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Invited Paper NS+NC-TuM11

Albert Nerken Award Lecture – Atomic Tool for Nanofabrication Based on Atomic Force Microscopy

Tuesday, October 21, 2008, 11:20am, Room 311

Session: The Frontiers of Nanoscience

Presenter: S. Morita, *Osaka University, Japan*

Authors: S. Morita, *Osaka University, Japan*
Y. Sugimoto, *Osaka University, Japan*
Ó. Custance, *NIMS, Japan*
M. Abe, *Osaka University, Japan*
P. Pou, *Universidad Autónoma de Madrid, Spain*
P. Jelinek, *Academy of Science of the Czech Republic*
R. Pérez, *Universidad Autónoma de Madrid, Spain*

Correspondent: Click to Email

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We have been developing a novel bottom-up nanostructuring system at room temperature (RT) based on ultra high vacuum (UHV) atomic force microscopy (AFM). It can image individual atoms, identify chemical species, and then manipulate selected atom species one-by-one to the designed site to assemble complex nanostructures consisted of multi atom species at RT under UHV environment. In this invited talk, we will shortly introduce principles of high-performance and high-resolution UHV-AFM, and then, introduce our recent results related to not only nanocharacterization but also nanofabrication based on UHV-AFM such as (1) site-specific force spectroscopy and force mapping related to chemical identification of individual atoms,[1-3] (2) vertical/lateral mechanical atom manipulation.[4,5] (3) atom interchange lateral/vertical manipulation and following assembly of embedded atom letters at RT.[6]

[1] Y. Sugimoto et al. "Real topography, atomic relaxations, and short-range chemical interactions in atomic force microscopy: The case of the Sn/Si(111)-(r3xr3)R30 surface", Phys. Rev. B 73 (2006) 205329.

AVS Art Zone Winner 2nd Place- "CuInSe2 Bicrystal" Courtesy of Allen J. Hall, University of Illinois at Urbana-Champaign, Dept. of Materials Science & Engineering

Albert Nerken Award

The Albert Nerken Award was established in 1984 by Veeco Instruments, Inc. in recognition of its founder, Albert Nerken, a founding member of AVS, his early work in the field of high vacuum and leak detection and contributions to the commercial development of that instrumentation. It is presented to recognize outstanding contributions to the solution of technological problems in areas of interest to AVS. The award consists of a cash award, a certificate, and an honorary lectureship at a regular session of the International Symposium.

-2008 Recipient: **Dr. Seizo Morita**

Dr. Seizo Morita, Osaka University, "for the development of room-temperature, non-contact atomic force microscopy technologies and applications." Seizo Morita is Professor, Department of Electrical, Electronic and Information Engineering, and Director, Low Temperature Center, at Osaka University, Japan. He completed his B.S. in 1970 and his Ph.D. research in 1975, in Physics at Osaka University, where he performed graduate work on LOphonon assisted cyclotron resonance. He was a Research Associate (1975-1987) and an Associate Professor (1987-1988) at Tohoku University, studying submillimeter-wave response in the Josephson junctions and the Anderson localization below 100 mK. From the mid-1980s, he started to develop the scanning tunneling microscopy and soon changed to atomic force microscopy (AFM). He was a Professor at Iwate University (1988-1989) and then moved to Hiroshima University (1989-1996), where he investigated the phase transition of microscopic negative charges on thin insulators and the twodimensional nature of atomic-scale friction using modified ultra high vacuum (UHV) AFMs in air. From 1992 he started to develop AFMs to achieve true atomic resolution. Then he went to work on non-contact (NC) AFM using the frequency modulation detection method. He was the first person to observe atomic-scale defects and their motion on InP(110) by NC-AFM (1995). Since 1996 he has been a professor at Osaka University, where he organized the first international conference on NC-AFM (1998). The main part of his work done with collaborators in Osaka University is atom manipulation and chemical identification on semiconductor surfaces using UHV-AFMs at room temperature (RT) and at low temperature (LT); He established the basic technologies and made clear the mechanisms of single atom identification, followed by interchange manipulation of selected heterogeneous atom species, and assembly of designed complex nanostructures consisting of multi atom species at RT. With the use of a LT UHV-AFM, reproducible vertical atom manipulation (extraction and deposition) (2003) and site-by-site lateral atom manipulation of semiconductor atoms (2005) have been carried out successfully. With use of a RT UHV-AFM, the well-controlled vacancy-mediated lateral manipulation of Si adatoms on Si(111)-(7x7) has been achieved and its mechanism has been made clear as tip-enhanced thermally activated hopping (2007). A novel phenomenon has been discovered of atom interchange lateral manipulation at RT that can interchange embedded and intermixed heterogeneous atoms with each other. Consequently, substituted Sn atoms with adjacent Ge atoms have been interchanged oneby- one, and finally embedded atom letters composed of 19 Sn atoms have been used to spell out "Sn" (the symbol for tin) at RT on the Ge(111)-c(2x8) substrate (2005). The details of force spectroscopy between the tip-apex atom and a surface atom have been also studied. Hence, identification of atoms at RT has been successfully carried out on semiconductor surfaces based on site-specific force spectroscopy (2007). He has published more than 200 papers, nine books and 16 book chapters. His work has been previously recognized by the 8th Surface Science Society Award (The Surface Science Society of Japan) (2003) and the 52nd Japanese Society of Microscopy Award (Setou Award) (2007). He established the committee for Utilization of Scanning Probe Microscopy in Japan Technology Transfer Association (JTTAS) (1992) and the 167th committee on Nano-Probe Technology in the Japan Society

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