

METHODS OF SURFACE CHARACTERIZATION • VOLUME 2

ION SPECTROSCOPIES FOR SURFACE ANALYSIS

Edited by
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Ion Spectroscopies for Surface Analysis

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Ion Spectroscopies for Surface Analysis

METHODS OF SURFACE CHARACTERIZATION

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Volume 1 VIBRATIONAL SPECTROSCOPY OF
MOLECULES ON SURFACES

Edited by John T. Yates, Jr., and Theodore E. Madey

Volume 2 ION SPECTROSCOPIES FOR SURFACE ANALYSIS
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About the Series

A large variety of techniques are now being used to characterize many different surface properties. While many of these techniques are relatively simple in concept, their successful utilization involves employing rather complex instrumentation, avoiding many problems, discerning artifacts, and carefully analyzing the data. Different methods are required for handling, preparing, and processing different types of specimen materials. Many scientists develop surface characterization methods, and there are extensive developments in techniques reported each year.

We have designed this series to assist newcomers to the field of surface characterization, although we hope that the series will also be of value to more experienced workers. The approach is pedagogical or tutorial. Our main objective is to describe the principles, techniques, and methods that are considered important for surface characterization, with emphasis on how important surface characterization measurements are made and how to ensure that measurements and interpretations are satisfactory, to the greatest extent possible. At this time, we have planned four volumes, but others may follow.

The first volume brought together a description of methods for vibrational spectroscopy of molecules on surfaces. Most of these techniques are still under active development; commercial instrumentation is not yet available for some techniques, but this situation could change in the next few years. The current state of the art of each technique was described as were their relative capabilities. An important component of the first volume was the summary of the relevant theory.

This book is the first of two volumes that contain descriptions of the techniques and methods of electron and ion spectroscopies which are in widespread use for surface analysis. These two volumes are and will be largely concerned with techniques for which commercial instrumentation is available. The books are intended to fill the gap between a manufacturer's handbook, and review articles that highlight the latest scientific developments.

A fourth volume will deal with techniques for specimen handling, beam artifacts, and depth profiling. It will provide a compilation of methods that have proven useful for specimen handling and treatment, and it will also address the common artifacts and problems associated with the bombardment of solid surfaces by photons, electrons, and ions. A description will be given of methods for depth profiling.

Surface characterization measurements are being used increasingly in diverse areas of science and technology. We hope that this series will be useful in ensuring that these measurements can be made as efficiently and reliably as possible. Comments on the series are welcomed, as are suggestions for volumes on additional topics.

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Preface

Determining the elemental composition of surfaces is an essential measurement in characterizing solid surfaces. At present, many approaches may be applied for measuring the elemental and molecular composition of a surface. Each method has particular strengths and limitations that often are directly connected to the physical processes involved. Typically, atoms and molecules on the surface and in the near surface region may be excited by photons, electrons, ions, or neutrals, and the detected particles are emitted, ejected, or scattered ions or electrons.

The purpose of this book is to bring together a discussion of the surface compositional analysis that depends on *detecting* scattered or sputtered *ions*, and the methods emphasized are those where instruments are commercially available for carrying out the analysis. For each topic treated, the physical principles, instrumentation, qualitative analysis, artifacts, quantitative analysis, applications, opportunities, and limitations are discussed.

The first chapter provides an overview of the role of elemental composition in surface science; compositional depth profiling; stimulation by an electric field, electrons, neutrals, or photons and detection of ions; and then stimulation by ions, and detection of ions, electrons, photons, or neutrals.

The second chapter deals with the molecular dynamics involved for sputtered particles, which are important in secondary ion mass spectrometry (SIMS). The third chapter deals with particle-induced desorption, particularly, as SIMS is applied to studying organic materials. The fourth chapter describes a SIMS method for surface analysis by postionizing sputtered neutrals with a laser. Thus, in the first four chapters various aspects of SIMS are considered that complement the book by Benninghoven, Rüdenauer, and Werner. The fifth chapter is on Rutherford backscattering, nuclear reaction analysis, and hydrogen forward scatter-

ing as a high-energy (~ 1 MeV) technique. The sixth chapter describes ion scattering as a low-energy (~ 1 keV) method for surface compositional and adsorbate-structural analysis. The final chapter presents comparisons of the major techniques described in this volume and in a volume to follow on Auger and X-ray photoelectron spectroscopies. Several ASTM standards relevant to ion spectroscopies for surface compositional analysis are reprinted in the Appendix; these were originated by the E42 Committee on Surface Analysis.

In view of the recent treatise on SIMS¹ we have focused on several rapidly developing aspects of SIMS. We recognize that there are other important topics in this area, such as electron-impact postionization of sputtered neutrals, that have not been included. These will have to be addressed in the future. The contributions in this volume also complement the book by Wilson, Stevie, and Magee.²

The editors are deeply grateful to the authors whose work made this book possible, and for taking the time from their active research programs to prepare their contributions.

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¹ A. Benninghoven, F. G. Rüdenauer, and H. W. Werner, *Secondary Ion Mass Spectrometry, Basic Concepts, Instrumental Aspects, Applications and Trends*, Wiley, New York (1987).

² R. G. Wilson, F. A. Stevie, and C. W. Magee, *Secondary Ion Mass Spectrometry, A Practical Handbook for Depth Profiling and Bulk Impurity Analysis*, Wiley, New York (1989).

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