Nanyang Technological University

# FORWARD

NEWSLETTER FOR INDUSTRY

21 NOV 2002

SCHOOL OF MECHANICAL AND PRODUCTION ENGINEERING

# Mysteries of Biofilm

## The living organism

Bacterial life dates back some 3.5 billion years ago. It is not only the oldest and the simplest life form but it also exists in numerous forms. Over a million different strains of bacteria live on this earth. For 200 years, these micro-organisms were studied exclusively in planktonic form (freely floating in aquatic media). In the late 1970's, with the arrival of advanced microscopic technology, microbiologists were surprised to find that biofilms were the predominant form of bacterial growth in almost all aquatic systems. Since then, it has become apparent that organisms can behave very differently when living within a biofilm than when the same species is floating freely. The scientific community began to appreciate that bacteria organise themselves in elaborate ways, such as in biofilms.

## Significance of biofilms

The biofilm matrix can protect organisms within it from the grazing of larger protozoa such as amoeba, from antibodies or leucocytes of a host organism, or from antibiotics. Because of these advantages, almost all microorganisms are capable of producing some amount of biofilm. The impact and significance of biofilms are widespread. In water treatment, biofilms are undesirable because they harbour pathogenic organisms such as *Legionella*, reduce heat transfer, cause increased friction or complete blockage of pipes, contaminate probes and contribute to corrosion. Biofilms, and the invasion of tissues by surface-active bacteria, are also primarily involved in a number of human health problems, including dental caries, prosthesis septicemia and interstitial cystitis. However, there are also many potential benefits from a better understanding of biofilm formation, such as improved waste water treatment (Newater), agriculture, preservation, and biotechnology (pharmaceutical products in drugs and vacines). A pictorial representation is shown in Figure 1.


**Figure 1** Impact and potential applications in biofilms (Adopted from Center for Biofilm Engineering)

The relationship between the free-floating bacteria and biofilms is very much inter-related. Controlling the bacteria adhesion rate will affect the rate in which a biofilm grows (either retarding or enhancing it). The successes in controlling their adhesion to surfaces will definitely provide many possible spin-offs in applications.

## Prevention of unwanted biofilms

Ideally, preventing the formation of biofilms would be a more logical option than treating it. However, there is presently no known technique that is able to successfully prevent or control the formation of unwanted biofilms without causing adverse side effects. Research on surface treatment to prevent bacteria adhesion, such as using organic surfactants in bio-barriers or a bio-electric charge to repel the bacteria, has met with limitations. The main problem is the formation of conditioning films that can be rapidly adsorbed onto clean surfaces, or even to specially treated surfaces that are intended to prevent bacteria adhesion once the surfaces are exposed to natural and *in vitro* solutions containing organic molecules. This conditioning film practically "neutralises" the anti-bacteria adhesion surface effects and creates favorable physieochemical conditions for bacteria adhesion.

## A multi-disciplinary-approach

The strategy of this project is to use a combination of several sciences, such as microbiology, physics and physical chemistry, coupled with engineering in **thin film coating technology**. Thin film coating is used due to the known fact that the atomic and subatomic effects at the surface and near-surface levels are predominantly much stronger than the bulk materials. This project aims to study the surface physieochemical effects from materials using thin film coating within a liquid media. The purpose is to understand these properties and to be able to alter the properties of surfaces to promote or inhibit surface adherence of these microbes.

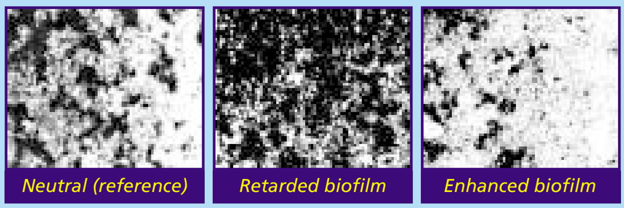



**Figure 2** In-vitro experimental results

## Progress on experimental work

So far, the experimental work using a thin film material has been able to either reduce the biofilm formation or enhance the biofilm formation substantially (see Figure2). The thin film material has a natural phenomenon to create an environment at surface and near-surface levels which is able to avoid the neutralizing effects of the organic-based conditioning film on the surface. At present, research work is in progress to further improve its performance.

For more information on biofilms, please contact:
**A/P Yeo Swee Hock**
Tel: 67905539
Email: MSHYEO@NTU.EDU.SG

# Engineering Liver Functions through Bio-interfacial Engineering

## Treating acute liver failure

Although organ transplantation is the ultimate solution for most patients diagnosed with hepatic malfunctions, severe shortage of donors prevents the extensive application of this approach. In collaboration with Dr. Mao Hai-Quan (Johns Hopkins Biomedical Research Centre) and Dr. Kam Leong (Johns Hopkins University), particular attention will be focused on *ex vivo* hepatocyte culture for liver regeneration in order to treat acute liver failure (ALF). While ALF patients suffer a high mortality rate, a fraction of the patients with residual liver function may recover under intensive care. There is yet another group of patients, whose livers are incapable of providing all vital functions but that still have the capability of self-regeneration if the patients' lives can be sustained by temporary liver support systems. In order to build a bio-artificial liver device for *ex vivo* plasma detoxification, hepatocytes must express the important hepatic phenotypes and biomimetic scaffold. This is because hepatocyte seeding must promote the prolonged expression of the differentiated functions. Recently, it has been shown that excessive spreading of adherent hepatocytes is a sign of losing hepatic phenotypes.

## Constructing a cell-based artificial liver

The anchoring of hepatocytes on biomimetic scaffold is a crucial step in the construction of a cell-based artificial liver. Until recently, mainly empirical approaches have been applied in the designs of biomaterial scaffolds for seeding hepatocytes in artificial liver devices. However, the precise role of ligand-receptor interactions in mediating the adhesion dynamics and contact mechanics of adhering hepatocytes on bio-functional surfaces remains largely unclear. It is shown that the molecular recognition between an asialoglycoprotein receptor and galactose ligand results in specific adhesion of hepatocytes on synthetic matrix and preserves the hepatic functions by promoting the formation of round adherent cells. In addition, the interaction between other adhesion proteins such as collagen on extracellular matrix and integrin receptor on hepatocyte is known to promote hepatocyte attachment despite its non-specificity for heaptocyte recognition.

## Using a conventional microscopy technique

Figure 1 shows the phase contrast images (a conventional microscopy technique) of hepatocytes on collagen gel and other galactose modified substrates at 2 minutes and 130 minutes after cell seeding. The result indicates that most cells on collagen gel adopt the geometry of the spread cell immediately following cell seeding. However, the initial geometry of hepatocytes on both galactose modified surfaces remains round and compact in shape. Thus it is shown that the initial geometry of surface-bound hepatocytes is highly dependent on the nature of immobilized ligands. By replacing collagen with galactose, the liver-specific recognition between the ligand and hepatocyte receptor preserves the round and compact shape of hepatocyte, which is known as a favorable morphology for hepatocytes.

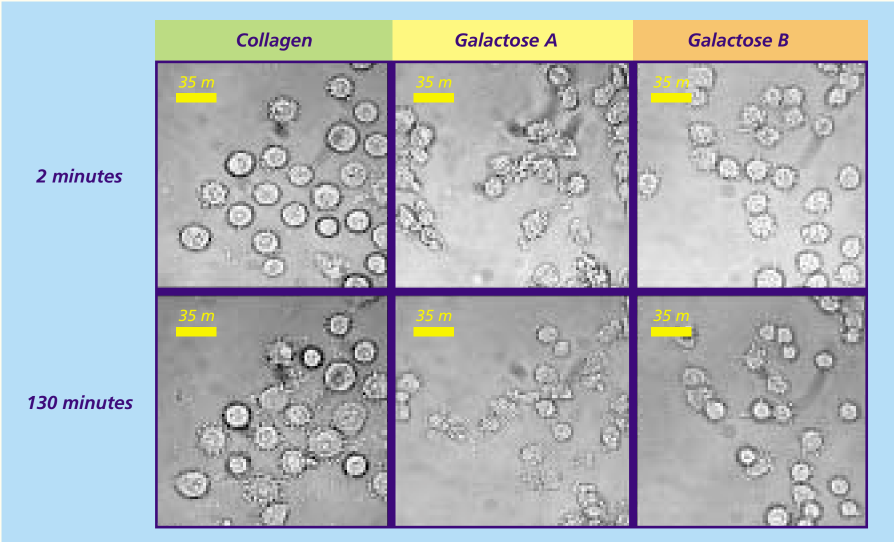



**Figure 1** Cross polarized light images using microscopy

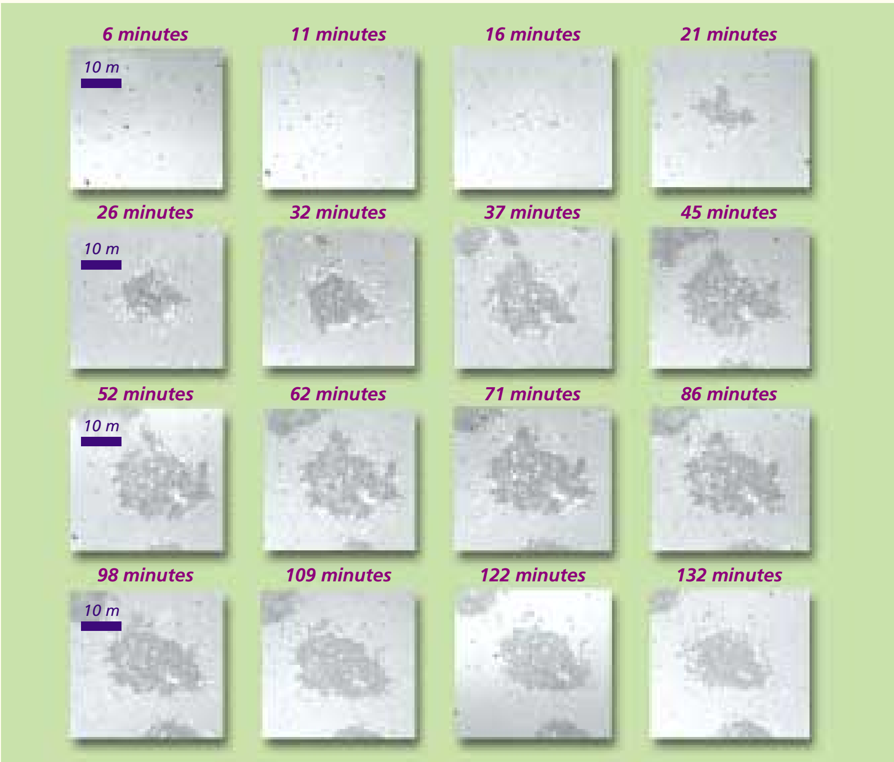



**Figure 2** C-RICM images of a typical hepatocyte

## Developing a novel biophysical technique

A novel biophysical technique known as confocal-reflectance interference contrast microscopy (C-RICM) has been developed for measuring the adhesion dynamics of hepatocytes during the initial stage of cell seeding on two types of galactose immobilized substrates with different types of linkage. Figure 2 shows a series of C-RICM images for a typical hepatocyte among a cell population adhering on galactose modified substrate at different times after cell seeding. Immediately after cell seeding, no detectable adhesion contact is formed between the cell and substrate in spite of the apparent immobilization of the cell on the surface. In comparison with the adhesion kinetics of liver cells on collagen gel, the cell takes a shorter time of about 11 minutes to develop flagella-like adhesion contact on the galactose modified substrate. Eventually, a strong adhesion contact zone is detected at 21 minutes after cell seeding while it only appears at 30 minutes after cell seeding on both collagen gels. Between 30 and 86 minutes, the contact zone of the adherent cell grows in size against time and reaches the maximum level while it maintains an asymmetric shape. After 86 minutes, the contact zone of the adherent cell starts to reduce in size until the end of the transient cell attachment. The result basically demonstrates that the galactose ligand induces a significant change in the kinetics of adhesion contact formation at the earliest stage of cell attachment.

## Combining C-RICM and phase contrast microscopy

To conclude, it is evident that this new approach of combining C-RICM and phase contrast microscopy provides interesting biophysical insights into the cellular responses of a typical type of anchorage-dependent cell on biomimetic substrate for engineering cell/tissue functions.

For more information, please contact:
**Ast/P Vincent Chan**
Tel: 67904040
Email: MVChan@NTU.EDU.SG

**Ast/P Liao Kin**
Tel: 67905835
Email: ASKLiao@NTU.EDU.SG

# Regenerating Skin Tissue

## The evolving field of tissue engineering

Tissue engineering is believed to be one of the keys to finding successful treatment of diseased tissues and organs in this millennium. Despite many advances in medical technology, tissue or organ failure remains a costly and serious health care problem. In situations where replacement for diseased or damaged tissues/organs is required but where existing medical devices are not viable and donor tissues/organs are scarce, the ideal solution is to replace damaged tissue with laboratory-grown living substitutes. The groundwork for developing replacement tissues is embodied in the evolving field of tissue engineering. Tissue engineering merges the important aspects of engineering, physical sciences as well as cell and molecular biology.

## A synergistic collaboration

To form a Tissue Engineering Research Programme, a memorandum of understanding was signed between the Nanyang Technological University (NTU) and Singapore General Hospital (SGH). The mission of the NTU/SGH group is to develop core competency in the science and technology of cell and tissue regeneration for tissue and organ replacement and/or repair. This programme has drawn together a multidisciplinary team of scientists, engineers, surgeons and clinicians working on various aspects of cell and tissue engineering. Some of the current projects include bone regenerations, synthetic skin, tendon repair, and autologous pericardial valve.

## Search for a biodegradable polymer

In the joint project on skin tissue regeneration, Dr. Sandy Chian and his colleagues, from the School of Mechanical and Production Engineering, and Professor Lee Seng Teik and Dr. Phan Toan Thang of the Skin Centre in SGH, have been actively seeking to develop a biodegradable polymer that will support the growth and regeneration of skin tissues. Although there are numerous products currently available in the market as dressing materials for wounds, their use is limited, due to problems associated with their clinical performance and cost.

## A polymer from crab shells

The research team has successfully developed a process to produce scaffold from *chitosan*, a biodegradable polymer derived from shells of crustaceans such as crabs. The use of *chitosan* in medical applications is not new and has been successfully used in dietary supplements and as dressing material for wounds. It is widely accepted to be non-cytotoxic among researchers.

## The process of engineering skin

In tissue engineered skin, the basic process is to grow cells on the porous scaffolds before transplanting the scaffold onto the patient's wound. Simultaneously, as the wound starts to heal and as the cells seeded on the scaffold start to multiply, the *chitosan* scaffold should start to dissolve away leaving behind the new skin tissue. Initial *in vitro* studies, using fibroblast cells, have shown that these *chitosan* membranes are non cytotoxic. Cells seeded on these *chitosan* scaffolds have grown well and have spread over the entire scaffold structure. Other skin cells on this scaffold have also been evaluated since and the preliminary results are promising.

## A patent for the new technique

One of the keys to a successful scaffold for tissue engineering is the ability to control the porosity of these scaffolds. To control scaffold porosity, many processes involve the use of leachable substances such as salt. However, the team has recently developed, jointly with the University of Washington, a new method of controlling scaffold porosity without the use of leachable substances. A process patent is being sought for the new technique due to its tremendous potential.

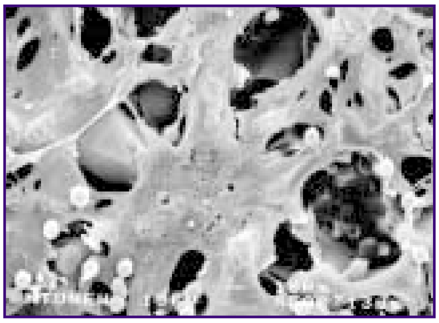


**Figure 1** Scanning electron micrograph showing the spreading of a fibroblast cell over the porous *chitosan* scaffold.

For more information on tissue engineering, please contact:
**A/P Sandy Chian**
Tel: 67904449
Email: ASKSChian@NTU.EDU.SG

# Establishment of a Centre for Project Management Advancement (CPMA)

## For Enterprise Innovation and Performance

### A new centre: CPMA

A Centre for Project Management Advancement has been established in NTU under the auspices of the College of Engineering. The School of Mechanical and Production Engineering is hosting the centre. The other participating schools are the School of Electrical and Electronics Engineering and School of Civil and Environmental Engineering. Associate Prof. Yeo Khim Teck is appointed as the Director of the Centre.

### CPMA's vision

The vision of the centre is to establish an NTU Centre of Excellence in Project and Program Management (P2M) for enterprise innovation and performance. Its mission is to conceive and conduct focused and multi-disciplinary research that promotes the widespread use of a Project Management (PM) approach in enterprise management and to facilitate knowledge dissemination and technology transfer to industry and organizations.

### Project and programme management

Project and programme management is increasingly recognised as an important and integral part of corporate core competency. In line with the growing body of knowledge in project and programme management, the proposed centre will develop competencies in addressing strategic, organisational, process, technological and performance related issues at both enterprise and systems levels.

### A multi-disciplinary approach

Over the past four decades, project management has evolved into a broad and multi-disciplinary field. As a field, PM builds on a strong theoretical foundation by drawing relevant concepts and knowledge in diverse disciplines such as system engineering, system analysis, organisational behaviour, decision theory, engineering economics, finance, costing, marketing, logistics, IT/IS and e-commerce.

### Focus Areas

The Centre's research architecture includes six important areas in project management:

1. **Strategic aspects of Project Management:** Including strategic project planning and analysis and decision making process.
2. **Project Management Processes:** Involving mainly the Project Management Body of Knowledge (PMBOK) on the initiation, planning and control of the nine project management process areas.
3. **Organisational Contexts:** Comprising the internal and external environments.
   **Internal context:** Culture, leadership, organisational structure, systems and human resource management.
   **External context:** Market and competition in project marketplace, macro-social, economic and political environments.
4. **Technological Contents:** Encompassing all industry sectors – Semiconductor, biotechnology, IT/IS, R&D/NPD and services.
5. **Change Management:** Involving management of innovation and project-enabled organisations.
6. **Performance Measurement:** Including costs and benefits management.

### A network of expert knowledge

The centre aims to build up a network of expert knowledge leveraging on research resources in the various engineering schools in key industries such as high-tech manufacturing and product development, biotechnology R&D, information technology, aerospace and defence, health care, as well as large-scale and complex engineering construction. The Centre will also endeavour to initiate and build up partnerships with the relevant industries and other international centres of research in project and programme management.

For more information, please contact the Director of CPMA:
**A/P Yeo Khim Teck**
Tel: 67905502
Email: MKTYEO@NTU.EDU.SG

# A Novel In-Line Inspection System

## For Silicon wafers

### Detecting defects in silicon wafers

Silicon wafers are widely used in the semiconductor and microelectronics industries. With this material, there is an immense need to obtain defect-free and highly-polished surfaces for improving yield and performance of the micro-components. The processing cost of silicon wafers and the control of defects (at sub-micron size and especially, those present at sub-surface level) on these wafers are critical to the wafer fabrication/reclamation industries. It has been reported that millions of dollars are lost each year owing to the failure of detecting these defects in silicon wafers prior to the wafer fabrication/reclamation processes. The cost of production of a wafer is very high; for example, a 12" wafer may yield about 200 chips, which may be worth about US$1 million. Thus, an hour of downtime due to the presence of defects can easily amount to a loss of millions of dollars.

### Developing a new defect detection system

The trend towards miniaturization is resulting in smaller features in ICs. This means that the size of a "killer defect" is also getting smaller and smaller. It is expected that new chips that will be produced by the year 2006 will have circuit features of less than 40nm in width. They are so tiny that they can easily be ruined by defects that are less than 30nm in size. This is only about 1/3000 the width of a human hair!

The current practice in the semiconductor industry is to inspect the wafers for surface defects only at the final polishing stage. At this stage, the sub-surface defects, if any, become visible once they have been exposed by polishing as minute spots, forming spiral rings or 'swirls' (See Figure 1). These sub-surface defects which cannot be detected before the reclamation process or wafer fabrication process would cause much higher wafer rejection rate at the end of the finishing stage. According to International Semiconductor Products (ISP) Pte Ltd, Singapore, about 10% wafer rejections would amount to approximately US$1million per year. To support the multi-billion dollar semiconductor industries, the Precision Engineering and Nanotechnology (PEN) Centre, School of MPE, NTU has developed an in-line surface/subsurface defect detection system by using a digital shearography/holography technique in collaboration with ISP (S) Pte Ltd.

**Figure 1** Example of sub-surface defectss in Si-wafer

### Building a prototype

Digital shearography is an optical interferometric technique that measures surface strain concentrations caused by surface and subsurface defects due to some sort of load, usually either thermal, vacuum or pressure excitation. Figure 2 shows the experimental system. With the success of using laser for detecting subsurface micro defects, the research team is working to build a prototype by a novel phase shifting digital x-ray shearography, utilising soft x-rays for detecting nano-defects in Si-wafers. Figure 3 shows a schematic diagram of this technique.

**Figure 2** Experimental set-up

NTU and ISP have jointly filed a U.S. patent on this new technology. Once such a technology is developed, it can be commercialised to benefit future wafer fabs in Singapore and abroad.

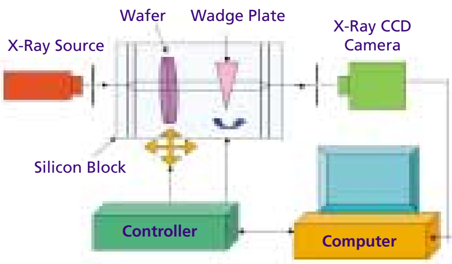



**Figure 3** Schematic Diagram

For more information on this research, please contact :
**A/P Ngoi Kok Ann, Bryan**
Tel : 6790 4500
E-mail : mbngoi@ntu.edu.sg

# Making SENSE of Biology with QuickSENSE

## Developing QuickSENSE

QuickSENSE, a novel rapid bio-sensor technology, has been developed recently. The researchers are an NTU team, comprising of Asst Prof Lim Chu-Sing (Team Leader), Prof Anand Asundi, Dr Anil Kishen, Dr Merchery Shelly John, Assoc Prof Chia Tet Fatt and Asst Prof Lim Siew Pheng as well as doctors and scientists of the Singapore General Hospital.

## Sensing target analytes rapidly and accurately

Prior to this invention, conventional methods to sense proteins, bacteria, viruses and DNA were slow and tedious and the instruments were generally bulky and laboratory-based. In contrast, the QuickSENSE bio-sensors provide a very rapid and accurate method of sensing target analytes. These sensors are easily made portable and are simple to use, allowing on-site sensing whilst saving the need for specialised manpower.

## Applying sensor technology to industry

A prototype portable hand-held system to sense bacteria rapidly has been developed and tested for the healthcare industry. As the team's R&D philosophy is to apply scientific discoveries to serve society, the research team is currently working towards applying the QuickSENSE sensor technology to industries such as healthcare, pharmaceutical, defence and security, environment and food. The team has recently started work with a local security agency to further develop one of its sensors.

# Interferometric Characterization of MEMS Devices with Digital Microscopic Holography

## Developing Micromeasurement Technology

In MEMS engineering, there is an urgent need for developing metrological tools to realise the accurate measurement and inspection of microstructures and devices. Among the major physical quantities to be measured, displacement and strain/stress determination that relate to the sensing and actuating characteristics is one of the primary concerns. Of the testing techniques that are being developed, interferometry-based optical techniques are able to accomplish non-invasive displacement measurement with nanometre sensitivity and micrometre spatial resolution. These techniques are best suited for micromeasurement.

**Figure 1**
Digital microscopic holography system

## Using a Hybrid Methodology

Digital microscopic holography, a hybrid methodology (Figure 1), combines optical measurement methods with digital information technology, and integrates in-line digital holography with a long distance microscope (LDM). It is capable of realising both imaging and interferometric measurement of micro-scale structures. As a novel testing tool, it presents the following favourable properties:

- High-resolution based upon the in-line configuration
- Optimised sensitivity with the incorporation of LDM
- Full-field sampling and computation
- Automatic data analysis and processing
- Flexible result presentation

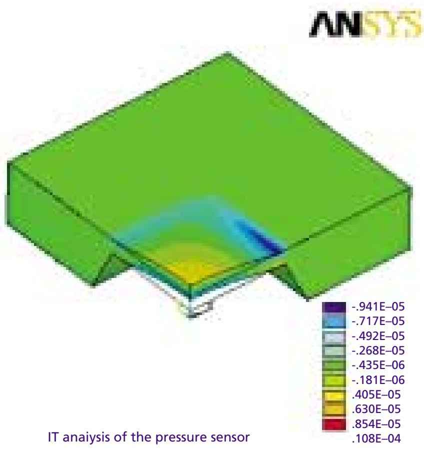



**Figure 2**
FE simulated stress distribution

## Applying the technology

The performance of digital microscopic holography with application in micromeasurement is demonstrated with the bulge test of a micromachined pressure sensor, one of the most popular MEMS devices. The pressure-induced membrane deflections are accurately measured with the experimental system, and serve as reliable reference data for numerical analysis. Further calculations of strain and stress are accomplished based on the FE model verified with the experimental results. From the simulation, as shown in Figure 2, the sensitivity of the pressure sensor can be characterized. In the experiments, the test sample is imaged with a lateral resolution of 3.68 $\mu m$ and measured with sensitivity of 0.1 $nm$.

For further information on the applications of this technology, please contact:
**Asst. Prof. Miao Jianmin, Prof. Anand Asundi and Xu Lei**
Tel: 6790 6038
Email: mjmmiao@ntu.edu.sg, masundi@ntu.edu.sg and i.leixu@osa.org.

***REFERENCES:***
*L. Xu, X. Peng, A. Asundi, and J. Miao, Hybrid Holographic Microscope for Interferometric Measurement of Microstructures, Opt. Eng., 40 (11), 2001, pp. 2533-2539.*
*L. Xu, X. Peng, J. Miao, and A. Asundi, Studies on Digital Microscopic Holography with Applications to Microstructure Testing, Appl. Opt., 40 (28), 2001, pp.5046-5051.*

# MPE Industry Symposium on "Thin Films for Thick Value"

*"Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius – and a lot of courage – to move in the opposite direction."*

*Albert Einstein (1879-1955)*

Over a hundred researchers and engineers from local industries flocked to the MPE Industrial Symphosium on "Thin Films for Thick Value" at the NTU campus on 28 September 2002. Its was organised by the Thin Film Technology Strategic Research Programme (SRP) as part of the Science .02 events planned by A*STAR islandwide. Prof. Yue Chee Yoon, Dean of MPE opened the symposium with his welcome remarks and gave a comprehensive overview of the importance of thin films in present day technology. He emphasised that often, the function of a component is dependent on its surface and that is why there has been much interest in the study of thin films and coatings.

The director of the Thin Film SRP, A/P Sam Zhang provided a gist of the R&D activities of his team comprising five major thrust areas: Protective Thin Films, Electronic Thin Films, Energy Thin Films, Structural Thin Films, and Biological Thin Films. The presentations by the academic staff of the school gave the participants a flavour of current research on thin films fabrication, characterization and modeling for various applications such as advanced tribological thin films, nano composite thin films, thin film diffusion barriers, thin film shape memory alloys and thin film membrane electrode assembly for fuel cells.

The morning tea and lunch breaks at the symposium provided an opportunity to the participants, especially those from the local Industries, to discuss their concerns with MPE researchers and helped generate ideas for joint collaborative research work. After lunch, all the participants were taken on a laboratory tour.

Among others, the symposium was graced by the Head of the Manufacturing Engineering Division of the School, A/P Tor Shu Beng, who also acted as an Advisor to the Symposium. Supported by the Advanced Materials Research Center (AMRC) and Shimadzu (Asia Pacific) Pte Ltd, this symposium was coordinated by A/P Lam Chung Yau and A/P Zhao Yong.

*Reported by Ast/P Sridhar Idapalapati, MPE*

A/P Sam Zhang explaining the working principle of the Magnetron Sputtering Machine

# International Conference on Project Management (ProMAC 2002)

## 31 July – 2 August 2002, Singapore

The International Conference on Project Management, ProMAC 2002, was successfully organised and concluded, with over 200 participants and speakers from 18 different countries. The conference was organised under the auspices of the College of Engineering in collaboration with the Society of Project Management (SPM), Japan. The SPM is strongly supported by major high-tech Japanese corporations such as IBM Japan, NTT, and NEC as well as academic institutions, particularly the Chiba Institute of Technology.

Guest of Honor-Prof. Er Meng Hwa giving his inaugural speech

A total of 100 papers were presented including 4 keynote papers. The four invited keynote speeches were delivered by Professor Arnoud De Meyer, Dean of INSEAD, Asia Campus, who spoke on "Matching Project Uncertainty with Management Style"; Mr. Sanjay Mirchandani, President of Microsoft, South Asia elaborated on "Enterprise Project Management: The next generation project management technology platform"; Professor Ali Jaafari, Director, Project Management Programme, University of Sydney focused on "Project Management and the New Economy" and Mr. Teruyoshi Kawai, Chairman of Application Service Provider Industry Consortium, Japan, spoke on "Information Systems for Society and the Future Prospects for Application Service Providers".

Prof. Er Meng Hwa, Deputy President of NTU and the Dean of College of Engineering and School of Electrical and Electronics Engineering, was the Guest of Honor at the opening ceremony. Giving his opening speech, he highlighted the necessity and significance of initiating and conducting higher-order projects in a knowledge-based and innovation-driven society to gain sustainable and competitive advantage. Welcoming the Conference participants, Prof. Yue Chee Yoon, Dean of School of MPE and General Co-chair of the ProMAC 2002 Organizing Committee recognized that project management is rapidly emerging as one of the major professional and academic disciplines. The General Co-chair from Japan, Mr. Akira Tominaga, the past president of SPM, Senior Managing Director, IBM Japan and Vice President of IBM - Asia Pacific Global Services, also highlighted the importance of project management in the information technology era and announced that ProMAC 2004, will be held in Tokyo.

Reported by Shaligram Pokharel, MPE.

The 5th Annual NTU-SGH Biomedical Engineering Symposium was held on 25 April 2002 at the College of Medicine Auditorium. Held in conjunction with the SGH 13th Annual Scientific Meeting, the theme of the event was "Innovation in Biomedical Engineering", in line with the government's emphasis on innovation. A highlight of this year's symposium was an essay competition, held for the very first time in the history of this annual event, and open only to staff and students of SGH and NTU. Writers who participated in this essay competition had to choose a topic from a pre-determined list.


Having been reviewed by the committee, three winners were declared for this essay competition. The winners include Wilson Oh (who is currently pursuing research in the School of Mechanical and Production Engineering) and A/P Khong Poh Wah of MPE. Their essay drew upon interesting metaphors from the field of Biomedical Engineering, highlighting the importance of leveraging on Human Capital in knowledge intensive industries like that of the Biomedical industry.

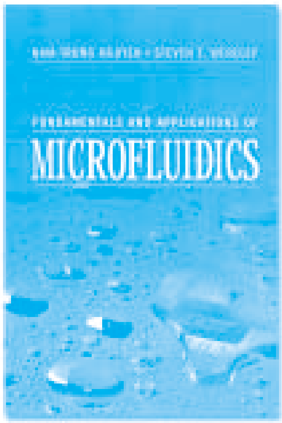
# An NTU bioMEMS Spin-off Company

Attogenix Biosystems Pte Ltd has been recently formed as an NTU and DSTA (Defense Science And Technology Agency) spin-off company, with support from EDB. To enable an automatic single-step multiple gene analysis from a variety of genetic samples on a chip, the company is developing and applying a portfolio of proprietary technologies conceptualized by A/P Thomas Gong in the BioMEMS Lab at the School of MPE, NTU and Dr. Eric Yap of the Molecular Genetics Branch of DMRI (Defense Medical Research Institute). Using an innovative microfabrication technology, Attogenix can make a chip that is not only cheap but disposable. Combined with its Molecular Analyzer, the Attogenix chip is aimed at providing rapid high-density genetic analysis capability with on-chip genetic sample preparation to biotech and pharmaceutical industries, clinical diagnostic labs, life science research institutions and for biodefense needs as well.

A/P Thomas Gong of NTU and Dr. Eric Yap of DMRI receiving the award on behalf of Attogenix from Mr Philip Yeo, Chairman of A*STAR/ Co-Chairman of EDB.

# Book review: Fundamentals and Applications of Microfluidics By N.T. Nguyen and S.T. Wereley

Here's a practical and authoritative resource that provides a comprehensive introduction to the emerging field of microfluidics. It explains how to take advantage of the performance benefits of microfluidics and serves as an instant reference for state-of- the- art technology and applications in this cutting-edge area. The book offers practical guidance on how to model, design and fabricate microfluidic devices.




This forward-looking book identifies and discusses the broad range of microfluidic applications, including fluid control devices, gas and fluid measurement devices, medical testing equipment, and implantable drug pumps. It includes simple calculations, ready- to- use data tables, and rules of thumb that help practitioners make design decisions and determine device characteristics quickly. Moreover, the book offers sound, time- saving advice on how to start a new project.

Nam- Trung Nguyen is an assistant professor at the School of Mechanical and Production Engineering at Nanyang Technological University. He received his M. Sc. and Ph. D. in electrical engineering from Chemnitz University of Technology, Germany.

Steve Wereley is an assistant professor of mechanical engineering at Purdue University. He received his M. S. and Ph. D. in mechanical engineering from Northwestern University.

**[1. Edition, Artech House, Boston, October 2002, 472 pages, ISBN: 1-58053-343-4]**

# Visiting Professor at MPE

Professor Vasudevan Radhakrishnan is a graduate in Mechanical Engineering from the University of Kerala, with a post-graduate degree in Production Engineering from IIT Kharagpur and a Doctorate in Mechanical Engineering from IIT Madras, India. For his doctorate, he did his research in the area of surface finish measurements at the Technical University, Braunschweig, Germany. He has been a German Academic Exchange Fellow as well as a Senior Alexander von Humboldt Fellow.

As a Professor in Manufacturing Engineering, he has been a faculty member of the Indian Institute of Technology, Madras for over 25 years and taught Metrology and Computer Aided Inspection, Precision Engineering, Automation in Manufacturing and Tooling for Production, to graduate and undergraduates in Mechanical Engineering. He also served as the Head of the Department of Mechanical Engineering and as the Dean of Industrial Consultancy and Sponsored Research, at IIT Madras, India.

His major research interests are in Surface Metrology, Grinding and Precision Manufacturing and he has to his credit over 200 technical papers, seven patents and 22 PhD supervisions.

He won two top National Research and Development Awards for the invention of a spiral grooved grinding wheel for reducing the corner wear in plunge grinding and for a Fluidised Abrasive Polishing (FAP) machine. The invention of the spiral grooved grinding wheel also earned him a Silver Medal at the International Exhibition on Ideas, Inventions and Novelties, held in Nuremberg, Germany. He has been on the editorial board of five technical journals including two international journals and has edited three conference proceedings.

In May 1996, Prof.Radhakrishnan was awarded the prestigious Alexander von Humboldt Research Award by the Alexander von Humboldt Foundation, Germany, in recognition of his research in the area of Manufacturing Engineering.

He is a Fellow of the Indian National Academy of Engineers, Fellow of the Society of Manufacturing Engineers (USA), Fellow of the Institution of Electrical Engineers (London) and a Fellow of the Institution of Engineers (India). He is a Chartered Engineer registered with the Engineering Council, UK.

Currently, he is a Visiting Professor at the School of Mechanical & Production Engineering, Nanyang Technological University. He has also been a Visiting Professor at the Technical University of Erlangen-Nuremberg, Germany and at the National University of Singapore.

# CONTINUING EDUCATION

The School of Mechanical and Production Engineering presently offers subjects under the BEng (Bachelor of Engineering) Part-time Programme and MSc (Master of Science) level for continuing education. These subjects serve to equip and update you with specific knowledge for your current or future work. The Continuing Higher Education for Engineering Professionals scheme enables you to pick specific modules under each subject that you are interested in. If a participant takes the entire subject, the fee is lower than the total fee of the combined modules. In addition, each participant will be awarded a certificate of participation if he/she attends at least 75% of the entire subject. However, no certificate will be awarded to participants taking individual modules. There is no examination for participants taking the modules or entire subject. Our courses have been accredited by the Professional Engineers Board. Please view our website for the latest details and professional development units (PDUs).

## *Continuing Higher Education for Engineering Professionals - starting January 2003*

**M6103 MATERIALS PROCESSING I (39 hrs - $650)**

Module 1: Metal Forming (12 hrs - $300)
Module 2: Joining (15 hrs - $375)
Module 3: Casting (12 hrs - $300)

**M6105 TRANSPORT PHENOMENA IN MATERIALS PROCESSING (39 hrs - $650)**

Module 1: Transport Phenomena Fundamentals (21 hrs - $525)
Module 2: Non-Newtonian Materials (18 hrs - $450)

**M6210 COLLABORATIVE PRODUCT DEVELOPMENT (39 hrs - $650)**

Module 1: Integration of Product Development (15 hrs - $375)
Module 2: Collaborative Engineering (12 hrs - $300)
Module 3: Computer Supported Cooperative Work (6 hrs - $150)
Module 4: Tools for Collaborative Product Development (6 hrs - $150)

**M6221 NETWORKING AND DATABASES (39 hrs - $650)**

Module 1: The Internet (9 hrs - $225)
Module 2: Web Technology (6 hrs - $150)
Module 3: Middle Ware (12 hrs - $300)
Module 4: Databases (12 hrs - $300)

**M6301 ADVANCED METROLOGY AND SENSING SYSTEMS (39 hrs - $650)**

Module 1: Basics of Measurement Technology (12 hrs - $300)
Module 2: Sensing Systems & Metrology (15 hrs - $375)
Module 3: Advanced Surface Metrology (12 hrs - $300)

**M6304 ULTRAPRECISION & MICROMACHININ (39 hrs - $650)**

Module 1: Ultraprecision Machining (15 hrs - $375)
Module 2: Micromachining (15 hrs - $375)
Module 3: Thin Film Processes (9 hrs - $225)

**M6403 APPLIED MECHATRONICS (39 HRS - $650)**

Mechatronics System and Automation using Digital Electronics and Digital Logic; Computer Interface, Measurements and Signal Processing; Embedded Controllers; Implementation issues, Motors and Motion Control.

**M6404 ADVANCED MECHANISM DESIGN (39 HRS - $650)**

Overview of mechanism design and simulation. Analytical synthesis. Advanced mechanism synthesis. Computer-aided kinematic modelling and analysis. Computer-aided dynamic modelling and analysis.

**M6601 HUMAN FACTORS ENGINEERING FUNDAMENTALS (39 hrs - $1,200)**

This course provides the students with the necessary background and fundamentals of human factors engineering. The topics include: Overview of human factors and its design process. Cognitive Human Factors and Human Computer Interaction. Human Machine Interaction. Physical Human Factors and Ergonomics. Organizational Aspects and Macro Ergonomics. Environmental Aspects.

## *Continuing Education for Engineers (BEng Level) - starting January 2003*

**M141 HUMAN RESOURCE MANAGEMENT & ENTREPRENEURSHIP (26 HRS - $550)**

The Entrepreneurial Mind & Human Resource Management. Developing a New Venture Business Plan. Business Organisations & Management. Individual Values, Attitudes & Motivation. Group Behaviours & Communication. Entrepreneurial Leadership. Managing Human Assets. Productivity & Total Quality Management. Industrial Relations in Singapore.

**M206 FLUID MECHANICS (39 HRS - $800)**

Submerged surfaces and bodies. Elementary fluid dynamics. Momentum equation and its application. Dimensional analysis and similitude. Internal flows and piping systems. External flow concepts. Principles and application of fluid machines.

**G264 MATHEMATICS 2A (26 HRS - $550)**

Fourier Analysis. Laplace Transform.Vector Differential Calculus. Vector Integral Calculus. Complex variables.

**G269 ENGINEERING MATERIALS (26 HRS - $550)**

Ferrous alloys. Light alloys. Alloys for special purposes. Ceramics and glasses. Civil Engineering materials. Polymers. Composites.

**M285 MECHANICS OF MACHINES (26 HRS - $550)**

Kinematic fundamentals. Kinematics of planar linkages. Planar linkage synthesis. Gears, gear trains and cams. Static and dynamic force analysis of mechanisms. Shaking forces and balancing.

**M303 HEAT TRANSFER (26 HRS - $550)**

Conduction: mechanism and rate equations, one-dimensional problems, fins and lumped capacitance method. Convection: thermal boundary layer concepts, flow over a flat plate and in pipes, convection correlations, heat exchangers and definition of performance. Radiation.

**M304 MECHANICS OF DEFORMABLE SOLIDS (26 HRS - $550)**

Response of single degree of freedom systems to harmonic, impulse and arbitrary excitation. Forced harmonic excitation of 2-DOF systems. Normal mode summation for systems with several degrees of freedom systems. Stationary energy methods. Theory of plane and axis symmetric elasticity.

**More options, on-line registration and other information at:**
**http://www.ntu.edu.sg/mpe/centres/cetm/ce/**

For registration and further information, please contact **Siew Khim** at Tel: **67905858**, Fax: **67944605** or email: **mskng@ntu.edu.sg**


## *Editorial Corner*

*A half-yearly newsletter from the School of Mechanical and Production Engineering of Nanyang Technological University, Singapore. For more information, you are invited to contact the Dean's Office. Please contact **Jesamine** (Tel: **6790 5486**) or fax (**6792 4062**).*

*Edited by:*
**Asst/P Kathpalia Sujata Surinder**
**Asst/P Tsai Tse Min**
**A/P Thiruvarudchelvan**
**A/P Guo Ningqun**
**Asst/P Charles Yang**
**Mr. Chong Eng Heng**