BOOK REVIEWS

Scanning Tunnel Microscopy and Spectroscopy: Theory, Techniques, and Applications

Reviewed by Andrew W. Phelps, Research Scientist, Materials Engineering Division, University of Dayton Research Institute, Dayton, OH 45469-0130

REFERENCE: *Scanning Tunnel Microscopy and Spectroscopy: Theory, Techniques, and Applications,* Dawn A. Bonnell, Ed., VCH Publishers, New York, 1993, 436 pages, ISBN: 0-89573-768-X.

Many technically oriented people have had their first introduction to Scanning Tunneling Microscopy (STM) and the other scanned probe microscopies in the form of the remarkable pictures which have been used as the cover photos for many technical and professional journals. The STM was invented in 1982 and was embraced with dramatic speed by a remarkable range of scientific and technical disciplines. Analytical techniques based on the STM are being applied even now to the field of fine-scale surface measurement and metrology. The number of papers and reports which rely in part or in whole on images and quantitative data generated by these systems has grown exponentially in the last few years. The award of the Nobel Prize for physics in 1986 to the inventors of the STM was simply a reflection of the fundamental and wide-ranging importance this technique has had and will continue to have in science and technology.

In this reviewer's opinion, 'real-time' sampling at an atomic or near-atomic scale of nearly all physical or chemical phenomena has been the main impact of the STM. The STM was originally developed to explore the electrical properties of superconductors on a nanometer scale but it has been extended to research in fields as diverse as biochemistry and tribology. Scanned probe microscopic techniques have quickly moved from homemade laboratory novelties to turn-key commercial units. This happened as problems such as systematic atomic-scale control and vibrational damping were solved.

The book is organized logically and includes a comprehensive index at the end. The chapters are: "Microscope Design and Operation," "Theory of Scanning Tunneling Microscopy," "Methods of Tunneling Spectroscopy With the STM," "The Surface Structure of Crystalline Solids," "The Preparation of Tip and Sample Surfaces for STM Experiments," "Force Microscopy," "BEEM and the Characteristics of Buried Interfaces," "Applications in Electrochemistry," and "Biological Applications of the Scanning Probe Microscope." The book stays fairly focused on the science and technology of STM and Scanning Tunneling Spectroscopy (STS). Atomic Force Microscopy is reviewed in its own chapter and is mentioned in several others. The chapters are written so they can stand alone but there is little overlap between the various sections and they are best when read somewhat in the order presented. A significant number of chapters were contributed by noted innovators in their particular fields of scanned probe microscopy. A quick review of my own personal files revealed dozens of research papers from this particular group of individuals on a variety of scanned probe topics.

I would recommend this book as a resource for those who are considering the addition of scanned probe microscopy to their analytical capability. Future commercial and university-based characterization efforts will likely include one or more forms of scanned probe microscopy. This book provides a solid introduction on which more advanced study may be based. Beginning and active researchers will appreciate the areas for further research that are suggested by the authors.

BOOK REVIEWS

Thermal Analysis of Materials

Reviewed by Alan T. Riga and Christopher G. Scott, The Lubrizol Corporation, 29400 Lakeland Blvd., Wickliffe, NY 44092.

REFERENCE: Speyer, Robert F., *Thermal Analysis of Materials,* (Materials Engineering Series/5), Marcel Dekker, Inc., New York, 1994, 304 pages, ISBN: 0-8247-8963-6.

This monograph discusses thermal science fundamentals including the underlying principles of Differential Thermal Analysis (DTA), Thermogravimetric Analysis (TGA), and Dilatometry and Interferometry. The inner workings and operation of DTA, TGA, and Dilatomery are put forth with some detail. The salient underlying principles are developed for a better understanding of these thermoanalytical techniques. This narrative focuses on thermal analysis instrumentation for materials property characterization, especially the thermal behavior of ceramics. Unique features of this book are the description of pyrometry, infrared and optical temperature measurements, thermal conductivity, and glass viscosity.

The basis of this book is elementary physical chemistry, heat transfer, materials properties, and device engineering. This book can be a primer on thermal analysis for materials engineering college students, corporate research and development personnel, as well as technical staff in a thermal analytical laboratory. The thermal instrumentation chapters and many case studies are rooted in clear and concise presentations of ceramic and inorganic materials.

The chapter on DTA highlights the differences between the various thermal measuring devices, either heat flux or power compensated. The descriptive, easy-to-read diagrams, DSC or DTA thermal curves, and simple explanations of the thermal events greatly add to the overall theme of the book. A scientist with minimal background in materials characterization will gain an important insight into the various thermal analysis instruments. Entry-level thermal analysts will gain an important insight on how DTA and DSC function in the analysis of reversible and irreversible transformations. Kinetic modeling using the Johnson-Mehl-Avrami approach for nucleation and growth processes is described for a DTA/DSC experiment.

The chapter "Heat Transfer and Pyrometry" starts with the introduction of heat transfer processes: conduction, convection, and radiation. The next sections on Pyrometry describe the instrumentation that uses optical means to determine the temperature of a self-luminous body. For example, the Disappearing Filament Pyrometer is a device that evaluates temperature from radiation at a single wavelength. A discussion of the latter device includes instrumental design, calibration, the assumption of a single wavelength, and the determination of spectral emissivity. Two Color, Total Radiation, and Infrared Pyrometers are also discussed. The "Thermal Conductivity" chapter includes a number of techniques to measure this property, such as Radial Heat Flow Method, Calorimeter Method, Hot-Wire Method, Guarded Hot-Plate Method, and the Flash Method.

The author attained his goals, set out in the preface, of clearly explaining the underlying principles of a number of thermal analytical techniques including a mathematical analysis and examples involving materials evaluation. All chapters conclude with a list of references. The two appendices on instrumentation vendors and supplementary reading are essential support for this thermal analysis primer.