

Ceramography

Preparation and Analysis of Ceramic Microstructures

Richard E. Chinn



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To Patsy, Melissa, and Heidi

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Preface

This monograph is an extension of a paper I wrote in 1998 for a contest in *Structure*, the Struers Journal of Materialography that is published in Denmark. Although I was employed as a process engineer at a reactive-metals producer at the time, the paper was based on a project that began in the late 1980s when I worked for Coors Ceramics Company and Coors Brewing Company in a corporate materials laboratory in Golden, Colorado. The Coors companies now have completely separate management and stockholders, but I spent over a decade preparing and examining microstructures for the company now known as CoorsTek, Inc. and its subsidiaries in the ceramics industry. That aforementioned project resulted in a paper that was published by the *Journal of the American Ceramic Society* and two binders full of notes, drawings, and micrographs. I used some of these notes and techniques that I had developed in my master's thesis. The *Journal* paper, the *Structure* paper, and parts of the thesis became the basis of this book.

This book is hardly an exhaustive research summary, but it does contain a list of references at the end of each chapter. The references include many of the more common metallography books and papers from the ceramic journals that detail novel etching techniques and measurement methods. The Suggested Reading lists direct the reader to more comprehensive sources of information, primarily engineering textbooks, on topics that are presented here only in brief.

In regard to the vernacular of ceramography, *optical* microscope is not used, because all microscopes, even electron microscopes, are optical instruments. *Microscope*, in this text, implies a visible-light microscope, and any other type of microscope is specified explicitly. All the micrographs in this book are bright-field images, except as noted. (*Bright-field* is the form of illumination that causes specularly reflected surfaces normal to the axis of the microscope to appear bright.) Most of the specimens are from actual ceramic devices manufactured in the late 1980s to the mid-1990s by numerous companies around the world. These devices were pulled from the production line for quality-control purposes or sent in from the field for failure analysis. The fabrication methods, where known, are provided in the figure captions. A few of the specimens are experimental compositions and are noted as such.

I thank the many colleagues and mentors who have aided in my understanding of ceramics and optical instruments over the years. Among them are Doris Cheever; the late Dan Briggs; John McLane; Terry Brog; Mike Readey and Dan Schmidt at Coors; Professors Mike Haun, Dennis

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Richard E. Chinn

About the Author

Richard Chinn earned his B.Sc. in metallurgical engineering and M.Sc. in materials science at the Colorado School of Mines in Golden, Colorado, USA. He worked for the Coors companies in Golden for a decade as a materials engineer, where he gained experience in both technical ceramics and aluminum beverage cans. He was a process engineer at a ferroalloys smelter in Ohio and a reactive-metals smelter in Oregon before joining the United States Department of Energy's Albany Research Center as a materials research engineer in 2000. He is a registered professional engineer in Colorado and Oregon and has been a certified quality engineer of the American Society for Quality since 2000. He also holds credentials from the American Society of Nondestructive Testing and the Materials Engineering Institute. He is active in the American Ceramic Society and the Oregon chapter of ASM International.

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