

# **Advances in Spectroscopy and Imaging of Surfaces and Nanostructures**

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# Advances in Spectroscopy and Imaging of Surfaces and Nanostructures

Symposium held November 29–December 3, Boston, Massachusetts, U.S.A.

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## PREFACE

There are, perhaps, three components that are vital to the success of any scientific quest. They are 1) creative thinking and courageous experimentation of researchers in the field, 2) an amalgamation of this research with approaches of the broader research community (which often creates the most exciting ideas), and, finally, 3) practical applications of the research that put it in the broader perspective of our lives.

All of these components are distinctive features of four symposia that were held at the Fall MRS 2010 meeting in Boston and are brought together in this volume, namely, Symposium SS: “Advanced Imaging and Scattering Techniques for In Situ Studies”, TT: “In Situ X-Ray Synchrotron Radiation Spectroscopies in Energy-Related Materials Science and Heterogeneous Catalysis”, UU: “Real-Time Studies of Evolving Thin Films and Interfaces” and VV: “Novel Development and Applications of Scanning Probe Microscopy.” A major unifying theme for these symposia is exploration of intricate properties of materials on the near-to-atomic length scale in the immediate vicinity of the free surface or at interfaces between materials. These symposia focus on various aspects and approaches of exploration of surfaces and interfaces from more traditional electron and x-ray scattering (the focus of symposia SS, TT, and UU) to more recent and rapidly advancing scanning probe microscopy, or SPM (Symposium VV). Together, they cover a field of great importance across the broad MRS community.

Of tremendous interest in modern material science, this key aspect of nanotechnology considers how interfaces and surfaces help to determine properties and functionalities of a wide range of materials, including oxides, metals and nanoparticles. Monitoring evolving surfaces in real time is a prerequisite for mastering the evolution process itself. Furthermore, surfaces and interfaces often display surprising properties that are qualitatively different from those of the corresponding bulk materials. Controlling and tailoring the physical properties at the interfaces between different materials on the atomic scale can therefore result in real scientific breakthroughs. Research in atomic control when fabricating interfaces and surfaces will help in understanding important structure-property relationships as well as in improving the design of nano-devices. Another aspect of this research is developing techniques to probe the structure and/or the properties of evolving surfaces and interfaces in environments where they are created and used.

Symposium UU was a forum for researchers who use or develop in-situ characterization and monitoring techniques for thin films, surfaces and interfaces. Experts in the fields of real-time 1) scattering (e.g., XRD and TEM), 2) imaging (e.g., SPM and 3) spectroscopy (e.g., XPS) came together to report on their respective progress and/or new developments. Different kinds of probes, such as light in a wide energy spectrum, electrons and scanning probes, and their various capabilities to adapt, case by case, to the very peculiar working conditions required for this research emerged. Also, a particular opportunity was given for researchers to show prospects for applications of novel techniques to real-time analysis.



The search for new sources of clean energy is rapidly becoming one of the most pressing technological challenges that we face today, and this was the focus of Symposium TT. Enormous progress has been made in developing new, tailored materials via nanostructuring, self-assembly and bio-mimetic methods, that are key for developing renewable energy sources, such as solar energy conversion, as well as for the rational design of highly efficient catalysts. The effort requires new materials developed through the control of the atomic, chemical and electronic structure, which in turn requires an intimate collaboration between materials synthesis and characterization of the electronic properties of complex materials. The presentations at this symposium show the opportunities that synchrotron radiation research can provide to answer some of the challenges associated with energy science research, including exploration of high temperature superconductors, lithium ion batteries, and fuel cells, to name a few. These materials come in a broad range of chemical and structural complexity, rendering their analysis and diagnostics difficult. A large number of critical issues relevant for energy purposes have been addressed with x-ray scattering and spectroscopy including devices in operation.

Finally, Symposium VV focused on novel SPM-related advances that are a vital and, often the only, tool allowing precise imaging and characterization of certain nanostructures. The papers spanned broad areas from chemical identification at atomic resolution (Mohn, Pethica, Schwarz) and new probe functionalities (Ko, Westervelt, Ashby, Hong) to nanomechanical (Carpick, Hurley, Kolosov), thermal (Narayanaswamy, King), optical (Wickramasingh, Haugstad) and electrical (Bonnell, Kim, Kalinin, Shin) SPM measurements. Novel developments in nanomanufacturing (Weaver, King, Li) and new high speed and dynamic measurements (Besenbacher, Miles, Frenken, Huey) showed their increasing impact on the future applications of SPM. The panel discussion chaired by Dawn Bonnell involved lead researchers of major scanning probe instrumentation companies, government agencies and leading researchers and touched upon the shortcomings, challenges and inspiration of this relatively young developing field.

The distinctive offering of Symposium VV was a panel of developers and users of SPM, also chaired by Dawn Bonnell. Given the close link between all four symposia, we held several joint sessions, allowing deep integration of research in this valuable area of material science. Overall, our symposia brought together the leading-edge expertise of various characterization methods, nanoscale and advanced materials manufacturing and fundamental electronic and chemical properties of the materials involved with a great selection of invited and contributed talks, eight large poster sessions and a panel discussion with the industry.

This joint preface was compiled by Oleg Kolosov, with contribution from all the editors of Symposia SS, TT, UU and VV – namely, John Cumings, Dillon D. Fong, Jianyu Huang, Stuart Lindsay, Guangwen Zhou, Jinghua Guo, Hendrik Bluhm, Michael Hävecker, Shu Yamaguchi, Gertjan Koster, Fabio Miletto Granozio, Gyula Eres, Chang-Beom Eom, Nicholas Ingle, Seungbum Hong, Hyunjung Shin and Bryan D. Huey.

John Cumings  
Jinghua Guo  
Fabio Miletto Granozio  
Oleg V. Kolosov

July 2011

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We were extremely fortunate to have great invited speakers who presented cutting edge research in this rapidly developing and indispensable area for material science research. We would like to express our gratitude to our Invited Speakers for the high scientific level and novelty of their contribution:

- Fleming Besenbacher, Dawn Bonnell, Robert Carpick, Yasuo Cho, Donna Hurley, Sergei Kalinin, Hyoungsoo Ko, Xiaodong Li, Sergei Magonov, Mervyn Miles, Fabian Mohn, Arvind Narayanaswamy, Christine Ortiz, Sang-il Park, John Pethica, Kumar Wickramasinghe

We also would like to thank Members of the Panel on Next-Generation SPM held at Symposium VV, namely,

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The organizers would like to thank the speakers, session chairs, and the symposium assistants for their contribution to make the symposia a success. The organizers are grateful to the MRS editorial staff for their diligent work in organizing the conference and assembling the volume.

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