications, for optics and related fields.

The book is divided in four parts. The initial chapters in Part I are devoted to classical topics and give a short review of each subject, including new advances. A survey of deposition techniques for optical thin films opens the book (Chapter 1), followed by a description of the methods of design of complex optical coatings (Chapter 2), these being two subjects of central relevance in each approach to optical coatings. Then, the monitoring of coating fabrication (Chapter 3) and the production technologies for high-precision coatings (Chapter 4) are described, with a look at historical developments and new strategies.

Part II is dedicated to some special features of optical thin films and coatings, like plasmonic effects for optical applications (Chapter 5), scattering in random structures (Chapter 6), thin film properties at short wavelengths (Chapter 7), thermal radiation control (Chapter 8) and color effects (Chapter 9).

Part III follows with some recent developments on film materials, starting with organic films and coatings (Chapter 10); then an overview of surface multiplasmonics with non-homogeneous thin films is given (Chapter 11) and finally a description of optical films containing quantum dots (Chapter 12) closes this part of the book.

The chapters from 13 to 22, in Part IV, are dedicated to applications and represent almost half of the book. They cover different fields, even though they are not exhaustive of all possible areas in which optical thin films can be useful. This last part of the book starts with antireflection coatings on plastic (Chapter 13) and protective coatings for optical surfaces (Chapter 14), then continues with applications in displays and lighting (Chapter 15), photovoltaic cells (Chapter 16) and security devices (Chapter 17). The next two chapters (Chapter 18 and Chapter 19) are dedicated, respectively, to the application of coatings in high-intensity femtosecond lasers and to coatings in large facilities involving lasers and space.

The last chapters give an overview on automotive and building applications (Chapter 20), transparent conductive coatings (Chapter 21) and the behavior of optical coatings in space (Chapter 22).

It is difficult to include in a single book all the interesting applications, such as for example: optical sensors, optical coatings for telecommunications, optics for art conservation, biological and medical applications, and more. Therefore a selection has necessarily been made. Moreover, characterization methods are not specifically dealt with, even though they are of great importance in this field not only to control the optical properties but

also to test the environmental resistance of coatings; there are many types of characterization methods for thin films and coatings and some of them are described in different chapters.

The diffusion nowadays of multimedia and the possibility of downloading from the web single chapters of the book, means that each chapter should be self-contained. As a consequence, some overlaps can be found between several chapters. For example optical monitoring strategies are described in both Chapters 3 and 4, plasmonics is present in the title of Chapters 5 and 11, organic thin films are mentioned in Chapters 10 and 16 and solar cells in Chapters 2 and 16, transparent conductive coatings appear in Chapters 20, 21 and others as well. However, even when similar topics are described by more than one author, the approach is substantially different and complementary. More details can be found in the contents of each chapter, which will be accessible through the web.

The authors come from both research institutes and industry, thus a combination of theoretical contributions and practical views can be seen throughout the whole book. All contributors are renowned specialists in their fields and many of them, as well as the editors, have been working in the area of optical thin films for more than thirty years. Several chapters are authored by experts who took part in the early developments in the specific sectors, and published many fundamental works.

We hope the book will be useful for scientists and technical people, providing an overview of the key role of optical coatings in different fields and stimulating the reader's interest to go deeper in each topic, taking advantage of the bibliographic material in all chapters.

The potential readers of this book may be physicists, chemists and engineers, including senior students, interested in both research developments and practical applications. Newcomers to the field of optical thin films and coatings could be attracted by the extremely wide range of applications, while specialists of a particular field could find information on the new trends in their area of interest.

We wish to thank all authors for their valuable contributions and efforts and we are also grateful to the Publishers for their assistance during the preparation of the book.

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