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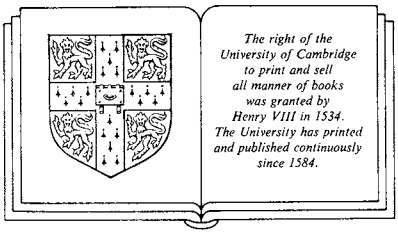
TIEN T. TSONG

Distinguished Professor of Physics The Pennsylvania State University



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Preface

The field ion microscope (FIM) was invented by Erwin W. Müller in 1951. By 1957 he was able to show atomically resolved images of surfaces of tungsten and other refractory metals. The FIM is very simple in design and it is hard to imagine that one can image atomic structures of solid surfaces routinely with this instrument. Of course, the simplicity is somewhat deceptive. While atomic images can be routinely obtained for refractory metals with the FIM, to widen its application to other materials has not been easy. It is no wonder that even now, after the FIM has been in existence and in active research for nearly forty years, I am still often asked by scientists outside the field, some of them are very prominent and are also very knowledgeable in science, whether or not FIM can now be used to image materials besides tungsten. The truth of the matter is that the field ion microscope has long been successfully used to study most metals and many alloys, and recently good field ion images of some semiconductors and even ceramic materials, such as high temperature superconductors and graphite, etc., have also been successfully obtained.

The atomic resolution aspect is no longer unique to field ion microscopy. Other microscopies have now also achieved atomic resolution. Some of these microscopes promise to have a great versatility and are currently very actively pursued. On the other hand, there are still some experiments unique to field ion microscopy. An example is the study of the behavior of single atoms and single atomic clusters on well characterized surfaces where quantitative data on various atomic processes can be derived routinely with the field ion microscope. In addition, there is the atom-probe field ion microscope with which single atoms and atomic layers of one's choice, chosen from field ion images, can be chemically analyzed. Also, defects buried inside the bulk can be brought up to the surface by low temperature field evaporation. Thus both the structure and the chemistry of these defects can be studied with a spatial resolution of a few angstroms. The material applicability of this instrument is much wider than that of the FIM, and there is as yet no other microscope capable of doing chemical analysis with the same single atom detection sensitivity, which is the ultimate sensitivity in chemical analysis.

There already exist a few books written on field ion microscopy. Most of these either were published before 1970 when most works were concerned with techniques and methods, or are later ones which emphasize applications to materials science. While some of the basic principles of field ion microscopy remain unchanged from those twenty years ago, when Müller and I wrote a book on the subject, there have been many important new theoretical and technical developments and applications, and also many more detailed studies of a variety of problems in surface science and materials science. In the book just referred to, the subject of atom-probe field ion microscopy was only barely touched. This is of course where most of the new developments are made, and is also the instrument now most actively employed by investigators in the field. In the present volume I try to emphasize basic principles of atom-probe field ion microscopy, field ion emission and applications to surface science. As books emphasizing applications to materials science already exist, only selected topics in this area are presented here. They are used to illustrate the various capabilities of atom-probe field ion microscopy in materials science applications.

This book is intended for general scientists who are interested either in having some knowledge of studies of solid surfaces and materials on atomic scale or in working in related fields, for graduate students who either are using this technique for their scientific studies or are entering this field, and for scientists working in this field who would like to have a convenient book of reference. A book of this size cannot cover all the important subjects in the field. The choice of subjects reflects very much my personal interest, and even so it is impossible to cover all these subjects with equal depth. Some of the views expressed in this book are somewhat personal, and a few errors are unavoidable. Nevertheless, I hope that it will be useful to those who read it. Scientists are now more than ever interested in atomistic understanding of physical phenomena. Field ion microscopy should be able to contribute further to this endeavor. If this book can be of some help in such an effort, all the labor of preparing it will be amply compensated. Finally, I would like to thank many of my colleagues for their fruitful discussions and contributions over the years; especially to those who have kindly supplied some of the materials used in this book. Without their support and help this book could not have been completed.

TIEN T. TSONG
University Park, Pennsylvania