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Victor E. Henrich and P. A. Cox
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This book is the first to give a comprehensive account of the fundamental properties of metal-oxide surfaces and their interaction with atoms, molecules and overlayers. It will act as a valuable reference for anyone interested in learning about the surface science of this fascinating class of materials, whose properties span the entire range from metals to semiconductors and insulators.

The surfaces of metal oxides are of great technological importance, and play a crucial role in an extremely wide range of phenomena. A detailed knowledge of their properties is central to the investigation of processes such as the environmental degradation of high- T_c superconductors, or in analyzing the nature of the bonding between grains of alumina in sintered ceramics. Metal-oxide surfaces are also of increasing importance in fields such as catalysis, the passivation of metal surfaces, and gas sensing for pollution monitoring and control.

As well as giving a general overview of the basic properties of metal oxides, an extensive and thorough compilation of the theoretical and experimental research which has been performed on well-characterized single-crystal oxide surfaces is provided, thus making the book suitable for those graduate students and established researchers in materials science, chemistry, physics or geology who have an interest in metal-oxide surfaces.

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THE SURFACE SCIENCE OF METAL OXIDES

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Preface

If the number of publications and the existence of specialized journals are good guides to the success of a field, surface science has developed remarkably over the last two decades or so. The routine use of ultrahigh-vacuum equipment and the development of many new techniques for studying the outermost atomic layers of well-characterized crystals have contributed to an enormous increase in our understanding of surface physics and chemistry. A very high proportion of this work has been performed on metals, although semiconductors such as silicon and III–V materials have received increased attention as the field has progressed. Metal oxides, in spite of their great scientific and technological interest, have been relatively much less studied; we discuss some of the reasons for this in Chapter 1. In spite of a late start, the number of groups now active and the volume of publications in the field of oxide surfaces are considerable. However, oxides are still barely represented in the otherwise excellent textbooks available in surface science, and this is the reason for the present volume. It seems to us that the field is sufficiently well-established that it is worthwhile to take stock of what is now known. At the same time, by pointing out the many things that are not understood, we hope to provide directions for future research, in a field that we are confident will continue to grow.

We hope this book will be useful to those graduate students and established researchers who already have some background in surface science ideas and techniques, but who are not familiar with oxides. Each of the main chapters contains introductory sections that cover essential aspects in outline before a detailed discussion of results is presented. We have not described in detail the various experimental techniques of surface science, as there are other books that cover these; but we have tried to explain what is *different* about oxides, both in terms of their basic electronic and chemical properties, and the ways in which these necessitate changes in experimental technique or interpretation. In discussing results, we have referred to nearly a thousand papers and reviews, and, although we do not claim to

be complete, we have tried to cover significant developments up to the beginning of 1992. We must point out, however, that we have primarily limited ourselves to work on single crystals and have not attempted to discuss the enormous literature (particularly in the catalysis field) on oxide ceramics and high-surface-area powders.

It would be impossible to write a book such as this without a good deal of help. Much of this has come from colleagues and students who have made our own research so enjoyable over a period of many years: they are too numerous to mention here, but their names appear frequently in the list of references. Our respective institutions, Yale and Oxford Universities, have contributed both by supporting our research and by the generous provision of sabbatical leaves, which has given us the time to travel and to work on this project. We are especially grateful to Victor Bermudez, Russ Egdell and Wendy Flavell, each of whom read a complete draft of the book and made many penetrating and constructive comments. We have tried to accommodate their suggestions, but obviously they cannot be held responsible for any remaining flaws. Special thanks are also due to Richard Kurtz for giving us his 'MacSurface[®]' program to draw the surface models and for patiently assisting us as we learned how to use the program. Finally we thank our families, without whose support and encouragement this book could not have been written.

V.E. Henrich
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Yale and Oxford