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BioMEMS and Bio-Optics Technology Seminar Held at PIDC

The fast-developing field of MEMS (Microelectrical Mechanical Systems) offers the advantages of low cost, smaller size, portability, noninvasive action, low power consumption and environmental compatibility. This area of biotechnology promises many applications in daily life and has attracted much research attention. "BioMEMS" refers to the application of MEMS to various bio-medical uses.

To promote biotechnology in Taiwan, PIDC (Precision Instrument Development Center, National Science Council) invited two experts in BioMEMS and Bio-optics from Louisiana Tech University to conduct a three-day seminar (Mar. 6~8). Louisiana Tech University's Institute for Micromanufacturing is one of the world's leading research organizations in bioMEMS and bio-optics. Thanks to widespread interest in the topics covered, the program was fully booked soon shortly after it was announced. While PIDC did its utmost to accommodate as many as possible of the numerous applicants, due to limited space only 98 participants could be admitted to the seminar. About half of the participants came from universities, one third from research institutes, and the rest from industry. Their educational background included medicine, biology, natural science, and engineering.

Professor Bruce Gale giving a presentation.

Seminar participants filled an entire conference room.

Professor Bruce Gale shared his research results and experiences with the participants concerning such topics as the Biocompatibility of MEMS Devices, Microfabrication of Polymers and other Biomaterials, Microsurgical Tools, Micro needles, and Drug Delivery, Miniature Bioreactors and Microsystems for Tissue Engineering, Micro Total Analysis Systems, Fluid Control Components, Sample Preparation and Handling, Separations, Systems for Biotechnology and PCR, and Biosensors and Detectors. According to Prof. Gale's definition, BioMEMS are MEMS designed for various biomedical applica-tions, and include blood pressure sensors, micro total analysis systems, DNA hybridization arrays, micro needles, and micro surgical tools. Some of these systems are reaching maturity, while others are still in the research stage. Prof. Gale appealed for more people to enter this very interesting and promising research field and develop applications that will benefit everyone.

Professor Mike McShane addressed the topics of Biomedical Optics, Optical Properties of Materials, Tissue Optics, Infrared and Raman Spectroscopy, Fluorescence Spectroscopy, Biomedical Optical Sensors, Micro-Optics, Application of Micro-Optics in Medicine, Biology,and Biotechnology.

Prof. McShane noted that applications of optical engineering can be found all around us, in fiber optic communications, printing, CD heads, cutting, welding, metrology and lithography, to name but a few. In fact optics have become a necessary part of everyday life. Furthermore, optical engineering is also a very powerful tool in biomedical research, and plays critical roles in applications such as contact lenses, physical sensors, chemical sensors, laser surgery, photodynamic therapy and endoscopes. Although optics is a well-developed science, it is only recently that researchers began to use optical applications in biomedical research. But due to its broad utility, bio-optics definitely has a bright future and offers much room for further investigation and research.

The presentations given by these two scholars were very stimulating and were warmly received. Although biotechnology is a complex inter-disciplinary field, and it was difficult to transmit all the intricacies of these areas in such a short period of time, the seminar surely supplied the participants with much overall knowledge and food for thought. It is also certain that the seminar has lent impetus to the development of bioMEMS and bio-optics technology in Taiwan.

Dr. Chien-Jen Chen, Director General of PIDC, warmly invited the visiting professors and their families to come again soon to discuss both the exchange of research results and experience and also the possibility of building a long-term research partnership.

NSC to Sign Large Hadron Collider (LHC) Project Agreement with CERN

CERN (European Council for Nuclear Research) receives funding from twenty European countries in proportion to their GNP. Ministry-level representatives from the member nations sit on the CERN council and direct the operations of this quasi-governmental international organization.

CERN is currently in the midst of building the next-generation Large Hadron Collider (LHC), which will be the largest research facility of its kind. The collision energy and luminosity offered by the LHC when it is completed in late 2005 will be at least one order of magnitude greater than those of the Tevatron at America's Fermilab. Experiments conducted at the LHC will simulate conditions only 10^{-28} second after the birth of the universe, allowing the birth of matter to be probed. The LHC will be the leading joint international project in physics during the early part of the 21st century. Apart from the twenty nations making up CERN, the observer nations US, Japan, Russia, Canada, and India, as well as non-member nations, will also participate in the construction of the LHC accelerator.

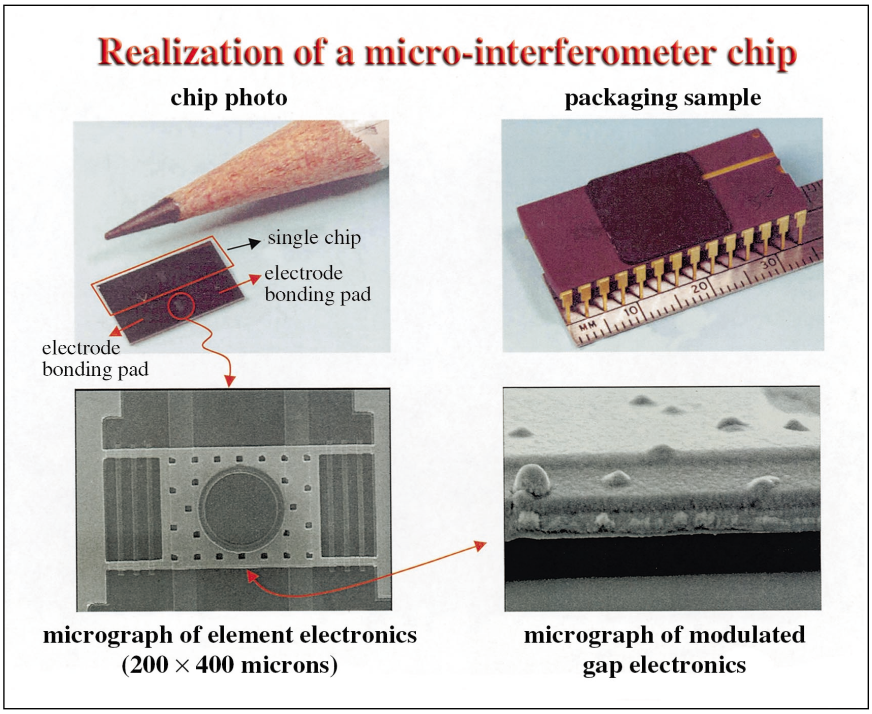
LHC Memorandum of Understanding signing ceremony between the NSC and CERN.

Four experiments will be performed soon after the LHC begins operations. The two largest of these will be the ATLAS and CMS detector experiments. At least 2,000 scientists from more than 30 countries will take part in these experiments, and the cost of fabricating the detectors alone will be approximately 500 million Swiss francs. Under plans made by the NSC, Taiwan will send a team to participate in the ATLAS and CMS experiments. While the NSC's plan received the approval of the ATLAS and CMS experiment divisions in June 1999, the NSC and the Taiwan scientific team must still sign a memorandum of understanding (MOU) with the ATLAS and CMS divisions and CERN headquarters.

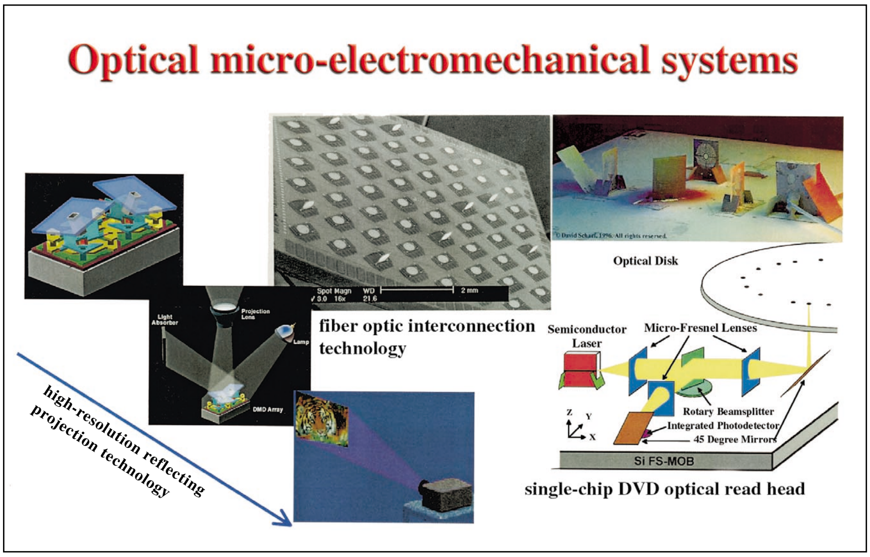
Prof. Cashmore, CERN's representative, is expected to soon arrive in Taiwan to sign an MOU with the NSC. The NSC plans to fund two experiment teams assembled from researchers at the Academia Sinica, National Taiwan University, and National Central University. These teams will cooperate closely with other domestic research organizations, including the Industrial Technology Research Institute, the Chung Shan Institute of Science and Technology, and Chung Hwa Telecom, as well as companies such as Chieh Yao Technology and Guang Huan Technology, and share information on the components of the 3 million Swiss franc ATLAS and CMS detectors.

The Micro-Interferometer—A Powerful Tool of the Future in Fiber Optic Communications and Bio-Medical Sensing

Micro-systems technology is widely reckoned to be one of the most promising technologies of the future. The scope of potential micro-systems applications includes electronics, computers, materials, medicine, biochemistry, communications, and aerospace. All of the leading industrial nations are vigorously forging ahead with research and development work, and it is projected that micro-systems applications will generate US$40 billion in revenue worldwide in 2002. To promote the development of the domestic micro-systems industry, government, industry, universities, and research organizations are actively committing themselves to R&D projects in this area. The *National White Paper on Science and Technology* specifically lists micro-systems as a key area of future scientific and technological development. Building on its many years of experience in laser micromachining and micro-EDM development, the Precision Instrument Development Center (PIDC) acquired excimer laser micromachining technology in 1997–Taiwan's first venture into the field of micro-system processing. PIDC has focused its R&D efforts on developing micro-instruments, micro-optics, and LIGA processes, and has currently become the world's sole research organization simultaneously possessing ultraviolet, laser, and plasma etching equipment. It is also the center of LIGA development efforts in Taiwan. As far as micro-instruments are concerned, PIDC has followed up on the successful development of a micro-spectrometer with a micro-interferometer and MST wafer-level packaging technology, establishing itself as a leader in the field.



Building a micro-interferometer involves the integration of optics, mechanics, and electrical technology. PIDC has combined an electrostatic micro-actuator with a resonant cavity to make the length of the resonant cavity adjustable, allowing the creation of adjustable-wavelength lasers for use in active fiber optic elements. The available of these lasers will sharply reduce the number of lasers and narrow-bandwidth optical filters needed in dense wavelength-division multiplexing (DWDM) elements. And because this micro-interferometer is



created in a low-temperature process, almost any kind of substrate can be used, including silicon or glass, etc., allowing it to take advantage of different materials' absorption spectra. This low-temperature process enables the micro-interferometer structure to be directly integrated into a vertical cavity surface emitting laser (VCSEL) fabrication process, facilitating the fabrication of integrated, adjustable VCSELs.

While many domestic fiber optic communications firms are making large investments in the development of DWDM passive-element optical components, an analysis of the market reveals that the main demand for key fiber optic communications components has shifted to active-element devices. According to an assessment by the Photonics Industry & Technology Development Association, the market for active optical elements will swell from US$10.3 billion in 2001 to US$20.2 billion in 2003, while the worldwide market for passive optical elements will be only US$4.3 billion in that year. This is why technology developed by PIDC will help relevant domestic firms enter the active optical elements market and improve their competitiveness. Furthermore, the spectral filtering capability offered by a micro-interferometer can be incor-porated in bio-chips developed using semiconductor technology. The resulting precision biological spectral measuring technology can be used analyze the chemical make-up of biological specimens, leading the way to the development of hand-held biomedical sensors, including non-invasive glucose detectors and uric acid monitors, etc.

In the area of key wafer-scale packaging technologies for micro-system elements, PIDC has taken advantage of new dry etching technology to make holes in silicon wafers, which can be filled with metallic conductors through electroplating to connect the two sides of the wafer. The resulting wafers can be soldered to micro-system elements, causing them to serve as protective caps for the micro-system elements, and also providing a connection between the chip's bonding pad and the outside world. Apart from application to micro-electromechanical elements, this technology can also used in the chip-scale packaging (CSP) of ordinary integrated circuit chips and in three-dimensional wafer stacking technology. It thus can help meet the need for miniaturization in e-Age hand-held communications products. Survey results published in the *Electronics Trend Report* indicate that the worldwide CSP market will grow to 6.1 billion units by 2002. Taiwan's packaging industry already had an output value of more than NT$70 billion (approximately US$2.1 billion) in 2000, and the chip drilling and lead connection technology developed by PIDC promises to give relevant firms a chance to move up to a higher technological level.

The micro-electromechanical system fabrication and testing technology developed by PIDC has enabled the drafting of standardized process criteria for the development of complete micro-system production technologies. In addition, PIDC's realization services allow domestic universities and high-tech firms to bring their innovative design ideas to fruition. Furthermore, PIDC is exchanging technology and sharing resources with universities by allowing graduate students to take part in research, which also trains the country's future micro-systems industry personnel. This is how PIDC is working to consolidate Taiwan's micro-systems technology foundation and realize the government's dream of transforming Taiwan into a "Green Silicon Island."

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