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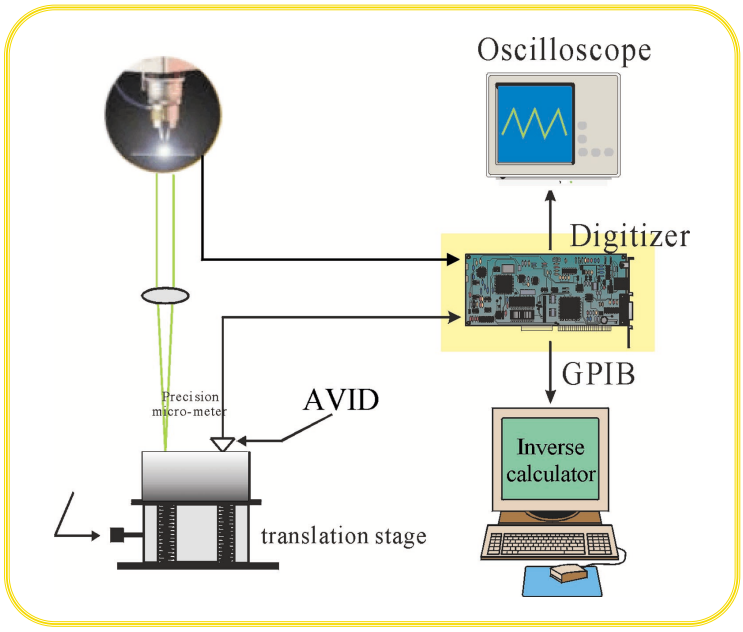
A New Quality Control Weapon Comes on Line: A Laser Ultrasound Nondestructive Testing System for Thin Coatings

To safeguard the quality, safety, and manufacturing efficiency of their leading products, the world's industrialized nations have applied ultrasound, electromagnetic waves, and other types of radiation to the nondestructive testing of product structures. For instance, in the area of aerospace, nondestructive testing technology can be used to detect fatigue cracks before they threaten the in-flight safety of aircraft. In the power and petrochemical industries, the thorough non-destructive testing of all high-pressure vessels and storage tanks is an essential part of the industry's public safety efforts. In the electronics industry, precision online non-destructive testing can reduce product defect rate, improve quality, lower costs, and improve international competitiveness. Taiwan has gradually acquired non-destructive testing technology since the 1970s to meet the needs of shipbuilding, aircraft maintenance, and power plant construction and operations. But while many nondestructive testing engineers have been trained over the past three decades, and are now widely employed throughout public and private enterprises, the country still lags far behind in advanced nondestructive testing technology R&D.

The Institute of Applied Mechanics of National Taiwan University has recently carried out the NSC-sponcered research project "Nondestructive Thin Layer Evaluation System Using Laser Ultrasonics." This project integrates ultrasound, an advanced pulsed laser source, optical non-contact measurement techniques, and inverse calculation theory to develop an advanced nondestructive testing system suitable for testing of fiber-reinforced composites, thermal barrier coatings on aircraft engine turbine blades, and surface coatings on electronics parts. The project's findings can be applied to many aspects of precision non-destructive testing, improving Taiwan's competitiveness in this area. For instance, in the measurement of wave signals, the system can be used to accurately measure high-frequency elastic wave signals with sub-nanometer resolution. It is expected that the system will make a large contribution to the calibration of ultrasound transducers and detection of sub-nanometer elastic wave signals. In the testing of materials, the system can be used to test the individual material parameters and ultrasound characteristics of five or more anisotropic materials or crystalline substances at once. The system is well-suited to testing the characteristics of advanced materials and can facilitate subsequent R&D and design tasks.



The system can be used to test for delamination in composite materials. It will help insure flight safety by performing non-contact inspection for delamination caused by impact on aircraft wings or fins. Applied to detection of bonding layers, the system can detect the mechanical properties and thickness of bonding layers hidden several tens of microns below the surface. It will thus be an important tool in the quality assurance of composite structures. In the nondestructive testing of thin layers, the situation will be able to detect defects in the thermal barrier coating of engine blades, and measure the depth of coating abrasion. These capabilities will increase Taiwan's

aircraft maintenance competitiveness. In addition, the system's testing frequency can be increased to several hundred MHz, and the laser ultrasound platform can be applied to the measurement of the thickness and mechanical properties of submicron films in semiconductor processes.

Since Taiwan expects to be an industrialized nation by 2010, improvement of nondestructive testing R&D and applications will play an essential part in raising the quality and safety of the nation's power, petrochemical, aerospace, and construction engineering industries. This "Laser Ultrasound Nondestructive Testing System for Thin Coatings," which draws on elastic wave theory, pulsed laser measurement, and inverse calculation techniques, is a nondestructive testing platform that can be applied throughout the aerospace, machinery, and electronics industries. It has the potential to greatly enhance the quality of Taiwan's products and insure aircraft safety.

NSC-Sponsored Research on Stomach Cancer – The Roles of Tyrosinase Kinase

Due to economic development and changing lifestyles, the incidence of stomach cancer in Taiwan has declined in recent years. Nevertheless, stomach cancer is still the second most common cancer worldwide – behind only lung cancer – and is the fourth most common cause of deaths involving cancers in Taiwan. While stomach cancer is an important cancer in Taiwan and abroad, its carcinogenic mechanism is still unclear. Because this mechanism may involve a multi-factor, multi-step process, research on this mechanism requires extensive cooperation between clinical physicians and research scientists. Sponsored by the NSC, an interdisciplinary research program project carried out by a team of the Academia Sinica, National Taiwan University Hospital, and Veterans General Hospital – Taipei has achieved many significant results over the past three years. The finding on gastric cancer tyrosine kinase expression profile is one of the examples.

Cells seem to be controlled by precisely defined programs similar to tiny computers, whose programs direct the cells' growth, maturation, differentiation, and death. The functions of cellular proteins include expansion, filtration, destruction, and transmission of signals etc. Cells express roughly 20,000 ~ 30,000 genes at one particular stage and thus generate even more different kinds of proteins following post-translation modifications. The mutual interaction and dialogue between these proteins results in decisions concerning whether the cell should grow/divide or maintain at a biochemical steady status. For their biological functions, genes are utilized to manufacture proteins, and constitute a smooth-running communication network within a cell. Oncogenes (cancer-causing genes) are often mutated versions of genes that may generate erroneous protein products. Oncogenes initiate cancer by telling cells to grow at inappropriate times or losing the appropriate checkpoint controls. Some genetic changes associated with stomach cancer have already been discovered, including microsatellite instability, telomerase activation, inactivation of tumor suppressor genes, and activation of oncogenes. One particularly important issue in research on the initiation and growth of cancer is the expression of protein tyrosine kinase (PTK) genes.

PTK is an important class of molecule transmitting growth and differentiation signals in normal cells via signal transduction pathways. Because PTK plays such a crucial role in regulating cellular growth, Prof. Wu Chew-wun of Veterans General Hospital – Taipei and Dr. Lin Wen-chang of Institute of Biomedical Sciences, Academia Sinica have focused their attention on PTK genes in clinical stomach cancer tissue and cultured stomach cancer cells. These researchers have used the polymerase chain reaction (PCR) to detect and identify new kinase genes with low expression levels. As of recently, Prof. Wu and Dr. Lin had identified more than 50 types of PTK from gastric cancers, many of which had not been studied in connection with stomach cancer previously. Among their findings, several types of non-receptor PTK (fyn, itk, tyk2), receptor PTK (c-fms, c-kit, cak, tie-1), and the dual kinase MKK4 are apparently expressed to a greater degree in stomach cancer tissue than in normal stomach mucosa tissue.

The research team employed immunohistochemistry to perform further clinical studies of certain types of PTK. They discovered that tie-1 and MKK4 have an important influence on prognosis and can serve as independent tumor markers. MKK4 showed a relatively significant effect on late-stage stomach cancer, while both play important roles in the spread of the cancer. It has also recently been discovered that two members of the axl family – axl and nyk – are both expressed in advanced gastric carcinoma, and can thus serve as significant prognostic factors. Research on arg kinase is currently underway.

Research over the next three years will study multiple cancers and

possible carcinogenic mechanisms involving the bacterium *Helicobacter pylori* and pesticides. It is hoped that the findings of this research can be used to improve the effectiveness of early diagnosis and treatment under clinical and preventive medicine contexts.

Important Visits to Spur International Cooperation

October 2002 has been a very important month for the NSC. On October 24, Dr. Lee Hartwell, the director of the Fred Hutchinson Cancer Center and 2001 winner of the Nobel Prize in medicine, visited the NSC. The Fred Hutchinson Cancer Center is America's largest independent biomedical research center and has an annual research budget in excess of US$245 million. And on October 23, Dr. Hermann Grunder, head of the largest national laboratory under the US Department of Energy – the Argonne National Laboratory – visited Taiwan at the invitation of NSC Chairman Dr. Wei Che-ho.

Dr. Lee Hartwell, director of the Fred Hutchinson Cancer Research Center, arrived in Taiwan early on October 20. Accompanied by Prof. Chen Ding-shin, dean of the National Taiwan University College of Medicine and Academician of the Academia Sinica, and Dr. Chen Pei-jer, director of the National Taiwan University Medical Center Hepatitis Research Center, Dr. Hartwell talked with NSC Chairman Dr. Wei Che-ho on the afternoon of October 24. Reporting on what had been said at the meeting, Chairman Wei afterwards mentioned the importance that Dr. Hartwell placed on this trip, his first visit to Taiwan and his first visit to Asia in over twenty years. Chairman Wei also emphasized that international cooperation is becoming increasingly important in most cutting-edge research fields, and declared that international teamwork has demonstrated clear superiority to a "go-it-alone" approach. Hence Taiwan must adopt systematic cooperation with foreign partners, and the NSC is optimistic that domestic medical centers or medical teams can cooperate with the Hutchinson Cancer Center. For his part, Dr. Hartwell affirmed that the Hutchinson Cancer Center will continue to pursue globalization, and that any medical centers in Taiwan that are interested in cancer research may join its partners. In his short visit to Taiwan, Dr. Hartwell was duly impressed by the academic standards of researchers at the Academia Sinica and National Taiwan University College of Medicine, and noted that he will certainly come back to Taiwan if he has the opportunity.

Because of its keen awareness that the sooner cancer is discovered, the sooner treatment can begin and the better the results are likely to be, the Hutchinson Cancer Center is devoting much effort to the establishment of new cancer markers. According to Prof. Chen Ding-shin, Taiwan's research teams engaged in the search for cancer markers hold rather similar views, and have much to contribute to international collaboration. Dr. Hartwell announced that because his goal is to create new knowledge, he would be very willing to cooperate with any interested medical centers, share information, and foster the spirit of knowledge-seeking. For instance, since Asians are particularly likely to suffer from liver cancer, nasopharyngeal cancer, and stomach cancer, which are all fairly uncommon cancers in the US, the sharing of information and experience with Asian workers will allow faster progress to be made.

The other major recent event was the visit to Taiwan of Dr. Hermann Grunder, head of America's Argonne National Laboratory, along with Dr. Lee C. Teng, an émigré Chinese specialist in synchrotron radiation working at the Argonne Laboratory, and Mr. Norman Peterson, the Argonne's executive in charge of international relations. Before becoming director of the Argonne National Laboratory, Dr. Grunder formerly headed America's Thomas Jefferson National Accelerator Facility and Lawrence Berkeley Laboratory. For his part, Dr. Teng is concurrently an Academician of the Academia Sinica and a member of the board of directors of the NSC National Synchrotron Radiation Research Center.

Because of the Argonne National Laboratory's lofty status, the NSC hopes that this recent visit will lay a foundation for further meaningful technological cooperation between the two parties. Chairman Wei reminded people in Taiwan that the Argonne's annual budget exceeds US$500 million – comparable to the NSC's entire annual funding – and it has access to vast research manpower. The NSC has frequently sent post-doctoral researchers and doctoral students to the Argonne Laboratory to perform research, especially in the fields of high-energy physics and synchrotron radiation. The NSC looks forward to strengthening cooperation in the areas of nanotechnology and biotechnology, and hopes that collaboration with the Argonne will improve the research ability and broaden the international outlook of Taiwan's young researchers.

Having attached great importance to Dr. Grunder's visit, Chairman Wei personally hosted a meeting to discuss cooperation arrangements. Among those present were also Academia Sinica President Dr. Lee Yuan-tseh, National Tsing Hua University

President Dr. Shu Frank Hsia-san, and Dr. Chen Chien-te, director of the Synchrotron Radiation Research Center. This meeting resulted in lively discussion, and many areas of common interest were found between the Argonne National Laboratory and domestic academic researchers. It is expected that both parties will list nanotechnology, structural biology, material science, fuel cell, and synchrotron radiation among their future cooperation items. Specific actions will include the holding of bilateral conferences and the arrangement of visits by scientists. Both parties saw the meeting as the beginning of a period of strengthened research cooperation.

The many organizations visited by Dr. Grunder and his entourage included the NSC, Synchrotron Radiation Research Center, Academia Sinica, Hsinchu Science-based Industrial Park, Industrial Technology Research Institute, National Taiwan University, National Tsing Hua University, National Chiao Tung University, and Yuan-Ze University. His visit unquestionably gave Dr. Grunder a keen understanding of the state of scientific and technological research in Taiwan, and laid the groundwork for closer future cooperation.

Research on Wind and Turbulence in the Upper Atmosphere: The Space Program's Plans to Launch a Sounding Rocket

Connection of the TMA payload to the body of the rocket.

The NSC, the Chung Shan Institute of Science and Technology (CSIST), and National Central University (NCU) have signed an agreement calling for the launch of a sounding rocket carrying a science experiment payload in the summer of 2003. The NSC intends to formally incorporate the sounding rocket within the nation's Second Phase National Space Program, and hopes to launch one sounding rocket annually for the purpose of suborbital science research.

The NSC Space Program Office has stated that the mission objectives for the 2003 rocket consist of measurement of wind speed and turbulence in the upper atmosphere at an altitude of 80 ~ 150 kilometers. CSIST has developed the two-stage solid fuel rocket to be used, and NCU will bear responsibility for developing the scientific payload. The rocket will carry the payload into space to an altitude of from 80 to 150 kilometers, where it will release TriMethane Aluminum (TMA). Photographic equipment on the ground will then observe the flame produced by the combustion of the TMA in space, allowing the wind field distribution and atmospheric turbulence to be inferred.

The Space Program Office also hopes to produce its own scientific research payload as part of the "Second Phase National Space Program." To achieve this goal, the NSC plans to launch one sounding rocket each year starting in 2003, and use the rockets to perform a program of suborbital science research. Universities are encouraged to submitt scientific research proposals addressing such areas as the atmospheric physics of the mesosphere and ionosphere, meteorology, earth science, high-energy space physics, and micro-gravity. In addition, the sounding rocket program will be used to further the development and testing of satellite components, allowing domestic firms to gain a foothold in the international satellite component market.

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