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NEWSLETTER

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EVENT HIGHLIGHTS (Contributed by NANOGLOBE Team)

Nanotech Europe 2009: Nanotechnology Conference and Exhibition (Ms. Yesie L. BRAMA, NanoGlobe)

Nanotech Europe 2009 attracted many participants including researchers, policymakers, industrialists, and investors to get together discussing a common topic: Nanotechnology in the areas ranging from technical, safety to investment issues. Big players (Bayer, FIAT, Nokia, etc) as well as startups (IZON Science, MagForce, Tethis, Imina Technologies, etc) participated in presenting their research activities, achievements, and products. Transportation is one important application where nanotechnology can play a significant role. Material is one important part of nanotechnology to enable product improvement and enhancement. In this article, we share our insights and learning obtained from the event. (Read the whole article)

Photovoltaic Carnival in Taiwan - Highlights on PV Taiwan 2009 (Ms. Jing JIANG, NanoGlobe)

PV Taiwan 2009 forum and exhibition held on 7 - 9 October 2009 at Taipei World Trade Center (TWTC) is a photovoltaic (PV) carnival for the domestic and international PV players. The exhibitors joined this event and the booth used for the exhibition increase by 52% and 67% respectively over the previous year. Combining a forum and exhibition, PV Taiwan 2009 provides a one-stop sourcing platform for global PV industry players to catch the latest trends and markets, order high-quality PV products and link business partners and agents. Well-known domestic PV firms including Gintech, Neo Solar, SAS, Auria Solar, Sun Well, Chi Mei Energy, Mosel, Ritek, Gloria Solar, PCM, Kinmac Solar, Sunner, Sintek, Solartech, Big Sun Energy, Everphoton and others attended the exhibition to introduce their latest and highly competitive products and attracted domestic and international buyers. Also, it provides good opportunities for over 8000 visitors to learn the progress of global and domestic PV industry and get educated on the latest technologies and products in PV industry. (Read the whole article)

Household Applications of Nanotechnology in Taiwan - Highlights on Taiwan Nano 2009 (Ms. Jing JIANG, NanoGlobe)

Taiwan Nano 2009 held in October 7 - 9, 2009 (see Fig.1) at the Taipei World Trade Center attracts 64 companies and agencies occupying 114 booths to present Taiwan nanotech R&D and commercialization, and education. This is the 7th annual Taiwan Nano 200X, hosting International Exhibition, APEC Nanoproduct Measurement Forum, Asian Symposium Nanoimprint Lithography, 2009 Global Regulation of Bionanotechnology Industry Conference. Nano Mark Products for household applications and Nano Imprint Lithography are the two main themes of this event and nanotech education exhibit organized by Nanotechnology Human Resource Development Program (NHRD) is a BIG feature of Taiwan Nano 2009. The exhibits of household applications of nanotechnology are more popular in this event than other nanotech events we have been. (Read the whole article)

ChinaNANO Is BIG - Highlights on ChinaNANO 2009 (Ms. Jing JIANG, NanoGlobe)

ChinaNANO 2009 is the largest conference we have ever attended in Asia. This is the third conference following ChinaNANO 2005 and ChinaNANO 2007. Over 1500 researchers, scientists and students from 40 countries attended this 3-day event. 7 distinguished scientists from Europe, USA and Japan are invited to give the plenary talks covering the updated state-of-the-art development in the fields of Nano Carbon, Nano Medicine, Nano Materials, Molecular Devices, Nanoelectronics Devices, Nanomaterials Engineering and Imaging. ChinaNANO 2009 consists of 8 sub-conferences and among them Nano-energy & environmental materials

and nanomedicine, nanopharmacy & biomedical sub-conferences are the most popular sessions. (Read the whole article)

The Magic of the Strongest Material – Carbon Nanotubes Overview of Zyvex Performance Materials (ZPM) Business (Ms. Yesie L. BRAMA, NanoGlobe)

Carbon nanotubes (CNTs), known to be the strongest material, possess many excellent properties including high thermal and electrical conductivity, high tensile strength and modulus, and rapid absorption of infrared and microwave energy. When incorporated to a polymer matrix together with carbon fibers, the composite strength and stiffness can be increased by 40% and 50%, respectively. This new composite can be very useful for sporting goods, military, marine, aviation, automotive and other structural applications. Zyvex Performance Materials (ZPM) is a world leader in commercializing CNTs via its branded products Arovex™, Epovex™, and Epovex Adhesive™. ZPM has been working with a number of sporting goods companies to develop stronger and lighter bicycle parts, more durable baseball bats, and numerous other products. ZPM is also working closely with other partners to provide application development solutions and is currently engaged in new development involving thermosets, thermoplastics, and elastomers. (Read the whole article)

Orienteering for Nano Convergence - Highlights on NANO KOREA 2009 ((Dr Lerwen LIU and Ms. Jing JIANG, NanoGlobe)

Since 2003, NANO KOREA Symposium & Exhibition has grown in scale by over 30% every year. the NANO KOREA 20XX has become the most powerful nano-micro nanotechnology platform for the Korean nanotech policy makers, R & D institutions and industries to interact and update on each other`s latest development and for facilitating partnerships and deal flows. NANO KOREA 20XX also provides a unique opportunity for players from overseas who are interested in partnerships and other business opportunities in Korea. The NANO KOREA 2009 is organized by the Korea Nanotechnology Research Association (NTRA) which consists of 100 members mostly from industry. The Nano Technology Research Society of Korea (KoNTRA) is co-organizer mainly responsible for symposiums and workshops. The Korean Institute of Science and Technology Information (KISTI) which provides free information services to the Korean nanotech community is also a co-organizer. This event is hosted by Ministry of Education, Science and Technology (MEST) and Ministry of Knowledge Economy (MKE). Korea International Exhibition Center (KINTEX) hosts 195 exhibitors from 9 countries and 6562 visitors including professionals, key researchers and investors from 30 countries for this 3-day event.

NANO KOREA 2009 consists of exhibition and international nanotech symposium. The exhibition categories include Nano Materials, Nano Devices, Nano Manufacturing, Nano Evaluation & Measurement, Biotechnology, Energy/Environment, Research Institutes and others. The topic of the 7th International Nanotech Symposium covers Nano Electronics, Nano Materials, Nano Tools & Manufacturing, Nano Biotechnology, Nano Chemistry and Nano Physics. 910 people are involved in the 7th International Nanotech Symposium to discuss about the latest research breakthrough and product development in Korea Nanotechnology. For NANO KOREA 2009, there is a special Nano Education Program targeting for the junior / high school students and general public to get educated about the nanotechnology in daily life and to closely experience the amazing nano world.

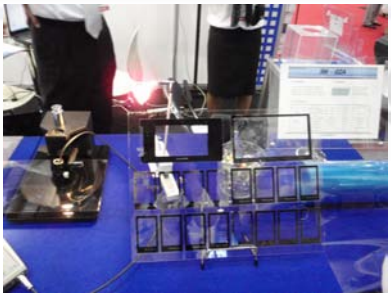
There are also keynote talks and plenary speeches held on the first two mornings plus a public lecture “Where’s nanotechnology going now in our daily life” on the third morning given by Prof. Jo-Won Lee who is the Chair of Nano Korea Symposium and the Director of Tera-level Nanodevices Program. NANO KOREA 2009 started from the keynote address “Semiconductor Nanoheterostructures: Physics and Technology” given by Prof. Zhores Alferov, the Nobel Prize for Physics in 2000, from the Russian Academy of Sciences, Konkuk University. Prof. Alferov used the history of Nobel Prize for Physics as a clue to show us the development of semiconductor nanoheterostructures. His topics include three kinds of heterostructures, which are the classic heterostructures, quantum well and superlattice heterostructures,quantum wire and quantum dot heterostructures. For each of these three topics, the fundamental physical phenomena, important consequences for applications and important technological consideration are discussed in detail. Other keynote and plenary speakers for the 7th International Nanotech Symposium include Dr Chang Mo Sung, from HYOSUNG R&DB Labs, Dr Tomas N. Theis from IBM Thomas J. Wataon Research Center and Dr Hideyuki Matsuoka from Hitachi Advanced Research Labs. The most popular technical sessions are Nano Materials and Nano Biotechnology.

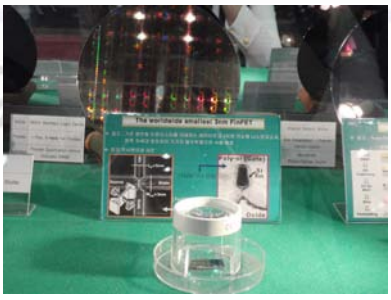
Details of the symposium program and exhibitors can be found at the NanoKorea website: http://www.nanokorea.or.kr/Eng

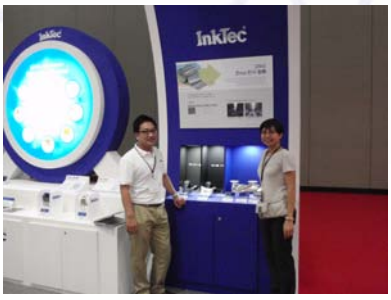
NANO KOREA 2009 attracted over 6500 visitors to the KINTEX, a three storey building on a 224,800 m2 plot of land. Among the 195 exhibitors, there are 17 from Japan, Germany and elsewhere in the world. BMBF / VDI Technologiezentrum GmbH used their classic car to exhibit the amazing nanotechnology made in Germany. More than 10 nanotechnology-related techniques have been applied to their car for improving the scratch & corrosion resistivity, easy-to-clean & antimicrobial performance, LED lighting and others.

The sexiest nanomaterials exhibited in the 7th International Nanotech Exhibition continue to be the CNT based nanomaterials and nano silver particles. However, compared with NanoKorea 2008, more high value-add & technology intensive CNT and nano silver products showcased in NanoKorea 2009. The CNT applications include transparent & flexible conductive thin films for touch screen, flexible display and flexible solar cell, CNT-composite / CNT-catalyst, conductive & flexible screen printing and lighting. Korea Electrotechnology Research Institute (KERI), Hanwha Nanotech and Changbo are closely working together for the high-tech transparent conductive CNT films with the transmittance of 86±2 % and the surface resistance of 400±80 Ω/sq. Their new products will come to market by the end of this year. The main applications of nano silver materials include the conductive & flexible screen printing, relective coating and antibacterial. Samsung, Hanwha nanotech, Changbo, Bioneer, Inktec, Top Nanosys, Applied Carbon Nano Technology, EM-power and Sukgyung AT are the most active players in the CNT-related fields. Not only the majority of startup companies and SMEs (such as Nanosquare, NTbase, Applied Carbon Nanotechnology, EM-power, J&L Tech, Top Nanosys, Sukgyung AT, InkTec, Sangbo and others) are focusing on the nanomaterials and nanotechnology applications, but many international companies (such as Samsung, Hanwha, Bioneer and others) have also identify nanotechnology and renewable energy as their future engines for growth. Samsung exhibited their fantastic R&D achievements including CNT flexible transparent electrode with the transmittance up to 85~90% and the resistance as low as 50 Ω/sq, high performance & multi-functional CNT-composite for anti-static, ESD and conductive applications, the first demonstration of the large-area graphene films by CVD process with excellent transparent and stretchable electronics properties, the first demonstration of 4 inch quantum dot display which is TFT-driven and mono-color, first generation of transparent & flexible nanogenerators based on the piezoelectric ZnO nanorods network and transparent, flexible, robust CNT based thin film transistor with high mobility.

Korea is the most impressive country we know in terms of the acceleration of nanotechnology advancement. Now about 50 nano products appear in Korea every year. It aims to become of the world`s top three nations in nanotechnology development (It targeted at the top 5 nanotech leaders in the world in 2002, but now it has become the 4th leading nanotech country). Currently South Korea ranked 4th in terms of the increase of No. of publication, ranked 2 in terms of increase of No. of US patent, ranked 4th in terms of level of nanotechnology development (reached 75% compared with USA 100%). (Read more insights on Nano Korea 2009)







Pictures from left to right is the worldwide smallest 3nm FinFET developed by Korea National Nanofab Center (KNNNC), CNT-based touch screen developed by Sangbo using CNTs supplied by Hanwha and NanoGlobe Director Dr Liu pictured with Mr Paul Chung, Sales Manager of InkTec during our site interview.

SRC/NSF/A*STAR Forum on 2020 Semiconductor Memory Strategies: Processes, Devices, and Architectures (Ms. Jing JIANG, NanoGlobe)

SRC/NSF/A*STAR Forum on 2020 Semiconductor Memory Strategies held on 20-21 October 2009 at Data Storage Institute (DSI) Singapore was organized by Semiconductor Research Corporation (SRC) and supported by US National Science Foundation (NSF) and Singapore Agency for Science, Technology and Research (A*STAR). Asia is an active region for the semiconductor memory research and development and there are many semiconductor memory key players in Asia such as Samsung in Korea; Toshiba, NEC, Tokyo Institute of Technology and AIST in Japan; Macronix and Elite Semiconductor Memory Technology (ESMT) in Taiwan; Chartered Semiconductor, Institute of Microelectronics (IME), DSI and National University of Singapore (NUS) in Singapore as well as others. Invited by A*STAR, SRC chose Singapore to host their first semiconductor memory forum out of US.

37 leading experts in the semiconductor memory field from US, New Zealand, Japan, Taiwan, Korea and Singapore gave invited talks in this forum. In addition to the experts from SRC and NSF, many other US leaders in the semiconductor memory field from Intel, GLOBAL FOUNDRIES, IBM, Texas Instruments (TI), Micron, Unity Semiconductors, RPI,

SUNY Albany, UC Berkeley, Stanford Univ., Carnegie Mellon Univ., Univ. of Wisconsin, and also came to join this form and presented their research achievements. This forum provides good opportunities for all the speakers to know and learn from each other and it is a platform for the participating members to learn the latest R&D trend on memory. The Forum consistsed of six panel discussion sessions: novel memory devices, prospective materials for memory applications, memory architectures, technological platforms for future memories, physical limits of memory elements as well as needs and models for collaborative research. It is expected to find out the promising research directions for emerging research memory devices, processes, and architectures through the panel discussions during the forum.

The limits of scaling and performance for emerging semiconductor memories with an emphasis on embedded applications are still the focus of discussion. In addition to traditional non-volatile memories such as magnetoresistive random access memory (MRAM) and flash memory as well as volatile memories such as transistor-based static random access memory (SRAM) and capacitor-based dynamic random access memory (DRAM), the latest R&D achievements on new types of memories discussed on this forum include phase-change RAM (PCRAM), resistive RAM (ReRAM), ferroelectric RAM (FeRAM), zero capacitor RAM (Z-RAM), Polymer memories, Nanocrystal Based Nanotube/Nanowire memories, CNT based NEMS memories, spin torque transfer MRAM (STT-MRAM) and Thermal Assisted Switching MRAM (TAS-MRAM). The barriers and potential for voltage (power) and density scaling of different memory devices beyond the 22 nm ITRS node is one of hot topics for current semiconductor memory R&D. Possible solutions suggested by speakers are centered around new materials such as Si nanowires / nanotubes, carbon nano tubes (CNT), graphene and polymers, new memory elements such as memristor, gate-all-around transistor, nanowire diode and nanoCMOS, and new architecture design including the cross-point memory array with selection cell/diode, crossbar MRAM design, 3-D integration architectures and others. The advantages that nanostructures such as nanowires, nanotubes and graphene offer over their Si-based predecessors include their tiny size, low power consumption, good retention time and high density.

The invention of nonvolatile embedded memory with high speed and high density would imply a revolution in chip architectures, create new global applications, markets etc. 3D structure with Through Silicon Vias (TSV) for embedded memories could lead to dramatically different ways to build memories, including the low-power provisioning of high bandwidth and low latency. As an example, 3D specific design in the 3D FFT for radar processors can achieve 65% power reduction and 800% increase in memory bandwidth at the cost of 22% increase in total Si area. The primary challenge for the applications of 3D integration circuts (3D IC) is to overcome the cost issue through unique product advantage and reduced Si Area. Hybrid Nano/CMOS 3D integration could be the future of 3D ICs.

DRAM and SRAM remains the main workhorse in embedded memory for logic applications. The selection of DRAM or SRAM depends on the situation. Simply to say, if you need more memory, you should choose DRAM, but if you need fast memory, SRAM could be your first choice. ReRAM is a non-volatile memory with low power consumption, which can be created with very small feature sizes, allowing the scalability for future process generations. ReRAM is a very popular topic on this forum and the first target for ReRAM is to replace the NOL flash in the future. Dr Yoo from Samsung, Korea gave four research suggestions on ReRAM: 1) business model and product for ReRAM can be created by evolution patterns; 2) chaos and complexity phenomena should be considered in ReRAM studies; 3) reconfigurable logic may be one of promising areas for ReRAM applications; 4) Application of oxide ReRAM materials can be expanded to transparent oxide electronics including transparent sensors. The advantage for application of MRAM in the embedded memory includes unification of RAM/ROM, low-voltage operation, zero stand-by current and reduction of process steps. Perpendicular STT-MRAM is presented for solving the scaling issues for MRAM such as high writing current, low density, large switching field distribution (sensitive to process) and half selection issues (retention). There is a “battle” in the memory field and the wise selection should depend on the balance between power, performance, cost and environmental requirements.

Before closing, Dr Hillenius from SRC (USA) presented the SRC model for industry collaboration in his keynote address, highlighting on collaboration among competitors to fund relevant research in universities. Dr Kwong from IME (Singapore) also briefly introduced the Government-University-Industry collaborative model in Singapore. What model would work best for the memory industry? In particular, are there models for international cooperation in pre-competitive memory research that would foster rapid advances in memory technologies? What’s the role of memory in More-than-Moore? How much scaling can we continue and what would we do with true 3-D memory system? Many emerging memory technologies show promising and most of them are discussed on this forum. We look forward to the new International Technology Roadmap for Semiconductor (ITRS) and see what happens in memory in 2020 and beyond.

Figure inset is a group picture at the site visit to fusionopolis organized by ASTAR.

Asia Nano Forum Summit 2009 (Ms. Hongfang JIN, NanoGlobe)

ANFoS09 was successfully held on the 8-9 October 2009 at Institute of Physics, Academia Sinica, Taipei. This event was hosted by Institute of Physics, Academia Sinica and co-organized with Asia Nano Forum and NanoGlobe from Singapore.

Bringing together about 40 invited delegates in government funding agencies, research institutes, and industries from 15 Asian economies, this Summit updated on nanotechnology development in each participating economy, held its Annual

General Meeting and set strategic directions for development and regional collaboration in nanotechnology among the member economies. The updates include past year's nanotechnology development in the areas of policy, R&D, education, commercialization, safety and standardization, infrastructure, as well as international collaboration.

ANF Annual General Meeting (AGM) was held on the Oct. 9th where ANF secretary working report, Working Group briefings and ANF election were conducted. ANF Secretary, Dr.Lerwen Liu gave a representation on ANF Financial Statement and Secretariat activities in year 2008-2009. Election of ANF office bearers for 2010-2011 was conducted. As a result, Dr. H.M.Kim , Mr. M. Takemura and Dr. Lerwen Liu were nominated and accepted as the President, Treasure and Secretary respectively. Dr. K.W.Lim was elected and accepted as the Vice President.

Dr. Prof. Horn Jiunn Sheen(Sinica, Taiwan) gave a presentation on the Current Status & Perspective of Nano-Education in Taiwan. The delegates were deeply impressed by achievement of Taiwan on K-12 Nanotechnology Education Program and Advanced Nanotechnology Education Program. He also gave a briefing on the Asia Nano Camp 2009 which was hosted by Taiwan. The ANC2008 and 2009 created a life changing experience for the majority of young scientists selected from 15 ANF network member economies and this summit pledged to continue this effort to inspire, support and foster young generation of nanotechnologists as they are the driving force of the region future growth. ANC2010 will be co-hosted by Singapore and Malaysia.

The coordinator of Standardization and Risk Management Working Group, Dr. Tsung-Tsan SU gave a liaison report on ANF participation in ISO/TC 229 which included a summary of recent activities including member economies activities on nano standardization and ANF liaison member activities related to ISO/TC229. The delegates agreed that the concept of NanoMark which has been well developed by Taiwan should be extended into ANF member economies. It was also suggested that new module on the ANF website will be set up for members to show database on EHS related issues. A list of active worldwide organizations working on EHS and its websites will be posted on the module.

Dr. Ramam Akkipeddi made a presentation on SERC Nanofabrication & Characterization facility. He also made a proposal that invited young researchers/scientists to do a short-time project in IMRE (Singapore). From AIST, Japan, Dr Hiro Akinaga presented an attractive career opportunity at the Nanodevice Innovation Research Center.

Both Vietnam and Iran enthusiastically proposed to host ANFoS2010 and ANF Executive Committee (ExCo) will decide the host for the next summit at his next ExCo meeting in Dec.09.

Figure inset is the group picture of all the invited delegates to ANFoS2009.

First Asia workshop on Helium Ion Microscope (Ms. Jing JIANG, NanoGlobe)

Abstract: National University of Singapore (NUS) hosted the 1st Asia workshop on the Helium Ion Microscope (HIM) on 10 September 2009. Seven speakers from NUS, US and Dutch joined this workshop for sharing their experience and insights on using HIM for improving their imaging & fabrication technique. HIM is an emerging powerful instrument for applications in the materials (including bio materials) characterization and fabrication, with the imaging resolution to be as high as 0.24 nm.

The 1st Asia workshop on the Helium Ion Microscope (HIM) was held on 10 September 2009 in National University of Singapore (NUS). Seven speakers from NUS (Singapore), Carl Zeiss SMT Inc (USA) and TNO (Amsterdam) gave the presentation to share their experience and insights on using HIM for improving their imaging & fabrication technique. Over 100 researchers and students attended this event to learn this new powerful instrument for applications in the materials (including bio materials) characterization and fabrication.

The HIM has been described as an impactful imaging technology. Combining a high brightness ion source with unique sample interaction dynamics, the HIM provides images offering unique contrast and complementary information to existing charged particle imaging instruments such as the SEM and TEM. By scanning the surface with a fine helium beam formed by a single atom at the tip of a 2 metre tall emitter, HIM can produce image resolution as high as 0.24 nanometre, which is the highest recorded resolution for secondary electron imaging. The small interaction volume between the helium beam and the sample also results in images with stunning surface detail. HIM has a five-time high depth of focus (DOF) than that of SEM, which is ideal for the inspection of high-aspect-ratio samples. HIM combines both the high resolution and the high surface sensitivity because of the extremely localized secondary electron (SE) launch location.

Prof. Dan Pickard shared his experience on direct patterning and imaging of grapheme structures with a HIM. Graphene ribbons with 10 nm width and 3.5 μm length can be reliably patterned with HIM, and they can increase the bandgap by changing the width of ribbon grapheme to very narrow size (smaller than 5 nm). However, contamination and substrate effects still remain challenges for the future devices. In addition to the imaging and patterning with HIM, Dr Diederik Maas from TNO, Science & Industry, Amsterdan described another significant applications with the helium ion beam, which is the Helium Ion Beam Lighography (HIBL) and Helium Ion Beam induced deposition (HIBIP). Their scanning HIBL technique can reach the resolution up to 6±1nm and 14±1nm for the HSQ negative resist and PMMA positive resist, respectively.

To-date, there are only 12 such microscopes in the world, and NUS is the first in Asia to acquire this high-powered microscope.

SMTC Workshop on Sensors and Monitoring Systems in Water & Membranes (Ms. Jing JIANG, NanoGlobe)

Singapore Membrane Technology Centre (SMTC) organized a special workshop on sensors and monitoring systems in water & membranes with the support of PUB (Public Utility of Board, Singapore) on August 13, 2009. Over 100 researchers and engineers participated in this event at the WaterHub Auditorium. Along with this workshop, around 10 local companies exhibited outside the conference area. They are manufacturers and distributors of filtration and waste water treatment products, including Spectra Teknik (S) Pte Ltd, Ultra-Flo Pte Ltd, Amiad Filtration Systems, Dayen Environmental Limited, Sanosil Ltd and others.

This workshop has four sessions: overview of membrane sensors and monitoring technologies, novel monitor for water quality assessment, membrane & fouling monitoring and monitoring flow distribution in membrane systems. Ten speakers from NTU (Nanyang Technological University)'s SMTC and IESE (Institute of Environmental Science and Engineering), University of Sydney, University of Clorado, Spectra Teknik (S) Pte. Ltd., and Waster & Wasterwater, Asia Pacific, Schneider gave presentations on their research breakthrough and technique innovation. The topic on this workshop covers:

- An online optical detector system for wasterborne bacteria
- A novel integrity sensor for membranes
- Continuous imaging particle analyser flowcham
- Acoustic sensing of membranes and membrane fouling
- Electric impedance spectrometry for characterization of membranes and membrane fouling
- Particle image velocimetry for flow characterization in and around membrane modules
- Constant temperature anemometry for flow characterization in and around membrane modules

Two research projects presented on this workshop has already started their commercialization pilot. At the last part of Mr. Nyunt Wai's presentation on their novel integrity sensor for membranes he concluded that this sensor has the better stability & sensitivity to operate at lower pressure, with smaller pore size membranes and to detect low-concentration particles in permeate within a short time.

Water is a vital resource, and is becoming increasingly scarce due to pollution and climate change. Membrane treatment systems are displacing traditional water treatment technologies due to the lower operating costs and higher water qualities achieved. Singapore is at the forefront of membrane technology with large investments in desalination and NeWater. In spite of this growth, the membrane industry has limited access to efficient sensors and monitors. This prevents end-users from fully optimizing the water treatment plant. Mr. Nyunt Wai from MINT (Membrane Instruments and Technology Pte. Ltd) presented a novel integrity sensor for membranes on this workshop and he concluded that this sensor has the better stability & sensitivity to operate at lower pressure, with smaller pore size membranes and to detect low-concentration particles in permeate within a short time. MINT is a Singapore-registered company with the aim of becoming a leader in membrane instrumentation and optimization technology. It will be the first specialist company of its kind to support the multi-billion dollar membrane industry. MINT's core business is the provision of both the hardware and software for improving both the design and operation of membrane processes and their "impossible dream" is the development of an automated control system which receives signals from the various specialized sensors, predicts the performance of the plant, and implements the correct control strategies. MINT's partners include the SMTC and the IESE. The founder, Dr Adrian Yeo, has strong education background in this field and high enthusiasm to spin-off companies. MINT is the third enterprise that he has founded. The first, Water Initiative for Securing Health Ltd is a NGO focused on bringing water to developing countries in ASEAN. Currently, WISH provides water to more than 150,000 people in Indonesia, Cambodia and Myanmar. His second enterprise, Blue Ocean Envirotech Pte Ltd, was an SME providing ultrafiltration membrane filtration systems for water production to factories and mines in Indonesia and the Philippines. Dr Yeo is heavily involved in introducing membrane technology to the youth of Singapore. Over the last 5 years, he has supervised more than 30 polytechnic students in various projects relating to membrane technology. He is currently working with PUB to spread Singapore's water message to schools.

Another commercializing research project is presented by Prof. Hans from the University of New South Wales on the afternoon session of this workshop. Prof. Hans gave an inspiring presentation on the electrical impedance spectrometry for characterization of membranes and membrane fouling. With this advanced impedance spectroscopy technology it is possible to precisely characterize the substructural layers within and on the surface of the membrane at the resolution of several angstroms. Inphaze Pte Ltd (website: www.inphaze.com.au), an Australian spin-off company, is now commercializing and marketing this internationally high resolution impedance technology.

TECHNICAL ACHIEVEMENTS

Electronics

Fabricating electrospun metal oxide nanowire films with improved diffusion property (Prof. Seeram Ramakrishna's group in NUS)

Prof. Seeram and his research team engineered a method to fabricate electrospun metal oxide nanowire (NW) films on substrates such that the resultant films offer improved diffusion coefficient. The method is to disperse the electrospun metal oxide nanofibers in mono carboxylic acids followed by the addition of chosen polymers and binders and pasting the resultant paste on a substrate. Films of thickness 500 nm to 100 µm could be developed using this procedure with excellent adhesion and fiber packing density. These films were used to fabricate dye-sensitized solar cells using the D131 dye and the iodide/triiodide electrolyte. Transient photocurrent measurements showed high electron diffusion coefficient in those nanowire films. The measured diffusion coefficient in those TiO_2 nanowires was orders of magnitude higher than that observed in nanoparticles under similar experimental conditions. The observed enhancement in Dn is attributed to a small electric field in dense NW due to partially depleted space charge region within its volume. The width of this space charge free region increases with increase in the particle size which further enhanced the Dn. Thus, electrospinning offers a possibility to enhance the charge mobility without compromising much to the specific surface area of the nanostructures thereby produced. The high electron diffusion coefficient observed in annealed electrospun metal oxide NW in the present study provides opportunities to fabricate electronic devices with better performance.

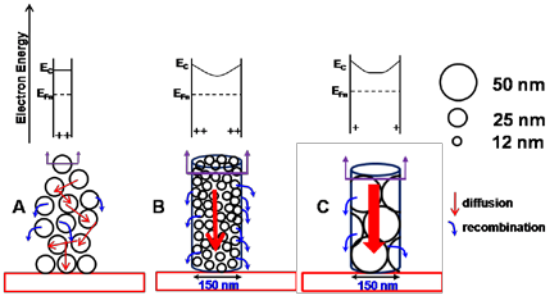


Figure on the right is the schematics showing the diffusion process in nanoparticle and nanowire systems. The bottom and top panel display the morphologies and energy levels, respectively. The red arrow indicates the diffusion process and the blue curves indicate the recombination processes. (A) Mesoporous nanoparticles system in which the conduction band is flat throughout the particle. Typically 25 nm particles have an effective surface area ~100 m^2/g. The mesoporosity of the films has the advantage of large dye-anchoring; consequently with increased recombination. (B) A nanowire of average diameter 150 nm composing particles of ~12 nm; in the present experiment similar structures were obtained by annealing the as-spun composite polymeric fibers for 1 h. These fibers had an effective BET surface area ~ 60 m^2/g. The dyes could be anchored only on their surface; consequently with reduced recombination rate. Close packing of nanoparticles in the nanowires lead to a depleted space charge region in the volume of the nanowires and therefore with an improved diffusion process. (C) A nanowire of average diameter 150 nm composing particles of ~50 nm; in the present experiment similar structures were obtained by annealing the as-spun composite polymeric fibers for 1 h. These fibers had an effective BET surface area ~ 50 m^2/g. Enhanced particle size further reduced the space charge region thereby leading to improved diffusion process.

More information please find from the following reference:

R. Jose, P. S. Archana, S. Ramakrishna, Invention Disclosure 09161N, ILO, NUS (May 2009)
P. S. Archana, R. Jose, C. Vijila, S. Ramakrishna, J. Phys. Chem. C (In Press)

IME goes green with energy efficient transistor solutions (Dr Zhi Xian CHEN and Dr Navab SINGH, IME, A*STAR)

"Green" is the new buzzword in semiconductor technology that has motivated researchers worldwide to develop low power consumption devices with good performance characteristics. IME has made a breakthrough in this area with tunnel field effect transistors (TFET) made by novel fabrication processes. The key features of the IME-developed TFET lies in its improved scalability, density and performance; desirable traits that provide opportunities in applications involving handheld-mobile and implantable devices, even movie-inspired national security applications. Given the proliferation of electronic devices on a global scale, this new piece of technology could hold the answer to our growing energy dissipation problem.

Tunneling device is not a new invention; it has been around, overshadowed by its metal-oxide-semiconductor field effect transistor (MOSFET) counterpart. Increasing device miniaturization imposes physical limitations on MOSFET-based technology, forcing researchers to relook to TFET-based technology for solutions. It is an interesting paradox which aims for both performance and low power consumption within the device. An ideal 'green' transistor should possess all three characteristics: maintain low off-state leakage current (Ioff), high on-state current (Ion) and reduction of power supply voltage (VDD).

The wide-spread use of TFET for energy-friendly solutions has been impeded by its low on-state current, ambipolar nature and lithography unfriendly source/drain implant patterning. TFET is essentially a gate tunable p+/i/n+ diode functioning through tunneling of carriers from source to channel, as the name implies. TFET possesses low off-state leakage current , weak temperature dependence, and more importantly a subthreshold slope smaller than the thermally limited 60 mV/decade, making it ideal for emerging ultra-low power green electronic applications.

IME researchers have developed a vertical gate-all-around (GAA) nanowire device architecture, which circumvented the

above-mentioned inherent nature of TFET. This unique device architecture was realised by independently controlling source and drain implants as well as controlling thermal budgets. Using an IME-patented technology, the researchers fabricated the GAA nanowire devices on vertical Si-wires of diameter ~70 nm with gate length of 200 nm and gate oxide thickness of 4.5 nm.

The schematic diagram and the band diagram of the IME-developed TFET device is as shown in Figure 1. Interestingly, the same device can work either as an n- or p-type device. When VG>0V, the tunneling barrier is at p+/i junction, electron being the charge carrier, device behaves as n-TFET, while for VG<0V, the tunneling barrier is at i/n+ junction, and device behaves as p-TFET with hole being the carrier.

Shown in Figure 2 are the transfer characteristics of the IME-developed TFET device. Although SS is ~70mV/decade, the device performed exceptionally well without any performance enhancers, giving an on-current of ~50μA/μm (about 10x better than the best reported literature value), low off-state current and low DIBL (drain-induced barrier-lowering).

The performance improvements are attributed to excellent gate electrostatic control in GAA nanowire architecture leading to enhanced tunneling along with ultimate scalability. In addition, the inherent asymmetry in the A/D junctions successfully suppressed the parasitic ambipolar effect with the top junction being more abrupt than bottom junction due to different thermal budgets.

The next stage of this research is to explore new materials which can be added at the tunneling interface to further improve the on-state current. The reported TFET device has demonstrated improved scalability, density and performance without additional complexity. It is expected to play a key role in revolutionizing the next generation of transistor technology for powerful, energy-efficient portable electronic applications.

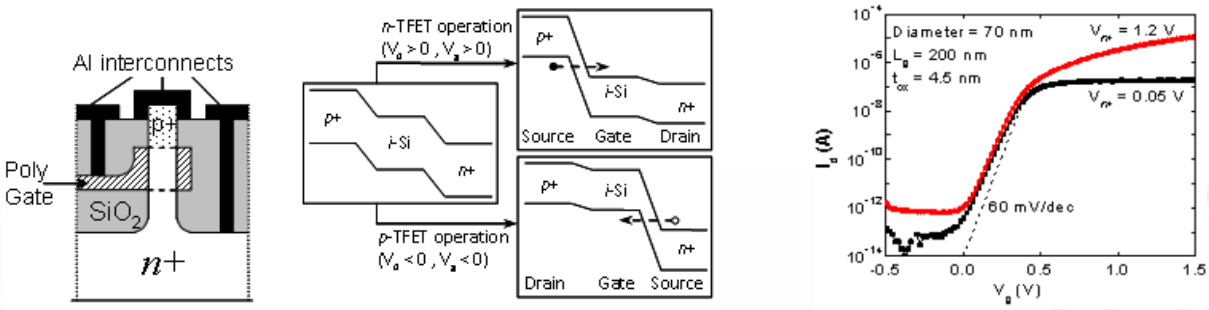


Fig. TFET schematic (left); corresponding operation through band-diagram (middle); Transfer characteristics of n-TFET (right).

MedTech

Nanoparticle-coated Stents (Prof Feng Si-Shen's group, NUS, contributed by Industry Liaison Office)

A team from the Department of Chemical and Biomolecular Engineering at the National University of Singapore has developed a cardiovascular stent, which is coated with drug-loaded, vitamin E d-alpha-tocopheryl polyethylene glycol 1000 succinate (TPGS)-emulsified nanoparticles of biodegradable polymers. This can result in high cellular uptake of the drug and thus low viability of vascular smooth muscle cell. The result is this stent demonstrates better effects in preventing restenosis compared to any other kind of cardiovascular stents.

The nanoparticles act as a reservoir for sustained and controlled release of the encapsulated drug after uptake by vascular smooth muscle cells.

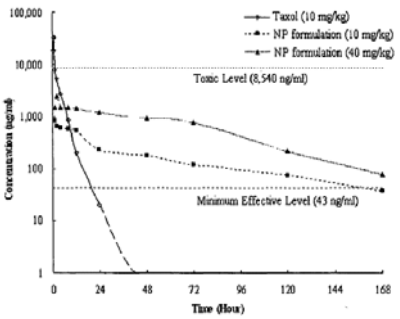


Figure on the right is plasma concentration-time profiles of paclitaxel formulated in Taxol® (paclitaxel) (10 mglkg) or TPGS-emulsified PLGA nanoparticles (10 mg/kg as well as 40 mglkg) after intravenous administration to male SprageDawley rats (180-200 gm and 4-5 week old). The paclitaxel loaded nanoparticles and paclitaxel (Taxol(ID) doses were dispersed or diluted with saline and administrated through the tail vein at the same paclitaxel dose of 10 mg/kg body weight. Blood samples were collected at intervals and the plasma extracted for HPLC or LC/MS/MS analyses. The concentrations between the side-effect level (8,540 ng/ml) and the minimum-effective level (43 ng/ml) show the therapeutic window of the drug.

Nanoparticle based Drug Delivery System: Oral Chemotherapy (Prof Feng Si-Shen's Shen's group, NUS, contributed by Industry Liaison Office)

A team from the Department of Chemical and Biomolecular Engineering at the National University of Singapore have developed a novel drug delivery system of montmorillonite (MMT)/poly (D,L-lactide-co-glycolide (PLGA) nanoparticle.

This drug is used for oral chemotherapy. The idea is to make use of the medical clay as a component material of the nanoparticle matrix, which can promote the mucosal adhesion and cancer cell uptake of the drug-loaded nanoparticles. This allows the anticancer agents to be delivered across the gastrointestinal barrier more effectively to realize oral chemotherapy. The medical clay itself has therapeutic effects for reducing some side effects of the anticancer drug. This invention provides two unique features:

a. It represents a new philosophy of drug formulation by nanoparticles – drug formulated by nanoparticles of another drug which is used as matrix material or a component of the matrix material of the nanoparticles and may have therapeutic effects against the side effects caused by the formulated drug.
b. MMT/PLGA nanoparticles have ability to deliver drugs across the gastrointestinal barrier to realize oral chemotherapy, which is necessary step towards a new concept chemotherapy.

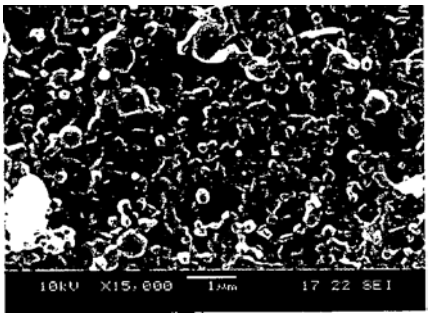


Figure on the right is SEM images of the paclitaxel-loaded MMT/PLGA nanoparticles with 100% MMT

Imaging & Patterning Technology

Biomimetic structures: Butterfly light (Dr Low Hong Yee's group, IMRE, A*STAR)

Patterned surfaces mimicking the nano-scale structure of butterfly wings can produce some impressive optical effects

Many animals, including birds, beetles, fish and butterflies, get their beautiful colors not only from pigments, but also from tiny structures that manipulate light. Now, such natural wonders have inspired Hong Yee Low and colleagues at A*STAR's Institute of Materials Research and Engineering to make polymer structures similar to butterfly wings[1]. Their structures produce optical effects that could prove useful in various electronic devices.

"I was inspired by the possibility of creating color without using chemical dyes and without altering the chemical composition of the pristine engineering polymer," explains Low. "The use of surface architecture to impart functionality could be a more green or sustainable approach."

The surfaces of butterfly wings, in particular, are made up of long thin parallel hair-like structures just 150 nanometres thick, separated by air spaces. The fibres and air have different refractive effects on light striking the wings, causing interference and producing bright iridescence.

"The butterfly wing structure is actually very challenging to mimic," says Low, explaining that previous approaches, though quite successful, have required expensive equipment and time-consuming deposition methods. To address this problem, she and her co-workers took a new approach based on a simple and cheap technique called nanoimprint lithography.

First, the researchers fabricated a silicon oxide mold containing evenly-spaced nanometer-sized trenches. They then heated and softened a polymer before pressing it onto the mold. Finally, they pulled the polymer off the mold at an angle to produce hair-like pillars on the polymer surface. The pillars, each just 200 nanometres in diameter and around 1.2 micrometres long, resemble a collapsed array of dominoes.

The researchers observed either rainbow patterns or single colors on their polymer surface, depending on the angle of incident light. This is because the collapsed pillars are parallel, creating ridge lines that look like a diffraction grating in one dimension, but resemble a multilayered reflective surface in the other dimension.

Eventually the researchers hope to be able to tune the fine structure of their butterfly surfaces and use different materials to produce a variety of optical properties. Low thinks the finished products could have some interesting applications.

"Initially I explored the possibility of using this structural color effect for contact lenses, but we are now seeing more promise in using it as a color indicator for gas sensing. This has attracted interest from food and drug packaging industries," she says. "Another potential application is in electronic displays with restricted viewing angles."

New AFM Technique Enables High-Resolution, Quantitative Electromagnetic Materials Characterization (Agilent Technologies, Singapore)

Scanning microwave microscopy (SMM) is an innovative atomic force microscopy (AFM) method developed by Agilent Technologies. Introduced to the scientific market in 2008, this unique mode of operation combines the compound, calibrated electrical measurement capabilities of a microwave vector network analyzer (VNA) with the nanoscale spatial resolution of an atomic force microscope for the first time. Data from a variety of representative samples have demonstrated that SMM mode is capable of mapping materials properties at a resolution ultimately limited by the sharpness of the AFM probe.

By utilizing robust electromagnetic environment compatibility elements and built-in precision electronic components, SMM mode permits calibrated, more sensitive measurements than are attainable with previously available AFM-based electrical characterization techniques.

Topography (left), capacitance (middle) and dC/dV (right) images of a doped SiGe device acquired with a scanning microwave microscope. Both capacitance and dC/dV images showed some dopant structure not seen in the topography. (W. Han)

SMM mode can be used on semiconductors (no oxide layer required), metals, dielectric materials, ferroelectric materials, insulators, and even biological materials to measure a variety of properties associated with slight variations in the electromagnetic interactions of different components of a sample with the incident microwave signal, either statically or dynamically. Such properties can exist under the surface of the sample and not be observable via topography.

In addition to imaging impedance, capacitance, and dielectric constants, SMM mode measures different dopants for semiconductors. The new method also paves the way for extracting reliable numerical estimates of the carrier densities in semiconductors from the impedance (capacitance) data.

SMM mode can also leverage the measurement capabilities of a VNA to expand AFM-based spectroscopy techniques for electromagnetic characterization. For example, the power sweep and frequency sweep capabilities of a VNA are very well suited for characterizing the frequency response of a given location on a sample. Even a VNA's most common methods for representing measurements, such as the Smith chart and the linear phase plot, offer many new possibilities for spectroscopic techniques with AFM.

Figure inset on the right is SMM system consists of the 5420 or 5600LS Atomic Force Microscope, Vector Network Analyzer and a special Nose Cone for the scanner.

For detail information, please visit www.agilent.com/find/nano

FUNDING/GRANT UPDATES (courtesy of NRF)

NRF Seeding Six Venture Funds with S$10 Million Each to Invest in Singapore-based Early-stage Start-ups (Source: NRF Press Release)

The National Research Foundation (NRF) announced on 31st July 2009 that it would be seeding six new venture funds with S$10 million each under the Early Stage Venture Funding scheme. This scheme is part of a package of programs under the National Framework for Innovation and Enterprise (NFIE) announced by the Prime Minister at the 3rd Research, Innovation and Enterprise Council (RIEC) meeting in March this year. The NFIE is a comprehensive national program to encourage innovation and entrepreneurship especially through the formation of start-up companies to commercialize technologies developed out of R&D.

One of the biggest challenges facing young start-up companies in Singapore is the dearth of venture funds investing in companies during the early stages of their development. This is because the risk of failure is very high at this stage and the entrepreneurs require guidance and nurturing in addition to funding, even though the returns on investment would be correspondingly greater if the companies succeed. The Early Stage Venture Funding scheme seeks to catalyse the set-up of several early stage venture capital funds. Under this scheme, NRF will invest S$10 million in each of the selected VCs, who are required to raise a matching sum of at least S$10 million from third-party investors to invest in locally-based start-ups. The fund managers will be given an option to buy out NRF's investment within 5 years at the price of 1.25 times NRF's original investment.

NRF launched a call to solicit proposals for the early stage venture funds on 18 April 2008. The call received very strong response, with 22 proposals submitted. An Evaluation Panel, comprising experienced entrepreneurs and investors, was formed to evaluate these submissions. The Panel, chaired by Mr Teo Ming Kian, Permanent Secretary (National Research &

Development) unanimously recommended 6 fund managers for award, who are The six selected fund managers are: BioVeda Capital II, Nanostart Asia, Raffles Venture Partners, Tamarix Capital, Upstream-Expara, and Walden International. The Awarded fund managers will operate venture funds of at least S$20 million each (including S$10 million from NRF) to invest in Singapore-based early-stage high-tech start-up companies. For more information, please refer to the website: http://www.nrf.gov.sg/nrf/uploadedFiles/News_and_Events/ESVF%20Press%20Release.pdf

The 3rd NRF Proof of Concept (POC) Grants call is currently open (Source: NRF Press Release)

The 1st and 2nd NRF POC grant call have already attracted ~ 400 proposals and the 3rd NRF POC grant call is currently open, from 28 September to 18 November 2009. This call is open to all staff, researcher and students of Singapore public-funded universities (NUS, NTU and SMU) and polytechnics. Staff and students of the Institutes of Technical Education (ITEs) and MOE-funded schools may also apply to the grant. The NRF POC grant scheme provides funding for proof-of-concept development to researchers in the institutions of higher learning (IHLs) so as to facilitate the commercialisation of technologies developed in the IHLs. The NRF POC grant will be awarded through a competitive application process to support projects which are technically proven and have potential for commercially viability. The grant will go towards supporting the R&D costs related to the development in a proof-of-concept project. The development work must be conducted in the IHLs, and should yield results pertaining to viability for commercialisation. Applicants awarded the grant will receive up to S$250,000 for their project, which should last no more than 1 year. The actual amount awarded will depend on the extent of work to be carried out. Submitted proposals will be shortlisted by their host institutions. Subsequently, a NRF POC panel will evaluate the proposals for their commercial viability. For more information, please refer to the website: https://rita.nrf.gov.sg/AboutUs/NRF_Initiatives/POC3_2009/default.aspx

NANOTECH NEWS

Bringing nanotechnology to schools (contributed by Nanyang Polytechnic)

Nanyang Polytechnic (NYP) was established on 1 April 1992. The School of Engineering at NYP was established from the amalgamation of the French-Singapore Institute, German-Singapore Institute and the Japan-Singapore Institute which were transferred from the Economic Development Board to the Polytechnic. NYP is the only polytechnic in Singapore that offers a diploma combining nanotechnology and materials science. The new Diploma Nanotechnology and Materials Science started in April 2009 with about 50 students and offers industry scholarship for top students.

NYP organizes adhoc courses and programs as part of its community engagement efforts. In October, NYP conducted 2 nanotechnology activities for the public and secondary school students. As part of the Engineering Week 2009 festivities, the School of Engineering (Manufacturing) organized a nanotechnology workshop called “Colorful Nanomaterials World” which let participants experience the special properties of nanomaterials through hands-on experiments. The exciting half day seminar attracted adults as well as students. It was conducted by Dr Hannah Gardner who has more than 5 years of experience applying nanomaterials in photovoltaics.

Nanyang Polytechnic also conducts Advanced Elective Modules (AEM) in “Nanomaterials and Applications” for secondary school students. This is an intensive 5 day program which is held year round for interested school students, and where students are given a theoretical introduction to nanotechnology and how nano-enabled devices work. They are also given hands-on opportunities to create nano-applications such as dye sensitized solar cells from vegetables/fruits and pressure sensors. This year, Nanyang Polytechnic has conducted these courses for Deyi Secondary, Serangoon Gardens Secondary and Chung Cheng High Schools.

DNA-carbon nanotube microprocessors - small hope for a big shift? (Source: Business Exchange News)

Right now, the cost of progressively shrinking the wires etched onto silicon is getting higher and higher with each successive shrink, and the lithographic techniques used today are going to hit a wall when they try to go below the 22 nanometers. IBM and Caltech outline the combined DNA origami and semiconductor manufacturing techniques in the journal Nature Nanotechnology. The DNA origami scaffolding technique might allow for future chips to be made using a million dollars worth of polymers and DNA sequences instead of hundreds of millions of dollars in etching and doping gear. Synthetic viral DNA has been domesticated by IBM and Caltech researchers to be a kind of coral reef upon which other kinds of future semiconductor technologies such as carbon nanotubes, silicon nanowires, and other nanoparticles can be grown. The DNA sequences are mini scaffolds or circuit boards, depending on how you want to think about it, says IBM.The neat bit is that the DNA origami technique allows for these DNA reefs to be placed on silicon wafers that are created using current semiconductor manufacturing techniques, and in an organized fashion that may make the production of chips based on carbon nanotubes or silicon nanowires economically feasible. The technique they came up with uses electron-beam lithography or optical lithography to etch DNA binding sites onto silicon dioxide or diamond wafers. While the Caltech team can mix the synthetic viral DNA with different lengths of shorter molecules called oligonucleotide strands that bend the DNA into different shapes — triangles, squares, stars, and so forth — all from a simple solution of slime, the DNA origami, as Rothemund calls these shapes, spread themselves randomly around a bit of silicon wafer. IBM has figured out how to punch little holes into the wafer at regular intervals, and based on the properties of each DNA origami bit, that allows the DNA shapes to be herded up and spaced evenly at resolutions as small as 6nm.

There is a long way from that point, though - if this technology even gets out of the lab and into a testbed, much less full-scale production. But once it does, we all know that resistance is futile. And that will be the case because of the downshift in the cost of making chips that such a strange process holds. Such a hybrid DNA-carbon nanotube chip would put the IT industry on a whole new Moore's Law curve.

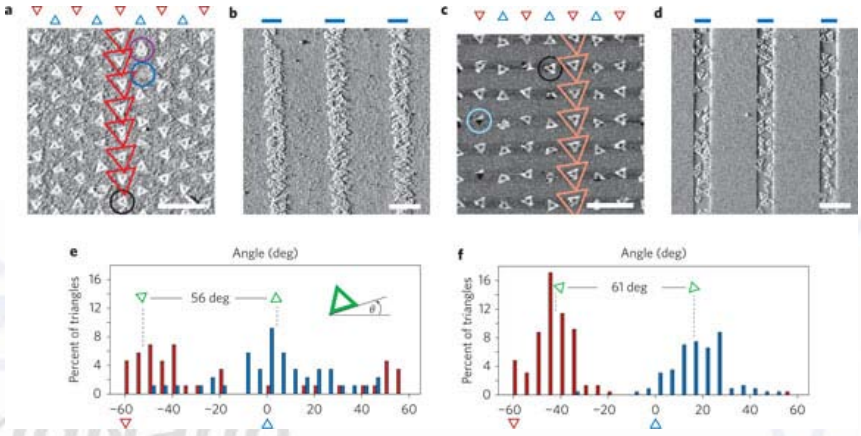


Figure inset is the alignment of DNA origami on SiO_2 and DLC surfaces.

MagForce Successfully Completes Final Clinical Trials for Nano-Cancer Therapy (Source: Nanostart Press Release)

MagForce Nanotechnologies AG, the Berlin-based medical technology company majority owned by Nanostart, today announced the successful completion of final clinical trials demonstrating the efficacy of its Nano-Cancer® therapy in patients with recurrent glioblastoma, a frequent form of brain tumor which is highly malignant. The actual study results significantly exceeded the study objective. Nano-Cancer® therapy is the world's first approach to use magnetic nanoparticles for treating tumors with virtually no side effects. This is done by injecting specially coated iron oxide nanoparticles directly and precisely into the tumor so that they remain concentrated in the tumor and do not diffuse into the surrounding healthy tissue. The nanoparticles within the tumor are then heated to an exact temperature by externally applying an external magnetic field. In this way, tumor temperatures of up to 70°C (158°F) can be precisely attained within a fraction of a degree. This heat damages the tumor or destroys it completely. During the treatment procedure, patients feel only a moderate warming sensation.

According to a previous study among a large patient population, the median survival time following diagnosis of a glioblastoma recurrence and treatment with conventional therapy (surgery, chemotherapy and radiation) is 6.2 months. The primary objective for the Nano-Cancer® therapy study was to demonstrate an extension of the median survival time in the recruited patient group by three months compared to this historical control group. In fact, the median survival time of the 59 patients participating in the final trials was 13.4 months following treatment with Nano-Cancer® therapy in conjunction with radiation. The median survival time was thus significantly greater, more than double that of the control population. The results were even more remarkable in that Nano-Cancer® therapy was tested not on newly diagnosed patients with primary tumors but rather as a study involving patients who had already endured treatment with conventional therapies, as well as the unpleasant effects generally associated with these. Following regulatory approval of the new therapy, it is expected that it will also be available for use in treating other types of localized tumors, as these are generally responsive to the same principle of using warmth to destroy or degrade cancer cells.

In addition to its high efficacy of which has now been conclusively demonstrated, Nano-Cancer® therapy offers an additional and very significant advantage compared to the existing conventional therapy alternatives of surgical intervention, chemotherapy and radiation: Nano-Cancer® therapy is tolerated extremely well by patients and, despite its high efficacy, has no serious or unpleasant side effects. The vision of MagForce is to establish this new technology alongside surgery, chemotherapy and radiation as an additional pillar of cancer therapy.
The results of these clinical trials will now form the basis of application for EU regulatory approval for the new therapy, which will be submitted before the end of this year. Once EU regulatory approval has been obtained, MagForce will be able to market its Nano-Cancer® therapy throughout the European Union. The detailed study results will be published shortly in a medical journal.

UPCOMING EVENTS (contributed by EDITOR)

Singapore

4th International Conference on Experimental Mechanics (ICEM 2009)
18-20 November 2009, Holiday Inn Atrium, Singapore
www.icem2009.net

IMRE Industry Day
9:00AM-2:00PM, 11 December 2009, Seminar Room 2, Institute of Materials Research and Engineering, A*STAR

2009 IEEE Asia-Pacific Services Computing Conference (IEEE APSCC 2009)
07-11 December 2009, Biopolis, Singapore
http://www1.i2r.a-star.edu.sg/~mkirchberg/

2010 International Conference on Nanotechnology, Optoelectronics and Photonics Technologies (NOPT 2010)
26-28 February 2010, Singapore
Website: http://www.iacsit.org/nopt/confs.htm

The 2nd International Conference on Computer and Automation Engineering
26-28 February 2010, NEC, Singapore
Website: http://www.iccae.org

Worldwide

Indo-US Workshop on Nanotechnology: Applications and Implications
10-12 November 2009, Indian Institute of Chemical Technology (IICT), Hyderabad, India
Website: http://www.iictindia.org/nano

Second International Workshop on Nanotechnology and Application 2009 (IWNA 2009)
12-14 November 2009, Vung Tau City, Vietnam
Website: http://www.hcmlnt.edu.vn/conference/IWNA2009

5th International NanoRegulation Conference
25-26 November 2009 in Rapperswill, Switzerland
Website: http://www.nanoeurope.com

1st International Conference on Advanced Nanomaterials and Nanotechnology (ICANN-2009)
9-11 December 2009, Indian Institute of Technology, Guwahati, India.
Website: http://www.iitg.ernet.in/icann2009/index.html

The 2nd ASME Micro/Nanoscale Heat & Mass Transfer International conference
18-21 December 2009, Shanghai Jiaotong University in Shanghai, China
Website: http://www.asmeconferences.org/MNHMT09/

The 3rd Thailand Nanotechnology Conference 2009: Health, Energy, Environment
21-22 December 2009, Bankok, THailand
Website: http://www.nano2009.ait.ac.th/conference/

Biotech Showcase™ 2010
12-13 January 2010 in San Francisco, United States
Website: http://www.ebdgroup.com/bts/

AMN-4: Conference on Advanced Materials and Nanotechnology
8-12 February 2010. Wellington, New Zealand
Website: http://www.macdiarmid.ac.nz

ICQNM 2010: The Fourth International Conference on Quantum, Nano and Micro Technologies
10-15 February 2010 in St. Maarten, Netherlands Antilles
Website: http://www.iaria.org/conferences2010/ICQNM10.html

Nano tech 2010 (International Nanotechnology Exhibition & Conference)
17 - 19 February 2010, Tokyo, Japan
http://www.nanotechexpo.jp/en

The 2010 edition of the International Conference on Nano Science and Technology (ICONSAT)
17-20 February 2010. IIT Bombay, Mumbai, India
Website: www.iconsat2010.in

ICONN 2010- International Conference on Nanoscience and Nanotechnology
24-26 February 2010 SRM University, Chennai, India
Website: www.iconn2010.com