

# Preface

What is the goal of a transmission electron microscope (TEM)? It is expensive and causes large running costs. The understanding of the results is sometimes difficult and they can be wrongly interpreted. It needs specialists and, connected with that, causes additional labour costs.

On the other hand, it is a microscope, i.e. its results are magnified pictures and everybody is able to understand pictures. Apparently, there are no problems understanding them. Why do we need an additional textbook about this topic?

**Goethe: „Mikroskope und Fernrohre verwirren eigentlich den reinen Menschensinn.“** [1] (Microscopes and telescopes confuse the human mind.)

However, analytical transmission electron microscopy does not only include the microscopic imaging. Electron diffraction and compositional analysis by spectrometers for X-rays and energy losses of the electrons complement it. The analytical transmission electron microscope covers four challenging methods: electron microscopic imaging, electron diffraction, analysis of characteristic X-rays, and electron energy loss spectroscopy. There are specialists for each of these methods; nevertheless the operator at the microscope should hold an overview about the possibilities of analytical transmission electron microscopy. He should be able to handle them and should be familiar with the basics of the interpretation of the measured results.

It is the goal of this textbook to give such an overview. The idea to write this book was arising during the work in our electron microscopic laboratory of the Leibniz Institute for Solid State and Materials Research (IFW) Dresden. While teaching the students of materials science in lectures and practical courses about analytical transmission electron microscopy as well as while instructing graduate students, Ph.D. students, and technicians at the microscope we have attained experiences regarding frequently asked questions by the beginners and the didactical procedure to explain the function and the practical handling of a transmission electron microscope.

These experiences are integrated in this book. It addresses people who want or have to work at a transmission electron microscope and have not yet a further knowledge about this topic. The book should also be helpful for service engineers to ensure an overview of the basic knowledge about the microscopes maintained by them. Additionally, the book should be also a little bit amusing to receive interest in electron microscopy from non-experts, too.

The focus lies on explanations with the help of simple models and on hints for the practical electron microscopic work. The headlines of the chapters already indicate this matter. This is the difference to other introductions into electron microscopy. As far as practicable, we tried to avoid explanations based only on mathematical formalisms.

In this context we would like to give a comment on the model assumptions in physics: On the one hand, we speak about electrons as particles, on the other hand as waves. Or the position of the specimen within the electron microscope: Sometimes we draw the specimen outside of the objective lens, sometimes within the magnetic field of the lens. One or two of the readers will see a discrepancy here. However, it is not a discrepancy but a property of models in physics suitable to explain special features in nature. Dependent on the experimental setup we observe sometimes the particle and otherwise the wave character of the electrons. Or: To explain the multi-stage imaging of the electron microscope we draw the specimen outside of the magnetic field since the beam path within the lens does not play any role in this case. Only the beam path outside of the lens is important. On the other hand, when we discuss the imaging of magnetic samples the direct interaction between the sample and the magnetic lens field is essential and we have to use another model. In other words: The physical models used in this book are chosen to be as simple as possible to explain a specific outcome.

Despite the attempt of plausible explanations some correlations can be better understood with the help of mathematics. Formulas are necessary to obtain quantitative values. Especially the last chapter 10 considers this. There are some special basics explained in more detail, where it is applicable we point to such detailed explanations within the text. Here and there equations are also listed in the earlier chapters containing elements of the infinitesimal mathematics like differentials and integrals. Describing definitions and physical basics sometimes it is absolutely necessary. This should be no reason to stop reading the book even if the reader has problems with this kind of mathematics.

For specialists the chapter 10 cannot substitute textbooks about special topics of electron microscopy. We suggest some of such books in the hints for further reading at the end of this book.

Finally, we would like to thank: our academic teachers, friends and colleagues who introduced us into the topics of electron microscopy or had facilitated the work at modern instruments later on. Some names we would like to mention: Prof. Alfred Recknagel, Dr. Hans-Dietrich Bauer, and Prof. Klaus Wetzig in Dresden as well as Prof. Manfred Rühle, Prof. Frank Ernst, Dr. Günter Möbus, and Prof. Joachim Mayer working at the “Max-Planck-Institut für Metallforschung” in Stuttgart in the relevant time.

Electron microscopic investigations are only possible using suitably prepared thin samples. Many of the electron microscopic images could be only presented in this book because of the careful specimen preparation by Dipl.-Ing. (FH) Birgit Arnold and Dina Lohse.

In an early state of our book project we spoke with Prof. Josef Zweck from Regensburg and Prof. Klaus Wetzig from Dresden about our concept. They had

encouraged us in our project and contributed by their advocacy essentially to the publication of the book by the Springer Verlag.

Stephen Soehnen B.S., Wil Bruins, and Annelies Kersbergen were our negotiators of the Springer Verlag in Dordrecht. Without their benignity this book had not been published.

Nora Thomas M.A. was so kind to help us finding Goethe's citations with her special knowledge.

We are indebted to the persons mentioned here, as well as to those electron microscopists from Dresden who had been reading the German book manuscript or parts of it, as well as this English version later on, and gave helpful hints for its improvement but also to the colleagues, friends, and students who inspired us by questions and comments to think about facts and circumstances which seemed to be "completely clear".

**Goethe:** „*Alles Gescheite ist schon mal gedacht worden, man muß nur versuchen, es noch einmal zu denken.*“ [2] (*All the prudent things have been already thought. One just has to try to think about them once more.*)

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## References

1. von Goethe, J. W.: Wilhelm Meisters Wanderjahre, ed. Erich Trunz, Goethes Werke—Hamburger Ausgabe Bd. 8, Romane und Novellen III, 12. Aufl. München, II/Betrachtungen im Sinne der Wanderer (1989), p. 293
2. von Goethe, J. W.: ibidem, p. 283

Common remark: Biographic Data: Wikipedia—the free encyclopedia, <http://de.wikipedia.org/wiki/Wikipedia>

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