SYMPOSIUM X

Frontiers of Materials Research

Authoritative Reviews for Nonspecialists

November 26 – 29, 2001

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* Invited paper

This symposium is the Society's principal vehicle to maintain the interdisciplinary and integrative nature of its mission within the materials community with invited reviews presented over the lunch hour. Leaders in various specialties represented by the topical symposia present reviews designed for materials researchers who are **NOT** specialists in the reviewed field.

SESSION X1/AA2: JOINT SESSION
Chairs: Bruce M. Clemens, Jerrold A. Floro, Julie A. Kornfield and Yuri Suzuki
Monday Afternoon, November 26, 2001
Grand Ballroom (Sheraton)

12:05 PM *X1.1/AA2.1
THE AGE OF MOLECULAR ENGINEERING. Philip Ball, Nature, London, UNITED KINGDOM.

Our view of the molecular world has changed profoundly in the past several decades. The stochastic picture of ensembles exhibiting statistical regularities has given way to the deterministic idea that we can specify, maintain and monitor the states of individual, selected molecules. The technological implications are enormous, and so far barely tapped. But familiarity with trends such as Moores law has encouraged the idea that this molecular engineering is simply another step in the shrinking scale of technology. It is now looking more likely that engineers of the atomic scale should start afresh that traditional ideas of how devices should be designed, how they operate and how they might be assembled may no longer be appropriate for technology at the smallest scale.

SESSION X2:
Chairs: Bruce M. Clemens, Jerrold A. Floro, Julie A. Kornfield and Yuri Suzuki
Tuesday Afternoon, November 27, 2001
Grand Ballroom (Sheraton)

12:05 PM *X2.1
THE SUBSTANCE OF CIVILIZATION - MATERIALS AND HUMAN HISTORY FROM THE STONE AGE TO THE AGE OF SILICON. Stephen L. Sass, Dept of MS&E, Cornell Univ, Ithaca, NY.

Materials have enabled revolutionary advances in how we work, fight, live and travel, hence the naming of eras after them the Stone, Bronze and Iron Ages. This talk explores the role of materials in the development of modern industrial Western civilization by putting technology into an historical context. It traces the advances made possible by innovations with stone, ceramics, glass, metals and electronic materials. By identifying relationships between crucial innovations and historic events, connections will be established among materials, agricultural techniques, the founding of large cities and the invention of written language in the fourth millennium B.C.E. Similarly, connections will be explored among the exodus of the Hebrews from Egypt, the tumult in the Eastern Mediterranean and the onset of the Iron Age late in the second millennium B.C.E. Finally, revolutionary discoveries from the Far East - in particular China - will be examined for their impact on our world. Slides of beautiful works of art will be used to illustrate early technologies.

SESSION X3:
Chairs: Bruce M. Clemens, Jerrold A. Floro, Julie A. Kornfield and Yuri Suzuki
Wednesday Afternoon, November 28, 2001
Grand Ballroom (Sheraton)

12:05 PM *X3.1
BEYOND VISION: DATA AS ART. Ivan Amato, Associate Editor, Science News/Freelance Writer.

Images always have been a striking and particularly accessible means of communicating scientific information. From the hand drawn renditions of Robert Hookes microscope observations in the 17th century to the computer-enhanced all-electronic images of the Hubble Space Telescope, images always have helped the scientific community tell its stories. Whats more, in the past few decades, these images have been providing information in a manner that fairly can be described as beautiful. Data, even as it serves its primary purpose of testing scientific hypotheses and solving technical problems, has become a new kind of art. As they chronicle the worlds natural and artificial phenomena with ever more powerful tools, scientific observers now can synthesize form, color, and composition into some of the most breathtaking imagery ever produced. So far, this imagery has appeared mostly in technical journals and at meetings like this one, but its slowly becoming part of the more public visual landscape, making it even to the covers of Time and Newsweek. In this talk, I will showcase some of the images that I have been harvesting from the vast reservoir of data available and I will provide a taste of how each one of these images tells a story. Images range from particle cascades that emerge in accelerators to the molecular landscapes of surfaces to the large-scale structure of the universe.

SESSION X4:
Chairs: Bruce M. Clemens, Jerrold A. Floro, Julie A. Kornfield and Yuri Suzuki
Thursday Afternoon, November 29, 2001
Grand Ballroom (Sheraton)

12:05 PM *X4.1

MRS MEDAL AWARD TALK PRESENTATION

ON THE ROAD TO AN ATOMIC AND MOLECULAR LEVEL UNDERSTANDING OF FRICTION. C. Mathew Mate, IBM Almaden Research Center, San Jose, CA.

While friction has always been part of everyday life, only in the last couple of decades have scientists begun to focus on how friction occurs between the atoms and molecules at contacting surfaces. In this talk, I will describe my personal journey on the road to an atomic and molecular understanding of friction.
This journey begins with the invention of the friction force microscope in 1987 [1], which enabled us, for the first time, to measure atomic level friction forces. Since then, the use of friction force and other types of force microscopy to investigate nanoscale contacts has exploded. Force microscopy has become an invaluable tool for measuring friction, elastic properties, microhardness, adhesive forces, capillary forces, etc. occurring at contacts as small as a few atoms across. Integrating the contact properties determined by force microscopy with theory and molecular dynamic simulations has enabled much the progress made in recent years toward understanding friction at the atomic and molecular level.
This journey is by no means over, with much still to be done to deepen our understanding of friction and to apply this knowledge to technology. One technology, which I will discuss, where this understanding is playing a critical role, is hard disk drive technology, in which two nearly atomically smooth surfaces move relative to each other at high speeds with less than a 20 nm air bearing between them [2]. Finally, I will discuss some of the new experimental techniques that we are developing in our laboratory for furthering our understanding of friction and lubrication, such as using air shear for pushing molecules across surfaces [3].
[1] C.M. Mate, G.M. McClelland, R. Erlandsson, and S. Chiang, Phys. Rev. Lett. 59 (1987) 1942.
[2] C.M. Mate, Tribology Letters 4 (1998) 119.
[3] C.M. Mate and B. Marchon, Phys. Rev. Lett. 85 (2000) 3902.

12:45 PM *X4.2

MRS MEDAL AWARD TALK PRESENTATION

TESTING THE FUNDAMENTAL THEORIES OF SURFACE DYNAMICS. Norman C. Bartelt, Sandia National Laboratories, Livermore, CA.

A long standing goal of materials science has been to predict the long-time evolution of the structure of materials from knowledge of atomic processes. This is of course usually extremely difficult to do in any detail: the problem is that there are a very large number of often poorly understood atomic processes to consider. On solid surfaces, however, progress can now be made because of advances in real-time microscopy which allow the characterization of time evolution in unprecedented detail. These observations reveal a complex interplay between collective thermal fluctuations and deterministic behavior. In this talk, I will discuss my attempts to construct theories of these observations. The problems considered will include the verification of equations of motion of atomic surface steps, the dynamics of surface alloy formation, and the thermal smoothing of surface profiles. I will conclude with a discussion of fundamental problems which remain in predicting and controlling surface dynamics.

PIZZA WILL BE PROVIDED COURTESY OF THE 2001 FALL MEETING CHAIRS