

A Full Day Workshop:

NanoManufacturing and NanoRobots

June 2, 2009

- **Objectives**

50 years ago, Feynman talked his vision of factories using nanomachines to build complex products, including additional nanomachines, which promise to bring great improvements in the cost and performance of manufactured goods, while making possible a range of products impossible today. Nanomanufacturing is a key enabling technology for fulfilling the promise of nanotechnology with special material properties and processing capabilities at the nanoscale. Nanorobotics is an emerging interdisciplinary field that has benefited from and made unique contribution to the advancement of nanomanufacturing. Bottom-up synthesized nanomaterials and top-down fabricated nanostructures have provided new building blocks for nanorobotic devices, whereas nanorobotic manipulation is enabling the assembly and instrumentation of these building blocks and devices.

To celebrate the 50th anniversary of Feynman's talk, this workshop aims to discuss how fundamental robotics and manufacturing research at the nanometer scale has made contributions to nanotechnology and to each other, and illustrate the trends and directions in the future for the development of nanotechnology. This workshop will bring together nanorobotists and nanomanufacturing scientists and engineers who have had success in a variety of related research areas.

- **Topics include but are not limited to:**

- Nanorobotics
- NEMS
- Nanomanipulation
- Nanofabrication
- Nanoassembly
- Nanoinstrumentation
- Modeling and simulation of nanoscale systems
- Control of nanoscale systems
- Nanoscale automation
- Nanotubes, nanowires, and other nanomaterials for nanodevices
- Nanomanufacturing

- **Intended Audience**

All robotics and manufacturing researchers can find something of interest here. Individuals interested in nanotechnologies specifically can see what robotics has to offer these fields and how manufacturing is scaling down to the bottom.

- Organizers

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● Program (Tentative)

June 2, 2009

No.	Time	Speaker	Affiliation	Presentation (Tentative)
1	9:00–9:50	Toshio Fukuda and Masahiro Nakajima	Nagoya University fukuda@mein.nagoya-u.ac.jp	Micro/Nano Bio Robotic Manipulation
2	9:50–10:40	Wei Lu	University of Michigan wluee@eecs.umich.edu	Building Circuits with One-dimensional Nanowires
Coffee Break (10:40-11:00)				
3	11:00–11:50	Hui Xie and Nicolas Chaillet	University of Franche-Comté xie@robot.jussieu.fr nicolas.chaillet@femto-st.fr	Meeting the Challenge of Pick-and-place Nanomanipulation in Ambient Environment
4	11:50–12:40	Guangyong Li	University of Pittsburgh gli@enr.pitt.edu	Seeing in Real-time during AFM Nanomanipulation
Lunch (12:40 – 14:00)				
5	14:00–14:50	Sylvain Martel	Ecole Polytechnique Montréal sylvain.martel@polymtl.ca	Micro- to Nanomanufacturing with Bacterial Nanorobots
6	14:50–15:40	Dan Popa	The University of Texas popa@uta.edu	Toward Wafer-scale Robotic Microfactories for Nanomanufacturing
Coffee Break (15:40 – 16:00)				
7	16:00–16:50	Mingjun Zhang	The University of Tennessee mjzhang@utk.edu	Nano-scale Biological Systems Inspired Engineering for NanoManufacturing and Robotics
8	16:50–17:40	Lixin Dong, Xinyong Tao, Li Zhang, Xiaobin Zhang, and Bradley J. Nelson	Michigan State University ldong@egr.msu.edu ETH Zurich bnelson@ethz.ch	NanoRobotic Fluidic Systems

Abstracts and Speaker's Biography

June 2, 2009

1. 9:00–9:50

Micro/Nano Bio Robotic Manipulation

Toshio Fukuda and Masahiro Nakajima

Abstract

Biography

2. 9:50-10:40

Building Circuits with One-dimensional Nanowires

Wei Lu

Abstract

Biography

3. 11:00-11:50

Meeting the Challenge of Pick-and-place Nanomanipulation in Ambient Environment

Hui Xie and Nicolas Chaillet

Abstract

Biography

4. 11:50–12:40

Seeing in Real-time during AFM Nanomanipulation

Guangyong Li

Abstract

Although many nano-materials have shown their superiority, they still remain curiosities in many research labs without practical applications due to the lack of effective ways to manipulate them. Therefore, the research in nano-manipulation, nano-assembly, and nano-manufacturing is tremendously important for the advancement of nanotechnology. The main problem of nano-manipulation using Atomic Force Microscope (AFM) is the lack of real-time visual feedback during manipulation because the size of nano-materials is beyond the diffraction limit. This problem can be solved by the augmented reality enhanced nano-robotic AFM system, which can perform nano-manipulation with real-time visual and haptic feedback. The real-time visual feedback is achieved by combining the physical model prediction and local scan adjustment. Through the augmented reality interface, an operator can control the AFM probe movement and simultaneously feel the interactive forces and observe the real-time changes of the nano environment.

Biography

Guangyong Li joined the Department of Electrical and Computer Engineering at the University of Pittsburgh in Jan. 2007. He received his Ph.D. in Electrical Engineering from Michigan State University in 2006. He received his M.S. degree in Aerospace Engineering from Beijing Institute of Control Engineering, China Academy of Space Technology, in 1999, and B.S. degree in Mechanical Engineering from Nanjing University of Aeronautics and Astronautics, China, in 1992. He has published more than fifty technical papers in refereed journals and conference proceedings. He is the co-inventor of four patents. He received the distinguished IEEE Transactions on Automation Science and Engineering 2006 Best Paper Award. Currently, his research interests include micro/nano robotics; scanning probe microscopy; biosensors; organic solar cells; bio-electrical engineering in cellular biology and proteomics.

5. 14:00-14:50

Micro- to Nanomanufacturing with Bacterial Nanorobots

Sylvain Martel

Abstract

Biography

Sylvain Martel received the Ph.D. degree in Electrical Engineering from McGill University, Institute of Biomedical Engineering, Montréal, Canada, in 1997. Following postdoctoral studies at the Massachusetts Institute of Technology (MIT), he was appointed Research Scientist at the BioInstrumentation Laboratory, Department of Mechanical Engineering at MIT. From Feb. 2001 to Sept. 2004, he had dual appointments at MIT and as Assistant Professor in the Department of Electrical and Computer Engineering, and the Institute of Biomedical Engineering at École Polytechnique de Montréal (EPM), Campus of the University of Montréal, Montréal, Canada. He is currently Associate Professor in the Department of Computer Engineering and Software Engineering, and the Institute of Biomedical Engineering, and he is the Director of the NanoRobotics Laboratory at EPM that he founded in 2002. Dr. Martel holds the Canada Research Chair (CRC) in Micro/Nanosystem Development, Fabrication and Validation since 2001. Dr. Martel's main expertise is in the field of nanorobotics, micro- and nano-systems, and the development of novel instrumented platforms and a variety of related support technologies targeted mainly for biomedical and bioengineering applications, and nanotechnology.

6. 14:50-15:40

Toward Wafer-scale Robotic Microfactories for Nanomanufacturing

Dan Popa

Abstract

Biography

7. 16:00–16:50

Nano-scale Biological Systems Inspired Engineering for NanoManufacturing and Robotics

Mingjun Zhang

Abstract

This talk will cover our recent research on nano-scale biological systems inspired engineering, including 1) venus flytrap sensing and closing mechanism; 2) ivy, marine mussel and barnacle nanoparticle secreting mechanisms; and 3) molecular immune system decision-making as well as viral dynamics. Both experimental investigations using AFM and Laser Scanning Confocal Microscope, and theoretical studies based on mathematical modeling and system theory will be presented.

Biography

Mingjun Zhang is an associate professor of biomedical engineering at the University of Tennessee, Knoxville. He received the D.Sc. degree from Washington University in St. Louis and the Ph.D. degree from Zhejiang University, P. R. China. He also received MS degrees in Biomedical Engineering and Electrical Engineering from Stanford University. He was an associate editor of IEEE Transactions on Automation Science and Engineering and a member of the Nanomedicine Editorial Board. Mingjun is also the co-editor of the books on "Nanomedicine -- A Systems Engineering Approach", "Life Science Automation -- Fundamentals and Applications", and "Medical Automation -- A Systems Engineering Approach". He was awarded the Early Career Award (Industrial/Government) by the IEEE Robotics and Automation Society in 2003. He along with colleague first discovered that ivy secretes nanoparticles in the process of affixing to surfaces. The discovery was featured by Science Magazine, Nature Nanotechnology and Nature Materials, and over 80 scientific press and media. The discovery was listed as one of the 8 most important nano news globally for the week of May 30, 2008 by NIL.

Mingjun's research interests lie in Nano Bio-systems and Bio-mimetics. Nano-scale biological systems inspired engineering and system theory. Over the past several years, his research has focused on fundamental techniques that may help to explore the above interests, including mathematical modeling techniques for cell biology, micro/nano-scale bio-control mechanisms, biological con-focal microscopy and AFM, inkjet technology for bio-chip fabrication. He is currently working on nanoparticle based adhesive and climbing mechanism, venus flytrap inspired micro-manipulator, bio-marker based controlled drug delivery, inkjet technology enabled probe tips for bio-nano-fabrication, dynamics and feed forward control of molecular systems, game theoretical formulation of biological immune system, integration of biological con-focal microscopy and AFM.

8. 16:50-17:40

NanoRobotic Fluidic Systems

Lixin Dong, Xinyong Tao, Li Zhang, Xiaobin Zhang, and Bradley J. Nelson

Abstract

Growing interests in nanofluidics have been motivated by the fundamental studies of physical, chemical, biological, medical, and engineering processes for such potential applications as mass and energy storage and transport, single chemical or biological molecule analysis, drug delivery, and electronics. The most fundamental elements in a nanofluidic system are nanochannels, which can be defined as channels with at least one cross section thinner than 100 nm. Due to the difficulty on the fabrication of nanochannels, nanofluidic systems may need new techniques for the implementation. Bottom-up approach is an important candidate, with which nanofluidic systems can be built by assembling as-synthesized or as-fabricated building blocks such as channels, valves, pumps, mixers, separators, sensors, actuators, etc. This talk will highlight our recent efforts on the construction and characterization of carbon nanotube (CNT) based nanofluidic systems using nanorobotic manipulation including (1) Controlled melting, evaporation and flowing of attogram copper and tin intra-/inter-nanotube shells. (2) Cap-to-wall and wall-to-cap mass transport in nanofluidic junctions. (3) Modes of melting and evaporation including electric current driven heating, diffusion, electromigration, charge, ionization. (4) Applications and potential applications in nanorobotic spot welding, self-soldering, fluidic actuation, etc.

Biography

Lixin Dong is an Assistant Professor at Michigan State University. He received the B.S. and M.S. degrees in Mechanical Engineering from Xi'an University of Technology (XUT) in 1989 and 1992, respectively. He became Research Associate in 1992, Lecturer in 1995, and Associate Professor in 1998 at XUT. He received his Ph.D. degree in Micro Systems Engineering from Nagoya University in 2003, and became Assistant Professor at Nagoya University in 2003. In 2004 he joined Swiss Federal Institute of Technology (ETH) Zurich as a Research Scientist, and has been a Senior Research Scientist at ETH Zurich from 2005 to 2008, where he led the NanoRobotics Group in the Institute of Robotics and Intelligent Systems (IRIS).

His main research interests include nanorobotics, mechatronics, nanoelectromechanical systems (NEMS), mechanochemistry, and nanobiomedical devices. He was a co-winner in Nano Today Cover Competition in 2008. He received the IEEE T-ASE Googol Best New Application Paper Award in 2007, Best Conference Paper Award at the Int. Conf. on Control Sci. and Engr. (ICCSE2003), Best Automation Paper Award—Finalist at 2007 IEEE Int. Conf. on Robotics and Automation (ICRA2007), RSJ/SICE Award for 2005 IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS2005) Best Paper Nomination Finalist, and Finalist in the Best Conference Paper Competition at ICRA2001. He serves as an Associate Editor of the IEEE Trans. on Nanotechnology and the IEEE Trans. on Automation Science and Engineering, and has chaired several international conferences and workshops.