CHEMICAL REVIEWS

Volume 97, Number 4 June 1997

Introduction: Force and Tunneling Microscopy

The invention of the scanning tunneling microscope (STM) by Gerd Binnig and Heinrich Rohrer in 1982 gave rise to the age of atomic-scale imaging of conducting surfaces. The subsequent invention of the atomic force microscope (AFM) by Gerd Binnig, Calvin Quate, and Christoph Gerber in 1986 extended this capability to insulating surfaces. In only 15 years, these instruments have had far-reaching impact on the study of systems in chemistry, physics, materials science, and biology. The nine articles in this issue describe how these extraordinary instruments have become critical tools for state-of-the-art research in fields ranging from atomic-scale imaging of semiconductors, metals, and molecules to electrochemistry, tribology, and lithography.

Two articles demonstrate particular applications of STM to atomic resolution imaging of semiconductors. Yu discusses cross-sectional STM, in which semiconductors are cleaved to expose a cross section of epitaxially grown layers or device structures fabricated on the wafer. Measurements of both topographic structures and spectroscopic features using the STM are used to give information on the spatial morphology and electronic structures of III–V and group IV semiconductor structures. Liu and Lagally review the use of STM to study the effect of strain on the growth of ultrathin Ge films on Si(001). They illustrate the applications of the STM to quantitative analysis of surface structures, morphologies, energetics, and stress for these systems.

Hwang and Bartelt discuss key contributions and discoveries found from STM studies of metal on metal epitaxial systems. Their review addresses and links the scientific issues of nucleation, structure, and composition for these systems.

Molecular imaging by STM is reviewed in three articles. Chiang discusses experimental STM imaging of small adsorbed molecules on metal surfaces in an ultrahigh vacuum environment. These molecules include small aromatic molecules, porphyrins, carbon monoxide, and ethylene, as well as molecules that have been observed directly during chemical reactions. A complementary article by Sautet discusses theoretical calculations of STM images of both atomic and molecular adsorbates, giving particular insight into the contrast mechanisms for images of these systems. Poirier reviews STM imaging of self-assembled monolayer systems composed of thiol-derivatized hydrocarbons on Au(111) substrates.

Finally, applications of STM and AFM to more specialized fields are reviewed in three articles. Gewirth and Niece review recent advances in using *in situ* electrochemical STM and AFM images to understand structure and processes at the solid–liquid interface. Carpick and Salmeron describe the use of AFM for atomic-scale studies of tribology, i.e., the science of friction, lubrication, wear, and adhesion. Nyffenegger and Penner discuss recent developments in the relatively new field of scanning probe lithography, which involves the use of STM and AFM to modify surfaces on a nanometer scale. The applications of STM and AFM to the fields of electrochemistry, tribology, and scanning probe lithography are making possible important advances in atomic-scale measurements and understanding in these fields, knowledge which cannot be gained by other techniques.

Although this journal issue gives only a small subset of the current applications of STM and AFM, the articles presented here survey many active fields of research which are chemically oriented. I am grateful to the authors for their enormous effort in writing these articles and hope that they will be useful to many readers in the future.

Shirley Chiang
University of California, Davis

Guest Editor

CR970041M

S0009-2665(97)00041-1 CCC: $28.00