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US – Taiwan Workshop on Simulation-Based Engineering and Science (SBE&S) in Enabling Transformative Technology

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Acknowledgment

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I) Introduction

The "US – Taiwan Workshop on Simulation-Based Engineering and Science (SBE&S) in Enabling Transforming Technology" took place February 18-21, 2008 at the beautiful National Cheng Kung University (NCKU) in Tainan, Taiwan. This unique workshop brought together researchers from outstanding Taiwanese and US universities and national labs in an intimately collaborative environment. The aim of this workshop was to enhance collaboration between research teams in Taiwan and the US in emerging technology through an intensive exchange of related state-of-the-art research being carried out in both countries. These interactions among researchers and students will lead to meaningful research partnerships, curriculum building, and technology transfer between these countries.

The workshop presented nano-engineering, energy harvesting, nano-manufacturing and nano-engineered medicine with one of the focuses on the viewpoint of simulation-based engineering and science. The discussions and interactions at the workshop identified research activities and roadmaps to remove the challenges associated with focused applications. In addition to technical discussions, US-Taiwan bilateral collaboration was stimulated by the issues proposed in the workshop.

II) Background

Funding for the workshop

Funding for this workshop was obtained from dual grants from the US National Science Foundation (NSF) and the Taiwan National Science Council (NSC).

Focus of the workshop

The focus of the workshop was primarily nano-engineered biomedicine, enabling materials and energy by demand. Given the rapid advance in genomics, informatics, sensing, wireless communication, and micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS) technologies, it is not difficult to envision that future medical treatments will be patient-specific and handled by integrated nano-devices which can sense, think, communicate, and act. These integrated nano-devices can be equipped with various functions to perform multiple special-purpose tasks. For example, a whole process of medication could include the use of nano-engineered devices and processes as described below.

While these advances are not yet readily available, many potential applications are possible. For example, a self-guided, or remotely steered, sensing device could be injected into the human body and move around for better detection and cell sample collection. Another application could be a special device designed to deploy a site-specific precise dosage of medicine. The nano-engineered therapeutics could incorporate special coatings to tailor the release profile of a given drug. A nano-sensor could also be added to monitor the effectiveness of the medication in real time. Each of these methods could improve the health and disease maintenance for many patients.

Although clinical researchers and biologists are very interested in the medication processes described above and are currently ambitiously pushing for the technology developments necessary to make them a reality, there are several basic engineering challenges. These challenges can be categorized into 3 areas: materials, energy, and manufacturing processes.

Materials selection is critical for these applications. In order to perform appropriate functions, some components may need to be strong but highly flexible. There also might be other components that require a certain level of stiffness along with shape memory capabilities. Coating materials to minimize stiction and friction, interaction between organic and inorganic materials, energy absorption, tribology, and Radio Frequency (RF) transmitting capabilities are all important consideration factors in nano-device designs.

Providing power to a nano-device to support movement and communication functions as well as minimizing power consumption could be among the most difficult challenges that nano-engineers are facing today. New nanotechnology-enabled energy sources have to be discovered and storage systems need to be identified. In addition, the development of new delivery systems should receive a high level of attention.

It is expected that during the delivery of drugs via nanoscale devices, all the nano-medicine will be consumed and most of the nano-device disposed. Therefore, robust and high through-put nanomanufacturing processes have to be developed for making nano-medicine and fabricating nano-devices. It is well known that there are many nano-building blocks (e.g. nanotubes, nanowires, nanorods, and nanoparticles) that provide special properties and can be used for special functions. However, how to control the growth of the building blocks to preferred sizes and shapes, and how to manipulate and arrange them to the desired organized patterns still remain major engineering challenges. Correlation of the nanopatterns and material properties also requires an intensive research effort.

In summary, the above focus areas serve as the Integrative Foundations for the emerging field of nanoengineered medicine with respect to device development. The coalescence of these integrative foundations serve as a 'Means to an End' approach of achieving critical advancements, whether it's a novel diagnostic system, organ-addressing implant, active biomaterial, and so on. While energy in the general sense is not the first thing that many think of when addressing nanomedicine, it is certainly a critical requirement for novel implant technologies.

III) Summary

Lecture Highlights

The lectures given at this workshop targeted the following highlighted topics: biomedicine and drug development, nanomaterials and nanodevices, nanomanipulation and nanomedicine, nanoenergy, and nanoengineering and their implications for simulation-based engineering and science for emerging and transforming technology, which was the overarching theme of the workshop. Each lecture discussed the idea of modeling and simulation enabled nanoengineering, or a smaller branch of nanoengineering, and its emerging applications and technologies. The lecture content depth and specificity was up to the discretion of the speaker, however, each talk had these basic themes.

In the biomedicine and drug development category, lectures were given discussing simulation based biomechanics, models of DNA molecules and their biosensor applications, the design for potent and selective integrin drugs, and the use of a stochastic multiresolution mathematical analysis frameworks for molecular bio-regenerative engineering.

Relating to nanomaterials and nanodevices, discussions were held on the development and molecular dynamics studies of nanostructures using nanomechanics, namely in human cortical bone and computational nanophotonics, molecular dynamics study of phase transformations for silicon under nanoindentation and its applications, Moore's Law and high-k gate dielectrics for advanced transistor technology, functionalized nanomaterials with applications in biology and technology, and the study of cell dynamics using force propagation and live cell interferometry.

Under the theme of nanomanipulation and nanomedicine, discussions included nanofabrication of carbon nano-cones as indenter tips, the use of bioregenerative engineering in the treatment of human disease, using time-resolved microscopy for molecular dynamics imaging and simulation, work towards scaffolds for regenerative medicine, and laser-induced transition of nanodiamonds. In the lectures on nanoenergy, we discussed nanostructured materials and nanoenergy and their technological and scientific barriers and economical opportunities.

At the end of the lectures, there was a panel discussion held to assess the success of this workshop. This discussion is discussed in the Section IV: Achievements – Panel Discussion. In this section, the goals and achievements of the workshop are discussed as well as suggestions for improvement and potential points of collaboration.

Honorary Doctorates – Dr Britton Chance and Dr Aaron Ciechanover

On Tuesday, February 19, 2008, honorary doctor of science degrees, honoris causa, from the National Cheng Kung University (NCKU) were awarded to Professors Britton Chance and Aaron Ciechanover. They were given this prestigious honor for their advancements in science and technology, as well as their close professional association with NCKU.

According to NCKU President Michael Lai, the honoring had two profound implications for NCKU. The first is that it will be the "consummation of relationships between Ciechanover and Britton with NCKU". The second is that it would be the first time NCKU awards honorary doctorates to "intellectual giants" from the United States and Israel. This, according to Lai, is a manifestation of NCKU's resolution to become an institution of higher learning on the world stage. Thus, these honorary degrees would provide the opportunity for NCKU to further cement and continue their relationships with Ciechanover and Chance.

Dr Britton Chance

Professor Britton Chance, the father of biophysics, has become an icon of science and technology in the past century. Professor Chance earned his BS, MS and PhD degrees from the University of Pennsylvania (in 1935, 1936 and 1940, respectively), at which he is now Professor Emeritus of Biophysics. He earned a second PhD degree at Cambridge University in 1942, and received his D.Sc. from Cambridge in 1952. However, his work began at age 18 with his first invention of "Compass Controlled Automatic Ship Steering", and then at age 25, he invented the first optical sensor for magnetic compasses. Shortly thereafter, he invented a "Mechanically Differential Analyzer for Solutions of Non-linear Differential Equations for Enzyme Action".

In 1943, Dr. Chance helped invent an antiaircraft 10 centimeter auto tracking radar directly coupled to Bell Labs electronic computer and 5" hydraulically controlled guns in MIT's Radar Lab (now known as Lincoln Lab). His invention helped the US at Anzio and Normandy in World War II. After the war, he invented the "electronic circuit for ENIAC", the first ever electronic computer. In addition to this long list of notable achievements, in the summer of 1952, he and his team won the Olympic gold medal in sailing for the US. In 1974, Dr. Chance won the National Medal of Science. Britton Chance is also a foreign member of the Royal Society, member of the National Academy of Sciences, and member of the American Philosophical Society, amongst many other prestigious memberships.

Dr. Chance's lifetime of outstanding achievements and accomplishments is one to be envied, and his productivity should be an inspiration to researchers and scientists. Now, at age 95, his contribution to science has yet to cease. His current research uses microoptical electronics for early detection of breast cancer.

Dr Aaron Ciechanover

Professor Aaron Ciechanover of the Technion-Israel Institute of Technology won the Nobel Prize in

Chemistry in 2004 with Avram Hershko and Irwin Rose for their discovery of the ubiquitin system for intracellular protein degradation. Dr. Ciechanover currently holds the position of Distinguished Research Professor of Biochemistry in the Rappaport Faculty of Medicine at the Technion in Haifa, Israel. In 2000, he was awarded the prestigious Albert Lasker Prize for Basic Medical Research. He is also a foreign member of the National Academy of Sciences of the US. In addition to these honors, he is a Visiting Distinguished Chair Professor in the Institute of Innovations and Advanced Studies at NCKU, for which he has made many contributions.

Professor Ciechanover's impressive collaborative work and contributions to science and biology with researchers in multiple countries including Israel, Taiwan and the United States should be a model that researchers aspire to follow.

Dr T.P. Ma

Professor Ma is Raymond John Wean Professor of Electrical Engineering at Yale University, and serves as Chairman of the Department of Electrical Engineering and as Co-Director of the Yale-Peking Joint Center for Microelectronics and Nanotechnology. He is also a Professor of Applied Physics and the Acting Chairman of the Electrical Engineering Department in 1988 and Chairman from July 1991 to June 1996. In February 2003 Prof. Ma was elected a member of the National Academy of Engineering.

Prof. Ma has served on many committees at Yale University, including the Executive Committee of the Graduate School, Executive Committee of the Yale College, Teaching and Learning Committee (Chair 1996), Senior Faculty Appointments Committee, Junior Faculty Appointments Committee, Minority Advisory Council, Physical Sciences and Engineering Advisory Committee, Engineering Faculty Development Committee, Bouchet Award Committee, Assistant Dean's Search Committee of Yale College (Chair), and Steering Committee of NEASC Accreditation.

After graduation from Yale University with a Ph.D. degree in 1974, Prof. Ma did research at IBM on advanced silicon device technology and ionizing radiation effects in MOS devices until joining the Yale faculty in 1977.

Prof. Ma's research and teaching at Yale have focused on microelectronics, semiconductors; MOS interface physics, ionizing radiation and hot electron effects, advanced gate dielectrics, flash memory device physics, and ferroelectric thin films for memory applications. He is a patent holder, co-editor of a book, has given numerous invited talks at international conferences, and contributed to several book chapters as well as over 180 research papers.

Prof. Ma has been actively involved in organizing, chairing, or serving as a committee member of numerous technical conferences, including the IEEE/SISC, IEEE/DRC, IEEE/NSREC, VLSI-TSA, SSDM, EDMS, ICSICT, ECS, and MRS meetings. He was the Symposium Chair of the 1999 International VLSI-TSA Symposium held in Taipei June 1999 and, since 2001, is a member of this Symposium's Steering Committee.

The awards and honors that Prof. Ma has received for professional achievements include the 2006 SIA (Semiconductor Industry Association) University Researcher Award, the 2005 IEEE Andrew S. Grove Award, a 2005 Pan Wen-Yuan Research Award, a 1998 IEEE EDS Paul Rappaport Award, two B.F. Goodrich National Collegiate Inventor's Advisor Awards in 1993 and 1998, respectively, the 1991 Connecticut Yankee Ingenuity Award, and the 1975 Harding Bliss Prize at Yale University. Prof. Ma is a member of the National Academy of Engineering (NAE), a Fellow of IEEE (Institute of Electrical and Electronics Engineers), a Member of the Connecticut Academy of Science and Engineering (CASE), a life member of APS (American Physical Society), and a member of ECS (Electrochemical Society), MRS (Materials Research Society), Sigma Xi, and Yale Science and Engineering Association (YSEA).

Prof. Ma is an Honorary Professor of the Chinese Academy of Sciences, an Honorary Guest Professor of Tsinghua University, Tianjin University, and of Shandong University.

T.P. Ma has served as a consultant for industry worldwide. He has also been the Principal Investigator of joint R & D projects with numerous high-tech companies worldwide, including IBM, Intel, Motorola, TI, Sematech, Micron Technologies, Lucent Technology, GE, AMD, Hughes, LSI Logic, Rockwell Semiconductors, JPC, ATMI, PSS, Philips, Siemens, Hitachi, NEC, Toshiba, Mitsubishi Electric, Macronix, and TSMC.

Technology Tours

In accordance with the second objective of the US-Taiwan workshop on simulation-based engineering and science in enabling transforming technologies, two days were devoted to conduct technical tours. The technical tours were developed to witness the successful stories about the federally-assisted industrial parks, including the Hsin-Chu Science Based Industrial Park and the Central Taiwan Science Based Industrial Park. Each science industrial park is affiliated with several premier universities, national laboratories, and hi-tech industries. The Hsin-Chu Science Based Industrial Park serves as the ideal model for industry-government-academia entrepreneurship primarily focused on electronics. The Central Taiwan Science Based Industrial Park is primarily focused on the R&D in Optoelectronics.

The technical tour consisted of a visit to the key national research facilities on the campus of NCKU and the Industrial Park members, the Taiwan Chi Mei Optoelectronics Corporation (CMOS) and the Taiwan Semiconductor Manufacturing Company Limited (TSMC).

Taiwan Chi Mei Optoelectronics Corporation (CMOS) is one of the world’s largest suppliers of liquid crystal displays for flat-screen for television sets and monitors. CMOS was founded in 1998 as one of the first Taiwanese on thin-film-transistor liquid crystal display (TFT-LCD) company with its own color filter production. CMOS also provides leading edge technology for organic LED displays with their largest display being presented in their showroom. CMO's Eco TV, a highly efficient dynamic contrast display was also showcased in their showroom.

Taiwan Semiconductor Manufacturing Company Limited (TSMC) has the broadest range of technologies and services in the industry. TSMC created the semiconductor dedicated foundry industry when it was founded in 1987. TSMC strives to provide superior semiconductor manufacturing services for worldwide customers and cultivate mutually beneficial, long-term partnerships. The company has readied its most advanced 12-inch GigaFabs for 45nm production, having the capacity to generate tens of thousands of 12-inch wafers per month. One of the GigaFabs, Fab-14, became the world’s most advanced process technology in the foundry industry and is the only 100% automated production line foundry in the world. A comprehensive tour of the foundry was provided, explaining the production process of highly integrated, very small and very low power devices for many conceivable markets.

The technical tours spurred many informal discussions and networking among the delegates. Through this close interaction, the researchers from the U.S. and Taiwan established the exchange and collaboration based on their research emphasis.

This photo was taken after a tour of the clean-room facilities at Taiwan Semiconductor Manufacturing Company Limited (TSMC) on February 21, 2008.

Many more pictures can be found at http://140.116.206.67/Activity_Photos/Activity_Photos.html .