Metallographic and Materialographic Specimen Preparation, Light Microscopy, Image Analysis and Hardness Testing

Kay Geels
In collaboration with Daniel B. Fowler, Wolf-Ulrich Kopp, and Michael Rückert

ASTM International
100 Barr Harbor Drive
PO Box C700
West Conshohocken, PA 19428-2959

Printed in U.S.A.
ASTM Stock No. MNL46

Library of Congress Cataloging-in-Publication Data

Metallographic and materialographic specimen preparation, light microscopy, image analysis and hardness testing

Kay Geels; in collaboration with Daniel B. Fowler, Wolf-Ulrich Kopp, and Michael Rückert

p. cm.—(Manual; 46)
ASTM stock number: MNL 46.
Includes bibliographical references.
ISBN 978-0-8031-4265-7
E-book ISBN 978-0-8031-5691-3
1. Metallography. 2. Metallographic specimens. I. Title.
TN690.G3785 2006
669′.95028—dc22 2006103391

Printed in City, State
Month Year

Preface

This book is written both for the experienced and unexperienced metallographer (materialographer) who wants specific advice and information. It is also for persons seeking a broader knowledge of metallographic/materialographic specimen preparation and the examination methods, light microscopy, image analysis, and hardness testing. Special emphasis has been made on relations between ASTM standards and metallography/materialography.

The book will be useful for students in courses devoted to practical metallography and materialography.

The scope of the book is to give relevant information, in an efficient and clear way, covering the daily work in a metallographic/materialographic laboratory.

Metallographic/Materialographic Preparation

Kay Geels and Michael Rückert (*Sections 13.5/6*)

Part I is a description of sectioning, mounting, grinding, polishing, and etching of specimens for examination in reflected light, enabling the reader to understand the mechanisms of the entire preparation process. This is combined with practical advice on specimen preparation and an introduction to existing equipment and consumables.

Part II is a "Hands-on" Manual guiding the metallographer/materialographer to the correct preparation method, based on the material to be prepared and the purpose of examination. More than 150 methods are indicated covering practically all types of materials, describing the preparation process from sectioning to etching. This part also includes a section on Trouble Shooting, covering all stages in the preparation process and artifacts developed during the preparation.

Light Microscopy

Wolf-Ulrich Kopp

Part III is a description of the optical reflected-light microscope with photomicroscopy giving the reader both an introduction to the subject and a manual for the daily work. Also, a short introduction to electron microscopy and scanning probe microscopy can be found in this part of the book.

Quantitative Metallography/Materialography—Automatic Image Analysis

Daniel B. Fowler

Part IV gives an introduction to quantitative microstructural analysis and automatic image analysis, both theoretically and practically, with emphasis on the examinations based on ASTM standards and other types of commonly used analyses.

Hardness Testing

Wolf-Ulrich Kopp

Part V gives a description of the hardness testing methods, Brinell, Vickers, Rockwell, microhardness and instrumented (nano) indentation testing based on ASTM standards, both theoretically and as a practical guide.

The Metallographic/Materialographic Laboratory

Kay Geels

Part VI gives directions on how to establish and maintain a modern metallographic/materialographic laboratory. The important rules and regulations covering occupational safety are described and commented on.

The authors of this book, representing more than 100 years' experience with practical metallography and materialography, have tried to make this book a practical tool and helpful source of information to all who are involved in the noble art/science of metallography/materialography—Kay Geels.

Acknowledgments

The authors wish to acknowledge the four reviewers, who brought forward valuable insight for improvement. Special thanks to R. C. Nester, for his advice and suggestions on extension and shortening of the chapters. Thanks to G. Petzow, F. Mücklich and L. E. Samuels for permission to use a number of illustrations, and to B. Ottesen and W. Taylor for reading the manuscript and giving good advice. A special acknowledgement goes to fellow-metallographers/materialographers for support and advice through the years and directly connected to the book. The list includes U. Täffner, S. Glancy, E. Weidmann, A. Z. Jensen and A. Guesnier. A special thanks to L. Bjerregaard for her very important advice on many of the preparation methods, and to H. Hellestad for her invaluable support in making the illustrations. Also, thanks go to W. Taylor and Struers GmbH for providing important micrographs. The authors acknowledge the following companies for supply of information and illustrations, Buehler Ltd., Carl Zeiss AG, DoAll Company, Emco-Test GmbH, Leica Microsystems AG, Olympus Optical Co. Inc., and Struers A/S. Particular thanks to G. E. Totten and K. Dernoga at ASTM International for establishing and maintaining the project of making this book. Last but not least, thanks to B. Freiberg and J. Hestehave for support and encouragement during the years of making the book.

Abbreviations

AFM	Atomic Force Microscope
BF	Bright Field
CBN	Cubic Boron Nitride
DF	Dark Field
DIC	Differential Interference Contrast

EBSD	Electron Backscatter Diffraction
EDS	Energy Dispersive Spectroscopy
EPMA	Electron Probe Microanalyzer
FIB	Focused Ion Beam
MFM	Magnetic Force Microscope
PCB	Printed Circuit Board
POL	Polarized Light
SEM	Scanning Electron Microscope
SPM	Scanning Probe Microscope
STM	Scanning Tunnel Microscope
STEM	Scanning Transmission Electron Microscope
TEM	Transmission Electron Microscope

Contents

Part VI: The Metallographic/Materialographic Laboratory