

# Preface

## About this Book

*“Auch schien’s ihm höchst verwundersam,  
Wenn jemand mit der Lampe kam,  
Er staunt, er glotzt, er schaut verquer,  
Folgt der Erscheinung hin und her  
Und weidet sich am Lichteffect.  
Man sieht bereits, was in ihm steckt.”*

*(engl. “It further seemed to him most strange  
When there a lamp came in his range  
Of vision. Looking, blinking, staring  
He follows the apparition glaring  
And feast on the effect of light.  
Thus are his gifts revealed all right.”)*

**About the baby-Maler Klecksel, in Wilhelm Busch: Maler Klecksel (engl. Klecksel the Painter), (1884), Translation from German by Laureate of Nobel Prize in Physics 1954, Max Born (!)**

Dear interested reader,

It is my pleasure to realize that you hold this book in your hands or maybe read this Preface at the website of Springer Publishing or your book dealer. You know that optics represents a fascinating subchapter of physics, and it is hard to describe the natural fascination arising from optical phenomena more convincing than done by Wilhelm Busch in the above given citation. But maybe you have not yet known that nobody other than Max Born performed the translation of that nice illustrated story into the English language [1]—I learned that only in the course of writing this book.

I do not know how many thousand books have been written on optical topics, but nevertheless at the moment you are reading this particular Preface. I would therefore like to use it to give you some information about the background motivation and purpose of this book, which might facilitate your decision on whether or not to read it.

First of all I would like to give you some information about the predecessors of this book. It was 18 years ago that I wrote a German textbook which was

published in 1996 with the title “Das Dünnschichtspektrum: Ein Zugang von den Grundlagen zur Spezialliteratur” (The thin film spectrum: from basics to specialized literature) with Akademie Verlag GmbH, Berlin. That first book has 190 pages crammed with derivations and equations, while the material selection was strongly influenced by the always individual experience on supervising and working with students. The emphasis of that book was definitely on the formal theoretical treatment of the optical response of thin solid films, the pursued audience was composed from German-speaking master and Ph.D. students of relevant topics.

Nine years later, it was my pleasure to collaborate for the first time with Claus Ascheron, Springer-Verlag Berlin Heidelberg, with a new book project, this time in English language. The result appeared in 2005 with the title: “The physics of thin film optical spectra: An introduction.” It has already 275 pages comprising to a certain extent the formal treatment from the first book, but enriched with more applicative aspects. It is again a typical textbook where everything is derived starting from Maxwells or Schrödingers Equations, and at present it is the textbook to the university course “Thin Film Optics,” which is given for Master of Photonics students at Friedrich-Schiller-University Jena, Institute of Applied Physics, Abbe Center of Photonics.

And now, again 9 years later, this new book appears. It is rather a complement to its predecessors, with another focus, and it is pursuing a somewhat broader audience. In contrast to its predecessors, it is not a textbook that could be in the basis of a university lecture course. In essence, it is based on materials that I have presented in various short courses aimed at further advanced professional training and qualification in a rather condensed manner. These short courses have been held in the frames of several Optical Interference Coating (OIC) conferences, as well as substantial part of applied optics professional network training workshops (Optence and OTTI, Germany). In such courses, practically no derivation of equations is provided, but the focus is rather on practical examples. Hence, a lot of experimental data are presented, sometimes combined with intuitive and illustrative approaches as well as with diverse “rules of thumb” and “quick and dirty” methods for data evaluation. It was my intention to condense this store of knowledge into a further book text while completing it with a few introductory chapters containing the essence of the standard background material, as well as some considerations on the relevance of the underlying model assumptions. Concerning the latter, it is in fact not so easy to find generally accepted and at the same time consistent treatments in the literature. Therefore (and this primarily concerns [Chaps. 3 and 4](#)), the discussion of the relevance of the physical models rather represents the personal view of the author of this book, which is not necessarily shared by all of my colleagues in the field.

Finally, some additional chapters on nanostructured and mixture coatings have been included. Also, the material from two tutorial texts, which I authored or co-authored by invitation of the Journal “Advanced Optical Technologies,” has completed the content of this book.

Thus, in this book, only few derivations are given, and when they are really necessary, they are (in most cases) exported into some appendices. Practically all

derivations concerning the basic chapters are given in [2], and therefore, *practically nothing is rederived* in this text. In this sense, this new book is a complement to the preceding one. A reader interested in the derivation of a certain equation is kindly referred to [2] or another thin film textbook. But the book can also be read without referring to other sources, when knowledge about the concrete origin of the equations is not of interest.

Furthermore, the present book is neither an introduction into thin film optics/thin film design nor a reference book on optical constants in its verbal meaning. These books already exist (see the introduction [Chap. 1](#)); and with respect to tables of optical constants, you are kindly referred to [3]. The present book is rather intended to develop a classical and sometimes illustrative physical picture of the origin and correlation between different coating material properties, and of how the knowledge on these correlations can be used in coating theory and practice, including oxide, fluoride, metal and organic coatings, as well as mixed and nanostructured coating materials. Quantum mechanical treatments are avoided, whenever possible.

One might question the sense of such an approach referring to the highly developed theoretical formalism of quantum mechanics, which supplies us with algorithms to calculate practically everything, whenever a suitable Hamiltonian may be formulated. So what might be the sense of applying these old but simple classical approaches today?

The answer is not so much related to their simplicity. Instead, what classical physics does is to supply us with vital pictures on what might happen in reality when the process described by a certain equation would be initiated in practice. It is that appeal to the power of a physicist's imagination, which turns classical models into powerful heuristic tools in physics. And it is my pleasure to refer in this context to the Preface of a book written by the highly appreciated surface and coating spectroscopy expert Peter Grosse [4], where this argumentation is developed with respect to today's use of applying the Drude theory throughout a full book text.

Once my first book had 190 pages and the second one 275 pages, I felt some obligation to continue (and finish) this series with a  $275 \times 275/190$  pages volume, i.e., approximately 400 pages. While completing this manuscript, I feel that the volume which you hold in hand or have on your screen comes close to this goal.

One more remark on history: when looking into classical literature, but also into modern novellas, you will be astonished about the multiplicity of literal reflections about physical and optical phenomena. The texts of Johann Wolfgang von Goethe, Wilhelm Busch, E. T. A. Hoffmann, and others contain plenty of hidden allusions to physical and optical phenomena, as well as to spectacular scientific observations which have been made in their times. Some of them even fall close to modern optical coating problems, such as the disappearance of human's mirror image in Hoffmann's ingenious story "The lost reflection." Of course, the magician Dapertutto is definitely not a coating scientist, but nevertheless the formulated reflection target is challenging even today, and I like to refer to it as the Dapertutto's antireflection problem.

While highly appreciating the creative ideas of these authors, I decided to start each of the chapters of this book with a (literature) citation that seemed suitable for introducing into the particular topic. Despite the already mentioned authors, interesting material can be found in texts of Edgar Allan Poe, John Ronald Reuel Tolkien, Stephen King, and others. I hope you can read this small collection of citations with some feeling of enjoyment, but in the case that you are a lecturer as I am, maybe you find some of them helpful and stimulating for further use in your own courses.

As one of the purposes of this book was to illustrate the validity of certain correlations by publicly available experimental material, I had to make extensive use of literature sources where the necessary data are tabulated. The reference to the original material is usually included directly into the text or into the figure captions. All references are then collected in the references section at the end of the corresponding chapter. Some of the sources appeared to be websites; I understand that they may no more be available at the moment when you read this book, but practically those references reflect what was available on the Internet in the year 2012.

There are so many people who gave me assistance and (sometimes even involuntary) stimulation to write this book, that I decided to export the acknowledgments into a separate subchapter. So that for the moment let me thank you for your interest and express my hope that you are biased enough now to proceed reading by switching to the introduction chapter.

With my best wishes

## Acknowledgments

It was a good piece of work, but nevertheless it appeared straightforward to give a survey on simple classical models applicable to the phenomena observed in thin solid films. But as soon as any practically relevant theory is to be supported or falsified by experimental data, it appeared necessary to complete the text with comprehensive experimental material. The latter had been collected over the latest decade with the help of plenty of colleagues and collaborators, and it is impossible to mention all of them here. Instead, I would like to express my thanks rather *en masse* to the consortia of the projects IntIon, nanomorph, TACo, TAILOR, and PluTO, and to acknowledge the support by the sponsoring ministries—the BMWi, the BMWA, and the BMBF in Germany. More concrete data on collaborators and companies/institutions are found in the relevant author lists and acknowledgments of the cited references, where all of these data have been originally published prior to the writing of this book.

I am very grateful to Johannes Ebert (Laseroptik GmbH), Thomas Köhler (*Bremen Center for Computational Materials Science BCCMS*), Todd Perkins (Kaiser Optical Systems, Inc.), and Bettina Loycke (Wiley-VCH Verlag GmbH & Co. KGaA) for the supply of specific pictures and the permissions to reproduce

them in this monograph. Plenty of material used in this book has been generated during project work at Fraunhofer IOF, and it is my pleasure to thank Norbert Kaiser for the permission to include corresponding experimental results into this monograph, as well as Torsten Feigl, Hagen Pauer, Ulrike Schulz, Kevin Füchsel, Astrid Bingel, and Steffen Wilbrandt for supplying me with corresponding graphical material.

The add-on for calculating the performance of gradient layers and rugate filters (Chaps. 4, 9, and 10) has been created by Tatjana Amotchkina (at that time Moscow State University). Data on aluminum–oxifluoride coatings produced by IBS (Chap. 11) have kindly been provided by Henrik Ehlers (Laser Zentrum Hannover). ITO and aluminum samples used for demonstration purposes in Chap. 5 have been provided by Daniel Gäbler (X-FAB Semiconductor Foundries AG). Their contributions were extremely helpful to complete the database which is in the background of this book with external material.

Steffen Wilbrandt performed a proofreading of Chap. 5. Rebecca Sequeira Schäffer (IOF) was able to organize absolutely every reference from the literature in the shortest time. Dieter Gäbler kindly supplied me with special material on aluminum hydroxide modifications.

Technical assistance in figure and manuscript preparation was provided by Josephine Wolf, Matthias Böhme, Johannes Gäbler, and Steffen Wilbrandt (all from IOF in Jena). The photograph in the title page was also taken by Johannes Gäbler.

I would like to express my special thanks to all of the mentioned persons.

Let me finally express my deepest gratitude to Prof. Angus Macleod, who quickly recognized the deepest intentions I had when planning and writing this book, and condensed them into a tailored and valuable Foreword, at the same time putting the book into the correct context with respect to the broader field of coating science.

## References

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