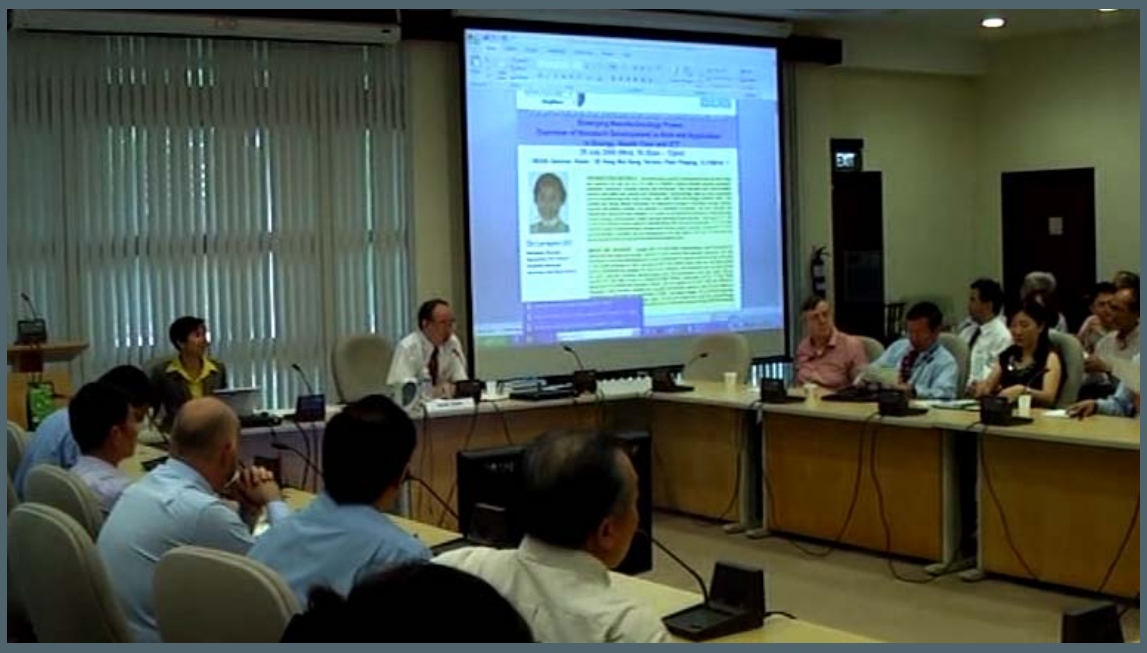
SingNano – Singapore Nanotechnology Network
NEWSLETTER

ISSUE No. 2 August 2009

THIS ISSUE



Special Topic: NanoSafety - We Need You!

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EVENT HIGHLIGHTS

Book Launch Seminar of "Emerging Nanotechnology Power – Overview on Nanotechnology Application in Energy, Healthcare & ICT Development in the Asia Pacific Region" by Dr. Lerwen Liu (Ms. Yesie L. BRAMA, NanoGlobe)

Happening full-house in ISEAS on 29th July 2009, a book launch seminar of "Emerging Na notechnology Power – Overview on Nanotechnology Application in Energy, Healthcare & ICT Development in the Asia Pacific Region" was successfully organized by NanoGlobe Pte Ltd, Institute of Southeast Asian Studies (ISEAS), and World Scientific Publishing Co. Pte Ltd, attended by over 100 participants. The seminar was delivered by Dr. Lerwen Liu to promote her recent book titled "Emerging Nanotechnology Power: Nanotechnology R&D and Business Trends in the Asia Pacific Rim". Dr. Liu is an Asia-based nanotechnology expert specializing in the government and corporate strategic services to policy makers and corporate executives. She has been actively building nanotechnology networks with the government agencies, R&D institutions and industries across the world and especially promoting nanotechnology policy and cooperation in the Asia region. She is the director and founder of NanoGlobe Pte Ltd, a consulting company specializes in micro and nanotechnology strategy, business development, and incubation in Asia. And she believes that nanotechnology is going to revolutionize the way we make things and transform the way we live.

Lerwen delivered her seminar in two parts; the first part was to introduce the concept of nanotechnology & its useful applications in daily lives and the second part to share her insights on nanotechnology strategy development and competitive analysis in AP region in the last 10 years. She stimulated active interaction from the audience to share their experiences in nanotechnology, including policy, research and commercialization.

The concept of nanotechnology was introduced by taking some examples of mm-size objects such as ant scaling down all the way to nanometer-size, which is one billionth of a meter, such as carbon nanotubes (CNTs) or DNA. Further, a video courtesy of IMRE on the CNT growth was displayed and the evolution of nano-component to final product was illustrated such as silver nanoparticles that were dispersed in a network mesh for making transparent conductive layer that can be applied for touch panel screen. As Lerwen moved on to the useful applications of nanotechnology, she cited a few examples in a house exteriorly and interiorly, car transportation, lifestyle, biomedical and clean environment such as the use of nanoparticles to enhance the efficiency of solar cells/panels, to improve the properties of wall paints and fabrics to become self-cleaning, anti-mould and anti-stain, to improve the properties of mirrors and glasses to become anti-reflective and anti-fog, to improve the fuel efficiency of a car through lightweight frames, low rolling-resistance tires, and LED/OLED lightings. In addition, the use of nanostructured material can better control the drug release in the human body as well as the use of CNT to assist the targeting of drug delivery.

Highlighted achievements in nanotechnology from home-grown companies include the success of Pasture Nanotechnology in getting the FDA approval and selling their NT-V and N95 masks to combat the spread of H1N1 and H5N1 viruses through the use of nanoparticles, and another success story of BioNano International Singapore Pte Ltd in developing their water treatment plants in China through the use of nanobubbles.

The second part of the seminar was focused on the evolution of nanotechnology national initiative (NNI) and the nanotechnology activities going on since then in Asia Pacific region. NNI in the region was all started from the first move of Japan setting up Atom Technology Program (ATP) for USD 250 million in 1992. One initiative example highlighted in the seminar was the setting up of RUSNANO – the Russian Corporation of Nanotechnologies in 2007 to enable the government policy in nanotechnology.

The seminar was ended with some highlights on the activities of the region in nanotechnology national investment and public funding, nanotechnology education and outreach as well as nanotechnology standardization and risk management. Apparently, Asia as a whole has spent the highest nanotechnology public funding ahead of Europe and United States over the years of 2003 - 2007, and individually Japan seemed to spend the most for its nanotechnology investment among the rest of the countries in the region or even in the world (as compared to Germany and United States). Besides being impressive in communicating and educating nanotechnology to the society, Japan and Taiwan have spent notable efforts in addressing the standardization and risk issues in nanotechnology, while Singapore has started to be more involved in the nanotechnology risk management by going to introduce nanotoxicity initiative later in this year.

Overall, Lerwen's vivid and interactive presentation allowed the audience to learn the exciting nanotechnology applications today, which any layman can relate to.

Business Opportunity in Traditional and Alternative Energy Conference 2009 (Ms. Yesie L. BRAMA, NanoGlobe)

Taking place on 26 June 2009 at Singapore Business Federation, this half-day conference was the second public event organized jointly by the Singapore Business Federation (SBF) and Russian Business Incubator "FUTURUS", as part of the bilateral cooperation initiative in promoting R&D and commercialization. The conference aims to showcase Russian technologies and businesses in the alternative energy industry. It also provides a forum to identify concrete collaborative areas for future development of business cooperation in traditional and green energy sectors between Russia and Singapore.

The conference was very informative and educational especially for Singapore based companies who are looking for opportunities of collaborating and having strategic partnership with Russian companies. RBI "FUTURUS" highlighted some strategic areas that will attract much collaboration between Singapore and Russia, such as efficiency enhancement in traditional energy utilization, heat and waste management, renewable energy source generation and quantum technologies.

The role of RBI "FUTURUS" in Singapore is to facilitate the increased volumes of innovative business traffic between Russia and Singapore, including R&D projects, innovations commercialization, supply of high technology and modern equipment, technologies, methodologies, and investment projects in various sectors. One of its clients, RUSNANO, has allocated up to 3 billion Euros for investing in commercialization projects in nanotechnologies. RBI "FUTURUS" is the RUSNANO representative in Singapore for projects search, terms negotiations, and assistance in preparing applications for RUSNANO financing.

The conference featured two companies from Russia, namely INTER RAO UES and EMAlliance, and a company from Singapore, Alpha Biofuels. These companies are all working in the same field, energy generation. INTER RAO UES is the principal exporter and importer of electric power in Russia while EMAlliance is mainly involved in boiler market, providing full scale engineering services from feasibility study to post guarantee service about boiler. Looking at possible strategic partnerships within South East Asia region, INTER RAO UES is interested in cooperation with owners of green energy and sustainable energy innovations and technologies. On the other hand, EMAlliance is interested in R&D of all types of integrated gasification technologies, all types of zero emission power (ZEP) technologies and nanotechnology for new materials, media cleaning, new fuels, new components and new processes.

In contrast to the two Russian companies, which are considered to be big players in their country, Alpha Biofuels is one example of successful Singapore start-ups involved in clean technology – renewable energy source, with carbon footprint conscious mind. Alpha Biofuels works by collecting liquid waste including the used vegetable oil from restaurants and homes and converting it to biodiesel to power vehicles. In 2007, it was the first local enterprise to produce and retail biodiesel B100 in Singapore. It is currently pursuing the development of anaeorobic digestion & ethanol production and algae photobioreactor.

To close the conference, a study on renewable energy conducted by Frost & Sullivan was presented. It identified that Asia is at tipping point for renewable energy where it is going from R&D to fast expansion. It also summarized the best technology opportunities owned by selected countries in Asia, barriers as well as the typical returns (IRR) for each technology.

Singapore International Water Week 2009 (Ms. Yesie L. BRAMA, NanoGlobe)

Inspired by the success of the inaugural of the Singapore International Water Week (SIWW) last year, SIWW 2009 was again organized as global platform that brings together policymakers, industry leaders, experts and practitioners to address challenges, showcase technologies and achievements, discover opportunities, and forge partnership in the water world. SIWW 2009 was organized by the Singapore International Water Week Pte Ltd, a company set up by the Singapore's Ministry of the Environment & Water Resources and PUB, Singapore's National Water Agency and co-organized by the Singapore Airshow & Events Pte Ltd. It took place on 23 – 25 June 2009 in Suntec Singapore International Convention & Exhibition Centre.

Themed "Sustainable Cities – Infrastructure and Technology for Water", SIWW 2009 offered a diverse mix of programmes on water infrastructures and technologies, including Water Leaders Summit, Water Convention & Water Expo, Regional Business Forum from 9 regions (Australia, Japan, Middle East, North Africa, China, SEA, North America, India and Europe), and Finance Forum. SIWW 2009 also marked the opening of the Singapore's largest and most advanced used water treatment facility, the Changi Water Reclamation Plant.

Over 200 academic papers and posters were presented in the Water Convention and more than 160 exhibitors from all over the world participated in the Water Expo. Among large-scale water treatment equipment, a water filter company from Switzerland, Katadyn, found itself in a niche market of the water industry. It provides a full range of portable water treatment that includes both salt and sweet water. Katadyn's mechanical water treatment technology involves impregnated silver nanoparticles ceramic filter of 0.2 micron pore size and superfine glassfiber of 0.3 micron pore size to filter out

bacteria and protozoa, and activated carbon to reduce harmful substances and remove unpleasant tastes, odours, chlorine, etc from the water. Katadyn aims to provide immediate and safe drinking water during disaster relief and emergency preparedness.

Interestingly besides showcasing its world first commercialized electro-osmosis dehydrator, Ace Korea Incorporation Co. Ltd also exhibited its latest FDA certified product AceNano Calcium Essential, sphere-shaped calcium nanoparticles produced by the world's first top down technology 4D nano pulverizer system. AceNano Calcium Essential enables almost 100% absorption of calcium into the blood stream for utilization by the body. It also provides the purest and most valuable source of calcium supplement free from chromium, lead, barium and mercury.

Other interesting exhibition includes membrane technology for Membrane Bioreactor (MBR) and Reverse Osmosis (RO), dominated by the Japanese companies such as Toray Industries Inc, Nitto Denko and Hitachi as well as ceramic membrane for small scale water treatment system and water re-use application developed by Metawater Inc.

And another unique exhibition was observed in Lavano booth, where the exhibitors showcased their green water-free urinal for both gents and ladies. It is the sealant liquid in the cartridge installed at the base of the urinal that helps to form a barrier between open air and urine and seal all odours within the cartridge. Therefore water is no longer necessary and cleaning can only be performed by wiping the urinal base surface. In the exhibition Lavano conducted a survey to create awareness to the visitors about this water-free toilet, which can save enormous amount of water used for flushing.

Public Lecture by Nobel Laureate: Biofuels - can they help to reduce global warming or to solve the energy crisis? (Ms. Jing JIANG, NanoGlobe)

On July 1st, 2009 in University Cultural Centre, National University of Singapore (NUS), the Nobel Laureate Hartmut Michel presented an inspiring public lecture with the title of "Biofuels - can they help to reduce global warming or to solve the energy crisis?" It is one of the three public lectures by Nobel Laureates organized in conjunction with ICMAT 2009 and IUMRS-ICA 2009. This seminar attracted more than 500 students and researchers.

Dr. Michel is the professor of biochemistry at the Johann Wolfgang Geothe University and has been the director of the Molecular Membrane Biology Department at the Max Planck Institute for Biophysics since 1987. For the success with the crystallization of membrane proteins and the elucidation of the three-dimensional structure of the photosynthetic reaction centre from the purple bacterium Rhodopseudomonas viridis, he was awarded the Nobel Prize in Chemistry (together with J. Deisenhofer and R. Huber) in 1988.

Prof. Michel gave a one-hour lecture to discuss how to take advantage of biofuels together with solar energy to help solve the global warming problem. He explained the theoretical limit for the efficiency of photosynthesis is around 4.5% but in reality less than 1% of the sunlight energy is stored in the form of biomass. He discussed 60% of the energy in the harvested potatos came from the fossil fuels. He showed an example how farms can earn more by selling energy by biomass than by selling milk. At last, Prof. Michel highlighted his vision to set up 3~4 big Photovoltaic fields (including Sahara, Gobi and Australia deserts) throughout the world connected by superconducting cable that can supply all electric power required by man power. He concluded that:

(1) The production of biofuels is very inefficient land use and the direct usage of biomass for heating or electricity conversion in power plants (replacing fossil fuels) is more efficient.
(2) Solar energy can and will be used to generate electricity either via solar thermal power plants or photovoltaic cells.
(3) The most efficient and green transportation in the future should be driven by the combination of photovoltaic cells, electric battery and electric engines.

Quantum-Pi receives the 2009 Frost & Sullivan Award for Technology Innovation in Integrated Nano-Sensing (Dr. Marek T. MICHALEWICZ, Quantum-Pi)

Quantum-Pi (Quantum Precision Instruments Asia Private Limited) received 2009 Frost and Sullivan South-East Asia Technology Innovation Award for integrated nano-sensing technologies. The Frost & Sullivan Awards are an annual event to recognise outstanding performances by companies in the electronics, industrial automation, process control, energy & power systems, chemicals, materials and food as well as environment & building technologies industries. The awards banquet, held on 2 April at the Shangri-La Hotel, Kuala Lumpur, was attended by Dr. Marek Michalewicz, Founder and Chief Scientific Adviser, as well as Mr. Krish Krishnan, Quantum-Pi's Corporate Development lead. In his acceptance speech, Dr. Michalewicz thanked several of Singapore's A*STAR institutions, especially the Institute of Microelectronics (IME) for its role in the world-first fabrication of Quantum-Pi's NEMS sensors. He also thanked the Institute for Materials Research and Engineering (IMRE) and the Singapore Institute of Manufacturing Technology (SIMTech) for their support in testing and characterising these pioneering devices.

Dr Michalewicz receives Frost & Sullivan 2009 South-East Asia Technology Innovation Award

Quantum-Pi's NEMS sensors address critical needs in a range of industrial and commercial applications, including semiconductor fabrication, oil & gas exploration and production, structural health monitoring, precision engineering and

manufacturing, navigation and defence, and numerous consumer electronics devices and system. The first commercial products will be launched through Quantum-π's development partnership with a listed US$ 2.0 billion electronics firm.

International Symposium on Space Technology and Science (ISTS) 2009 (Ms. Yesie L. BRAMA, NanoGlobe)

ISTS 2009, held on 5 – 12 July 2009 in Tsukuba City, Japan and sponsored by the Japan Aerospace Exploration Agency (JAXA), was the 27th symposium to encourage the specialists of space engineering, space science, space medical and space law to exchange information and promote space related activities through presentation, exhibition, and panel discussion. At the same time, ISTS 2009 celebrated its 50th anniversary since the first symposium held in 1959 in Tokyo Japan and therefore was themed with "Toward the Next 50 Years".

The symposium drew over 470 technical papers and it covered not only the technical presentations, but also special programs and events such as panel discussion on innovating ISTS towards the future and 50th anniversary keynote speech, reception and award presentation. It also exhibited the latest results of space-related R&D and business activities from 17 prominent Japanese organizations/companies/universities working on space technology and science. In addition, a technical tour was also arranged for visitors to find out more in details the activities and facilities available in JAXA.

Various space-related topics were presented over the five-day symposium such as surface exploration, international space station, earth observation, lunar exploration, electric propulsion system, thruster and detonation engines, small satellites, mission design, attitude maneuver and orbit control, formation flight, satellite communication and broadcasting, materials characterization, space debris, liquid solid and hybrid rockets, space tourism, space elevator, and many other interesting topics. It also covered panel discussions on space solar power systems, international cooperation in Asia Pacific region and space contribution to the Earth's sustainability.

Being a beginner in space technology and science, I found myself learning very much about the advancement of technology being developed, applied and achieved for space applications. One in particular is space elevator, which is another form of space transportation enabling safer and lower cost system than chemical rockets that are currently in the mainstream. It was mentioned that once upon a time (pre-2000), space elevator was science fiction simply because there was no known ribbon materials that were strong enough to build it as its concept outlines the hanging of a ribbon in space and reaching down to Earth, while a vehicle that climbs up or down is attached to the ribbon. However, the discovery of carbon nanotubes in the 90's changed the destiny of space elevator, as it potentially provides the necessary strength and weight required in space elevator concept.

On slightly different approach, the Japanese are now developing their own space vehicle, referred as space train. It differs with the space elevator concept mainly on the power delivery methods and climbing mechanism. Space train concept involves the use of cable, made of carbon nanotubes with high strength and high conductivity, as powered rail equipped with counter lightning features. It also involves the use of solar power as much as possible as it will be the primary energy source from the altitude of 10-100 km upwards. It was estimated that the weight of the whole system will only be about 20-40 tonnes and Earth Track Corporation – Japan, spin-off company that is developing the space train, estimated that it will be ready for commercialization in 2030.

It was also interesting to learn the enthusiasm from Asian countries in space technology development, for example Indonesia acknowledged and recognized the importance of education on basic space technology. The experience of small satellite development is also recognized to be very useful and efficient to foster young space engineers. In the same way, Vietnam is also striving to self-educate aerospace engineers, self-manufacture hardware and software, and to master the manufacture technology of ground station, small satellite technology. Small satellites including micro/nanosatellites, of which components fabricated by micro/nanotechnology, seem to be in the trend now for the near future form of satellites, since similar capability but at lower cost can be expected.

Lastly, space tourism is another emerging trend that was discussed in one full session. In conclusion, Asian countries have shown their enthusiasm in developing space technology, especially small satellites, and space education for manpower development. Nanotechnology plays its role in enabling the fabrication of micro/nanosatellites as well as the development of space vehicles, including space elevator and space train.

SPECIAL TOPIC

NanoSafety – We Need You! (Dr. Hiran VEDAM, NanoConsulting)

Nanotechnology is becoming increasingly ubiquitous from consumer products and food to electronics and communication. The benefits of nanotechnology arise from the fact that nanomaterials exhibit behavior different from the corresponding macroscopic form. It is also possible to engineer nanostructured materials which exhibit novel properties hitherto unseen in nature. Because of these properties, nanotechnology is gaining commercial applications. There are currently over 200 nanotechnology based products available commercially in the global market. These products are being used in electronic, magnetic, biomedical, cosmetic, energy, chemical and material application areas. As these commercial applications increase, there is growing concern about the health, safety and environmental (HSE) risks associated with these materials.

More specifically, the following HSE related concerns are to be understood:
(1) What is the exposure potential for nanomaterials in different parts of its life cycle?
(2) What are the risks that the nanomaterial will cause harm to exposed persons or ecosystems?
(3) What is the impact of these materials on biological systems at different dosages? Is the effect transient or permanent? What is the potential for other hazards such as fire and explosions?
(4) How much of an exposure is required for how long before the impact is felt? How many times should the exposure be before impact is felt?
(5) How can exposure be minimized or eliminated? For example, can a more toxic nanomaterial be replaced by a less toxic one without affecting performance?

Understanding the risks and managing them well is an imperative to effectively commercialize nanotechnology based products and realize their potential. At present although we know that there are potential risks to health and environment from manufacture and use of nanoparticles, we do not fully understand what these risks are and how to deal with them. Also, while we understand that potential for exposure of people and environment is high due to increased use of nanomaterials in processes and products, there is not enough information available on toxicity, exposure and risk involved.

A recent EMERGNANO report (March 2009) by Institute of Occupational Medicine summarized the current status of nanomaterial HSE as follows:
(1) Progress has been made in identifying candidate materials to develop characterized nanoparticles for toxicology.
(2) Filters such as those used in respiratory protective equipment and in air cleaning systems are highly effective in removing nanoparticles from the air.
(3) There is very little data relating systemic exposure of nanoparticles to toxicity outside of the lungs, hence limiting our ability to study the effect of these particles on liver or blood components.
(4) There is considerable progress being made in understanding the kinetics of nanoparticles in invertebrate and vertebrate models and their relationship to toxicity. There is also increasing understanding of nanoparticle impact on microorganisms.
(5) There is sufficient evidence to show that carbon nanotubes may have adverse effect on human health; and that silver and titanium dioxide nanopartices are detrimental to the environment.

Providing impetus to the HSE efforts around the world is the development of standards by ISO/TC229 standardization committee. This committee is developing standards related to:

- Terminology and nomenclature standards provide a common language for scientific, technical, commercial and regulatory processes
- Measurement and characterisation standards provide an internationally accepted basis for quantitative scientific, commercial and regulatory activities
- Health, safety and environmental standards improve occupational safety, and consumer and environmental protection, promoting good practice in the production, use and disposal of nano-materials, nanotechnology products and nanotechnology-enabled systems and products. – an effort led by USA

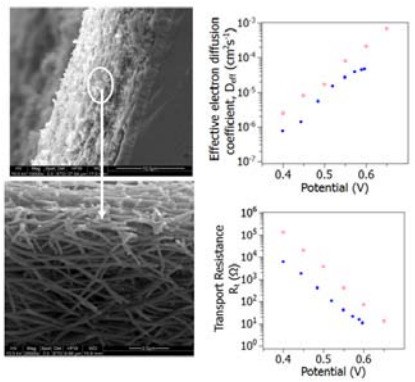
The committee expects that many of the documents produced by it will be anticipatory and become change agents to guide the market and research in these areas.

Nanosafety related work in Singapore is largely limited to academic institutions and research institutes in Singapore. As a technology that has impact on all major manufacturing sectors in Singapore, nanotechnology and its safety implications should be a matter of concern to all industry players here. However, to date very little has been done to address this critical area. To address this gap, NanoConsulting Pte. Ltd. along with NanoGlobe Pte. Ltd. is coordinating between the different government bodies, industry players and academic institutions in Singapore to define how Singapore should address this area of nanosafety. As a first step, we are organizing a focus group discussion in the middle of September with all interested parties to identify the industry needs in this area. If you are interested in participating, please send an email to hiranvedam@nanoconsulting.com.sg and we will send further details on the event soon.

TECHNICAL ACHIEVEMENTS

Electronics

Enhance the Charge Transport Properties in TiO_2 Nanofibers (Dr. Jose RAJAN / Prof. Seeram RAMAKRISHNA, NUSNNI)



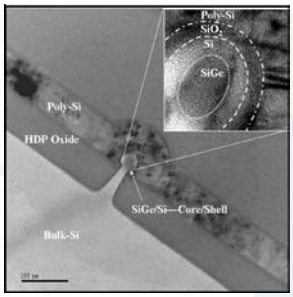
Prof. Seeram and his research team demonstrated that electrospun TiO_2 nanofibers features low transport resistance and comparable electron diffusion coefficient to the conventional nanoparticles using the state-of-the art impedance spectroscopy. A large number of surface traps were observed in the TiO_2 nanofibers using Open Circuit Voltage Decay measurements. Increasing the crystallinity of the electrospun TiO_2 nanofibers can avoid these surface traps thereby improving the electron transport through these fibres. One of the focuses of the energy research group of Prof. Seeram's laboratory (http://www.bioeng.nus.edu.sg/seeram_ramakrishna/) is to enhance the charge

transport properties in nanostructured materials.
In an effort to increase the charge transport through one-dimensional nanostructures, Prof. Seeram and his research team developed a method to fabricate nanowire films of high aspect ratio with appreciable film thickness on desired substrates. The method comprises of dispersing electrospun continuous metal oxides in monocarboxylic acids and making a film of the resulting nanowires on desired substrates. TiO_2 nanowire films developed using this technique gave diffusion coefficient of the order of 10-4 cm^2/s.
Figure shows the morphology of the electrospun nanofibers on conducting glass substrates and their charge transport properties.

IME blazing the nanoelectronics trail beyond Moore's Law (Yong Chua TEO / Dim Lee KWONG, IME)

The Institute of Microelectronics (IME) is a research institute of the Science and Engineering Research Council of the Agency for Science, Technology and Research (A*STAR). Positioned to bridge the R&D between academia and industry, IME's mission is to add value to Singapore's semiconductor industry by developing strategic competencies, innovative technologies and intellectual property; enabling enterprises to be technologically competitive; and cultivating a technology talent pool to inject new knowledge to the industry. Its key research areas are in integrated circuits design, advanced packaging, bioelectronics, MEMS, nanoelectronics and photonics. IME has big plans and grand vision to be a world class research institute through its multi-disciplinary research team and state-of-the art research infrastructure to stay at the forefront of advanced technology developments.
The Nanoelectronics and Photonics Programme in IME focuses on advanced electronic materials, novel processes and innovative device structure technologies. In 2008, the team won the Singapore National Technology Award and IEEE EDS George E. Smith Best Paper Award in recognition of their contribution to groundbreaking research in nanoelectronics. The programme actively collaborates with universities to push new research frontiers and engages with innovative industry partners to align research to enable the industry. Here are some exciting research areas to watch out for:

- ***Gate-All-Around (GAA) nanowire (NW) transistor***

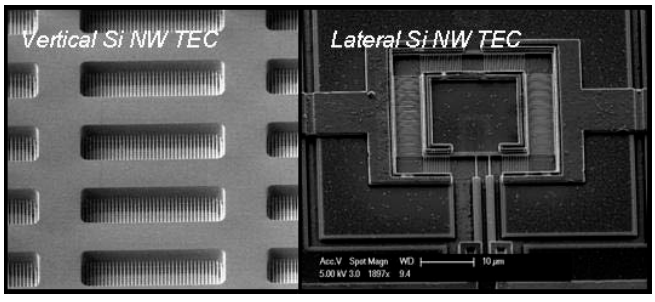


The Gate-All-Around (GAA) SiGe/Si core/shell nanowire (NW) transistor is one of the most promising device architectures for ultra scaled high performance CMOS requirements due to: (1) high carrier mobility in SiGe core, (2) improved interface quality due to Si shell, and (3) superior short channel controllability of GAA nanowire architecture. IME has demonstrated uniaxially strained SiGe/Si core/shell nanowire pFET in GAA device architecture on bulk wafers using CMOS-compatible process technology. High drive current of 650 µA/µm (15% higher than Si counterpart) is achieved through a channel comprising of 12 nm SiGe NW core with a 4 nm thick Si shell. This is the best performance reported so far. The use of bulk wafer can significantly reduce device cost by 90% without resorting to SOI wafers.
Figure at the right is a cross-section Transmission Electron Microscopy (TEM) image of a Gate-All-Around nanowire transistor

- ***3D nano-structures for high density non-volatile memories applications***

IME has successfully demonstrated a vertical, high quality single-crystal Si nanowire with a highly scaled diameter (~50nm) channel that is able to overcome the limitations faced by conventional planar flash memory technology (eg. short channel effects (SCE) and less amount of electrons for information storage). The vertical nanowire device exhibited well-behaved memory characteristics, in terms of the program/erase window, retention, and endurance properties. This signifies the first effort using surround gate in 3D nano-structures for high-density.

- ***Thermoelectric cooling and generation***



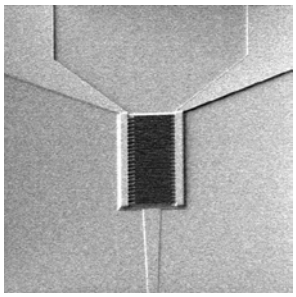
Thermoelectric units have always been strong contenders at microprocessor cooling and power generation at a micro-watt level. Thermoelectric materials can cool localised hot spots thus allowing the microprocessor to drive harder for better computing performance. They can even potentially convert any low grade waste heat into electricity to self power smaller units. The efficiency of these materials can be greatly improved by nano-structures. But it has been a challenging task to scale down conventional thermoelectric materials like Bismuth Telluride and the processes are not CMOS compatible. Recent works in IME have suggested that SiNW arrays show great promise as highly scalable and efficient thermoelectric materials. As the dimensions of silicon go below 50 nm, there is a 100 fold decrease in its thermal conductivity (1.6 W/mK) without affecting the Seeback coefficient or electrical resistivity. This makes SiNW a very promising thermoelectric material because of the low thermal conductivity and established CMOS infrastructure. We

are currently working on harnessing the potential of SiNWs as on-chip hot spot coolers and self powered ICs. Figure at left shows the different configurations of silicon nanowires for thermoelectric cooling.

- ***Enhancing solar cell efficiency with Nanocone Arrays on silicon thin film***

The research community has been actively pursuing "3rd Generation Solar-Cell for the year-2020". The aim is to improve the efficiency while reducing fabrication cost. Through finite element simulations, IME has demonstrated that silicon nanowire arrays with thin film as bottom substrate layer have obvious advantage over the pure thin film substrate or SiNW array structure in solar cell application. This is due to the enhancement of photon absorbance in both high and low energy regime. For the first time, IME proposed that silicon nanocone arrays decorated silicon thin film can enhance the efficiency by around 1.5X.

- ***Nano-photonics (plasmonics)***



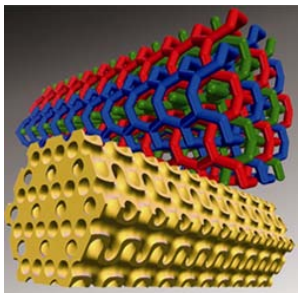
The evolution of silicon photonics will become increasingly promising with the development of cutting edge nano-photonic technologies. However, the aggressive downsizing of physical dimensions compromises device performance. The application of surface plasmon technology to boost the quantum efficiency of both active and passive nano-photonics devices such as photodetectors, modulators, laser sources, and waveguides emerges as a practical solution. The discovery of surface plasmons works on the principle to generate resonance at the metal-dielectric interface with the same frequency, as the impinging electromagnetic waves, but with a much shorter wavelength. By exploiting this effect, it becomes possible to guide and manipulate optical signals in nanoscale structures. Such nano-photonic technologies could potentially change the landscape for silicon photonics allowing for greater miniaturization of photonic circuits and taking performance to newer heights.
Figure at the right is a Scanning Electron Microscopy (SEM) image of a Ge-on-SOI metal-semiconductor-metal (MSM) photodetector featuring interdigitated grating electrodes for enhanced surface plasmonics effect.

- ***3rd generation photovoltaic solar cells***

The conventional wisdom that 1 photon yields 1 set of electron-hole pair defines the first and second generation solar-cell technologies but these technologies are limited to low yield due to a large percentage of high-energy (e.g. blue UV) of the whole sun-light spectrum being wasted as heat. In collaboration with University, we have observed that with silicon nanowire it is feasible for multi-electron-hole pairs generation upon high-energy photon (threshold ~2.4eV) strike. In addition to the tremendous advantage of shortening the n/p collection distance, Si-nanowire is potentially an efficient material system to be explored further for the 3rd generation solar-cell technology.

MedTech

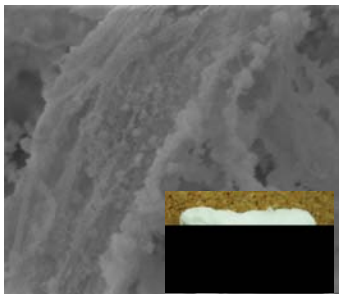
World's First Tri-Continuous Mesoporous Silica Complex Structure Developed by IBN



IBN scientists have engineered the world's first tri-continuous mesoporous material using a specially designed surfactant template – this completely new porous structure had previously only been predicted mathematically. Recently published in Nature Chemistry, this novel material, named IBN-9 after the research institute, is the first hexagonal nanoscale construct with 3 unconnected interwoven channels. It is by far the most complex mesoporous nanostructure to have been synthesized in real-life and represents a new class of mesoporous materials. "IBN-9 demonstrates that it is possible to create three interwoven but independent pore channel systems along with a unique nano-fiber morphology. Such a mesostructure makes distinct diffusion rates in different directions possible. This property would be very attractive for gas separation and drug delivery systems," said IBN Executive Director Professor Jackie Y. Ying, who led this research. Figure at the right is the schematic of IBN-9's channel topology (top) and pore structure (bottom), showing three interwoven but unconnected channels (Structural model developed in collaboration with Stockholm University, Sweden.) More information please read: http://www.ibn.a-star.edu.sg/images/cms_press/press_47.pdf

Mimicking Nanofibrous Nature of Native Scaffolds for Improved Tissue Regeneration (Dr. Wee Eong TEO / Prof. Seeram RAMAKRISHNA, NUSNNI)

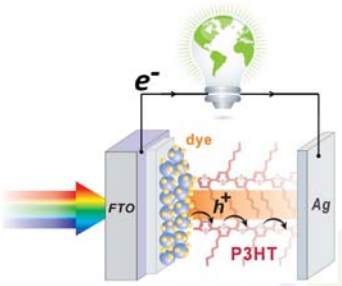
Many studies have suggested that nano-topography is able to influence and in many cases enhances cellular activity. In clinical application such as joint replacement, surfaces with nano-textures have been shown to improve adhesion between the host tissue and the implant. Current commercial man-made regenerative scaffolds are mainly made from traditional mass production machine which are unable to produce nano-textures or nano-structures. NUSNNI is one of the pioneers in using



electrospinning to fabricate nanofibrous regenerative scaffolds. Using the same principal technology, they are able to fabricate scaffolds that mimic native extracellular matrix (ECM) of various tissues. With global market for orthobiologics alone estimated at US$4.8 billion in 2008, improvement in regenerative scaffolds performance through mimicking host tissue will certainly increase their acceptance and demand. New products in development from NUSNNI laboratory include skin, bone, cartilage and nerve regenerative scaffolds. By working closely with surgeons, they are able to develop products that enhance tissue restoration while meeting clinical conditions. In one case, surgeons using their nerve guidance nanofibrous scaffold for bridging peripheral nerve gap are positive about their animal study results and express preference of their scaffold over existing commercial products. Other scaffolds are currently undergoing animal studies and they are confidant that these new products with nanostructures will form the next generation of regenerative scaffold and improve patient's quality of life.

CleanTech

Energy from Hybrid System: Efficient TiO_2-Polythiophene Hybrid Solar Cell (Dr Bin LIU, CME-NUS)



The U.S. National Academy of Engineering has announced 14 grand challenges for engineering in the 21st century. Making solar energy affordable is among the challenges, because solar energy is largely abundant and can surpass the present global energy crisis. In recent decades, some low-cost novel photovoltaic systems have been developed for the "next-generation" photovoltaic technologies, such as dye-sensitized solar cells, bulk heterojunction photovoltaic cells, and polymer-inorganic hybrid solar cells.

Polymer-inorganic hybrid solar cell is of the most popular candidates for the "next-generation" photovoltaic technologies. (see figure 1) However, few groups could achieve a high efficiency of above 1%. In the recent research work by Dr. Liubin's group, highly efficient nanoporous TiO_2-polythiophene hybrid solar cells are achieved. (see figure 2) A metal-free organic dye (D102) is employed to modify the TiO_2/polythiophene interface. The interfacial energetic is further adjusted by some additives to enhance the charge collection. A high efficiency of 2.63% is finally achieved, which is a new record efficiency for the polymer-inorganic hybrid solar cells. Moreover, dual-mechanism is proposed for the improved performance, indicating the crucial roles of dye engineering and interfacial engineering on improving the device efficiency.

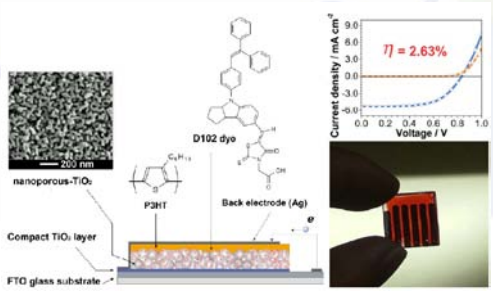
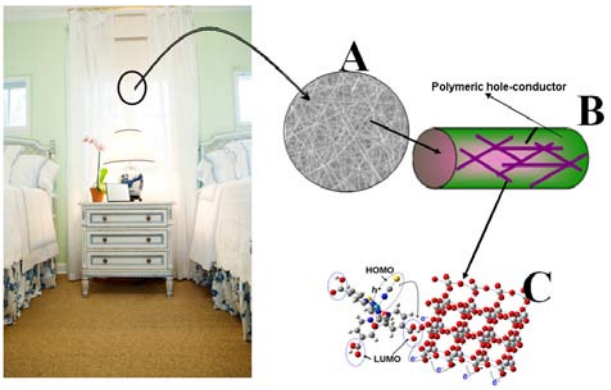


Figure 1 shows the lighting the future world with hybrid energy. Figure 2 shows the chemical structures of polythiophene and D102 dye used in the work. A schemed structure of the hybrid device, a Scanning Electron Microscope (SEM) image of the nanoporous TiO_2 film, Voltage-current characterization and a picture of finished device are also displayed. More information can be obtained from the following website: http://www3.interscience.wiley.com/journal/121581732/abstract

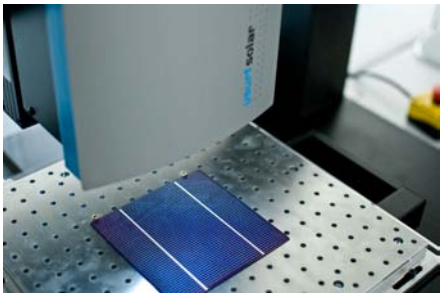
NUSNNI has initiated research programs to develop solar cloths (Dr. Jose RAJAN / Prof. Seeram RAMAKRISHNA, NUSNNI)



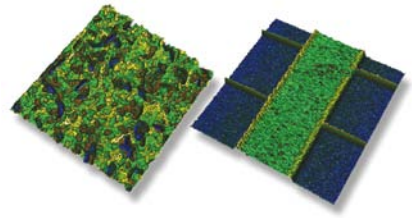
Prof. Seeram and his research team has initiated research programs to develop solar cloths – a non-woven fiber cloth made by electrospinning a polymeric solution containing a hole-conductor in which dye-anchored wide bandgap semiconductor is dispersed. The concept is schematically shown below. Efficiency of photovoltaic conversion depends on the degree to which the two species, i.e., dye-anchored semiconductor and the polymeric hole-conductor, form a percolating network in addition to the efficiency of charge generation, separation, transport and collection. The solar cloths fabricated in his laboratory by dispersing N3 dye anchored TiO_2 in a polymeric matrix containing P3HT, PANi, and PEO gave an open circuit voltage of ~300 mV and current density ~20 A/cm2. The team targets to develop solar cloths with efficiency ~2% in five years.

Figure shows the concept of photovoltaic fibers. The PV fibers are visualized as a non-woven fiber cloth (A). The fiber is a percolating network of one-dimensional nanostructures such as nanowires dispersed in a polymeric hole conducting medium (B). Organic flourophores such as dyes or semiconducting quantum dots could be anchored to the nanowires widen the absorption wavelength window (C). Light absorption by the flourophores leads to excitation of electrons to unoccupied molecular orbitals which are then injected to the conduction band of the wide bandgap metal oxide semiconductor; the oxidized flourophores are regenerated by a hole-conductor.

Flexible 3D solution for solar applications: µsurf solar (Mr. Alan ONG, Nanofocus Asia Pte Ltd)



NanoFocus AG, specializing in 3D surface analysis equipment, extends its product portfolio by introducing µsurf solar, a high precision optical measurement solution for the broad range of crystalline solar applications in laboratory and production. As a business solution, the µsurf solar is adapted to the requirements of solar industry from hardware to software through system integrated automation.



From laboratory research & development down to the component level manufacturing processes, the continuous monitoring of the product specifications and surface parameters in the micrometer and nanometer ranges becomes increasingly more important. The optimum flexibility of the µsurf solar allows all solar measurement tasks to be performed with nanometer accuracy using confocal technology. This extensive evolution delivers the highest stability of data – with high dynamic and intuitive handling.

The system is able to conduct up to 12 area measurements within one minute, including procedure time and evaluation. A vacuum chuck guarantees the safe fixture of the solar cell while the high precision x-y stage is in motion. The positioning tables are available up to the meter range, in length and width, which is a necessary feature in measuring entire solar modules.

µsurf solar enables non-destructive analyses without preparation of the samples. For the 3D inspection system, it does not matter if the surfaces possess etched structures or an anti-reflective coating; accurate surface data acquisition is achievable. Also for samples with awkward surface characteristics, such as steep slopes, complex geometries, and minute structures in the nanometer range, µsurf solar delivers exact and repeatable 3D measurement data within a few seconds.

The software works with unique algorithms and variable exposure time, which especially improves the evaluation of alkaline textured surfaces. Due to the combination of height and reflection data, edges can be determined precisely with nanometer-accuracy. The integrated industry specific automation function with data base access provides an even more efficient measuring process.

“Namable solar companies, such as Schott Solar and centrotherm photovoltaics, already trust in the reliable NanoFocus technology. The development of a specific business solution for this industry occured as a result of the increasing demand within solar energy companies and research entities”, states Dr. Hans Hermann Schreier, CEO of NanoFocus. “Numerous requests and some initial sales of the system immediately after the market introduction show that µsurf solar meets exactly the requirements of solar applications and that it is the right tool to improve solar cell quality and efficiency.”

High Performance, Energy Saving Nanofiltration Membranes for Water Filtration (Dr. Rajendrakumar Suresh BARHATE / Prof. Seeram RAMAKRISHNA, NUSNNI)

Nanofiltration is an emerging an energy-efficient separation process with the potential applications in many industries ranging from water, chemical, food, pharmaceuticals, petrochemical and environmental (pollution prevention) industries. Reduced operation cost, avenues for integrated processing, clean and environmental friendly processing are the main drivers for the nanofiltration operation. However, the limited choices of commercially available nanofiltration membranes, low fluxes, high cost of the nanofiltration membranes, membrane fouling and membrane stabilities during operation (chemical, thermal and structural stabilities) remained as the major concerns for the processors.

NUS Nanoscience and Nanotechnology Initiative (NUSNNI) researchers have developed the energy saving (highly permeable membrane flux) high performance, structurally durable, pressure tolerant, low fouling nanofiltration membranes using electrospun nanofibers. These membranes are useful for newer applications in water treatment such as pretreatment in the brackish water or seawater desalination, drinking water treatment (removal of fluoride, nitrate, arsenic, hardness responsible dissolved salts, colouring and naturally organic matter, microorganisms likes viruses and bacteria, emerging micro-pollutants such as pesticides, herbicides, personal care and pharmaceutically active compounds) and pretreatment in production of industrial process water. The developed membranes are the low pressure membranes having improved flux, engineered surface to reduce fouling phenomena and good mechanical properties.

This work is supported by the Environment and Water Industry (EWI) Development Council (Govt of Singapore) through the funded project “Development of low pressure, high flux UF and NF membranes based on electrospun nanofibers for water treatment” and NUS Nanoscience and Nanotechnology Initiative(NUSNNI), National University of Singapore.

NUSNNI is looking for a partner, who can join for the scale up and device/module build up to make the use of developed membranes in the real field water purification applications.

FUNDING/GRANT UPDATES

Boost for Singapore R&D with $60 Million New Research Award from NRF

NRF's Competitive Research Programme (CRP) grants have spawned a sizeable pool of scientists carrying out internationally competitive high impact science and technology research in Singapore. Six research projects to receive funding under the CRP Funding Scheme's fourth grant call, bringing the total number of CRP awards to twenty. The six new research awards are:

- Interface Science and Technology (PI: Christos Panagopoulos, NTU)
- Tailoring Oxide Electronics by Atomic Control (PI: Thirumalai Venkatesan, NUS)
- Nanonets: New Materials, Devices for Integrated Energy Harnessing& Storage (PI: Subodh Mhaisalkar, NTU)
- Frontiers in Magnetic Recording Research: Vision for 10 Terabits per square inch (PI: Charanjit Singh Bhatia, NUS)
- Membrane Protein Sciences – Tools for Rational Discovery of Novel Therapeutics and Diagnostics Targeting Integral Membrane Proteins (PI: JaumeTorres, NTU)
- Adult and Induced Pluripotent Stem Cells for Neurological Disorders and CNS Repair (PI: George Augustine, Duke-NUS GMS Singapore)

Two of the awards, "Interface Science and Technology" at the NTU and "Tailoring Oxide Electronics by Atomic Control" at the NUS, were assessed by the IEP to be highly complementary and would achieve greater research outcomes if carried out in close collaboration. This is the first time that two teams from two separate universities are awarded the funding to bring about cohesive scientific collaboration, to achieve even greater outcome than each of the programme could deliver on its own. More information at: http://www.nrf.gov.sg/nrf/NewsEvents.aspx?id=124

S$15 Million Awarded to Eight Research Teams under The Clean Energy Research Programme

The Clean Energy Programme Office (CEPO) awarded S$15 million to eight research teams under the Clean Energy Research Programme (CERP) in July, 2009. Singapore's location in the tropics, coupled with our highly-urbanised landscape, gives rise to the opportunity to harness solar energy through innovative roof-mounted solar energy systems suited for the tropical climate. In addition, given that there are many urbanized cities similar in size to Singapore throughout the tropical region, there is also vast market potential for successful end-products to be exported.
The eight selected proposals span a vast range of innovations such as solar driven cooling systems, hybrid thermal systems and optimization of the performance of solar systems under the diffuse sunlight conditions typically experienced in the tropics. Executive Director of the CEPO and Managing Director of Singapore's Economic Development Board Beh Swan Gin said, "These CERP projects are also in line with Singapore's aim to be a ' Living Laboratory' where companies can develop, test-bed and demonstrate innovative urban products and services before scaling up these solutions for Asia and the rest of the world."
The S$50 million CERP was launched in 2007 to accelerate R&D efforts to help drive the growth of the clean energy industry in Singapore. The third CERP grant call opened on 13 July 2009. The two topics under the third call are (i) improving solar cell efficiency; and (ii) storage systems for renewable energy.
More information at: http://www.sedb.com/edb/sg/en_uk/index/news/articles/s_15_million_awarded.html

MND Research Fund for the Built Environment

To encourage and support applied R&D that will raise the quality of life and make Singapore a distinctive global city, in alignment with the vision and mission of MND (Ministry of National Development). MND has set aside $50 million over the next five years for the new "MND Research Fund for the Built Environment" and appointed BCA as the secretariat. The third RFP closed on 8 Aug 2008, with 43 proposals received. Of which, 17 have been accepted for funding support. Ngee Ann Polytechnic and Kok Fah Technology Pte Ltd are granted to co-work for studying the feasibility of using photovoltaic (PV) system to offset electrical costs for automating greenhouse ventilation and supplementary lighting in vegetable cultivation.
More information at: http://www.bca.gov.sg/ResearchInnovation/mndrf.html

Quantum-Pi and Nanomotion get grant from EDB SIRD and the CSI for 18-month product development (Dr. Marek T. MICHALEWICZ, Quantum-Pi)

Quantum-Pi together with Nanomotion from Israel has been successful in securing a US$740,000 grant from EDB SIIRD (Singapore Israel Industrial R&D) and the CSI (Chief Scientist of Israel). The grant will be split 50%-50% between the two companies for 18-month product development. Nanomotion will build a new piezo-motor for their line of nanopositioners, and Quantum-Pi will incorporate nanoTrek tunneling encoder of position into Nanomotion's systems creating a closed-loop metrology system with nano-meter positioning capability. Quantum-Pi is raising funds to match the SIIRD grant.
Nanomotion can be found at: http://www.nanomotion.com, Quantum-Pi at: http://www.quantum-pi.com

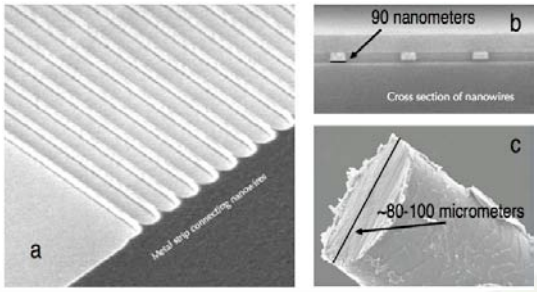
NRF 8M SGD Grant for to Prf. Seeram (NUS) and Prof. Subodh (NTU) for the Project on Nanonets for Energy Conversion and Storage (Prof. Seeram RAMAKRISHNA, NUSNNI)

A research team led by Prof. Seeram (NUS) and Prof. Subodh (NTU) succeeded in receiving ~S$8M research grant for their Competitive Research Project on Nanonets for Energy Conversion and Storage from the National Research Foundation. A "Nanonet," comprising a planar network of electrically interconnected nanowires, may be considered as the fourth form of materials that promises a revolution in the world of electronics with low-cost, inventive, and fault-tolerant properties that will stimulate opportunities in large-area electronics and green energy systems.

NANOTECH NEWS

Nano-sensors primed to deliver future immersive gaming

The future of Wii Fit-style interactive games that deliver real exercise is hotting up, promising a new generation of trully immersive, precise-response consoles using nanosensors - thousands of them embodied in your gamesuit. Here in Singapore, Quantum PI, a company founded by a Polish-born inventor, Dr Marek Michalewicz, has created NanoTrek sensors, the first ever based on quantum tunneling. The micro-mini NEMS (Nano Electro Mechanical Systems) beasts, with a sensing area measuring just 50 x 50 micron, are supposedly more robust than their larger MEMS brethren, with 5x to 10x better vibration- and motion-sensing capabilities.



(a) Current nanoTrek® devices consist of 12,000 nanowires ; (b) each nanowire is only 90nm across; (c) which is only ~1/1,000th width of a human hair

The technology could be applied in environments as diverse as oil drilling to concrete wall condition monitoring, to maglev train propulsion (keeping say precise 8mm levitation height across 100 metre train length) or UFO-style anti-gravity engines. But for our IT nerdy enjoyment, it will be fun to wear a sensor suit sporting a few thousand of these little things, for an immersive, realistic movement simulation experience, maybe inside a 3-D VR cave for matching visual immersion.

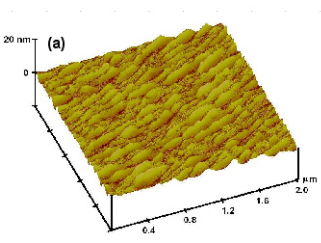
The device's potential is enormous, especially when combined with MEMS - or future NEMS - sized processing elements. The future roadmap includes wireless, self powered NEMS sensors - now, imagine what this can sense, or do, travelling through your body on its own!

No wonder governments and "unique" investment groups are showing interest in the device. Singapore's A*Star science tech research agency was the first - and another small defence-focused country in the other corner of Asia is the next up. More information at: www.quantum-pi.com

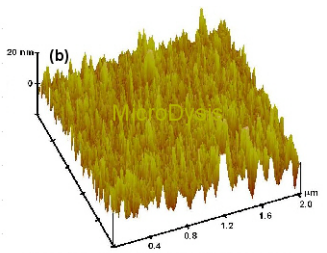
Break-through CNT Assembly on Polymer Surface (MicroDysis / Patented)

Recently, MicroDysis demonstrated this technique to entrap single-walled carbon nanotubes (SWNTs) onto a polymer surface, such as elastomer or silicone rubber, and plastics. This approach increases the functionalized surface of a device by 10,000 times and provides an ideal matrix for attaching molecular probes and other chemically active absorbers for maximum detection sensitivity. MicroDysis further developed an 8-well strip microplate with the bottom surface entrapped SWNTs for pharmaceutical and biomedical applications.

Atomic Force Microscope (AFM) images (in Tapping-Mode) shows that SWNTs are vertically assembled on polymer surface. The average height of the entrapped SWNTs is around 40 nm. The nanotubular features of the nanotubes on the surface significantly enhance the surface area to about 10,000 times greater than a blank surface. With the functionalized surface feature (-COOH groups) on the nanotubes, this technique will find broad wide applicat ion in immobilizing sensing molecules for DNA assays, protein analysis, and chemical compound and ion detection.



Blank polymer surface



Polymer surface entrapped SWNTs vertically (AFM image in Tapping-Mode)

Advantages of this technique:

- Vertical assembled single-walled carbon nanotubes on polymer matrix.
- Surface area increased about 10,000 times.

- Highly dense-COOH groups for chemically binding sensing molecules.
- Versatile sensing platform.

More information at: www. nanotech-now.com/news.cgi?story_id=34070

Nokia and University of Cambridge launch the Morph - a nanotechnology concept device

New York, US and Espoo, Finland - Morph, a joint nanotechnology concept, developed by Nokia Research Center (NRC) and the University of Cambridge (UK) - was launched today alongside the "Design and the Elastic Mind" exhibition, on view from February 24 to May 12, 2008, at The Museum of Modern Art (MoMA) in New York. Morph features in both the exhibition catalog and on MoMA's official website.

Morph is a concept that demonstrates how future mobile devices might be stretchable and flexible, allowing the user to transform their mobile device into radically different shapes. It demonstrates the ultimate functionality that nanotechnology might be capable of delivering: flexible materials, transparent electronics and self-cleaning surfaces. Dr. Bob Iannucci, Chief Technology Officer, Nokia, commented: "Nokia Research Center is looking at ways to reinvent the form and function of mobile devices; the Morph concept shows what might be possible".

Dr. Tapani Ryhanen, Head of the NRC Cambridge UK laboratory, Nokia, commented: "We hope that this combination of art and science will showcase the potential of nanoscience to a wider audience. The research we are carrying out is fundamental to this as we seek a safe and controlled way to develop and use new materials."

Professor Mark Welland, Head of the Department of Engineering's Nanoscience Group at the University of Cambridge and University Director of Nokia-Cambridge collaboration added: "Developing the Morph concept with Nokia has provided us with a focus that is both artistically inspirational but, more importantly, sets the technology agenda for our joint nanoscience research that will stimulate our future work together."

The partnership between Nokia and the University of Cambridge was announced in March, 2007 - an agreement to work together on an extensive and long term programme of joint research projects. NRC has established a research facility at the University's West Cambridge site and collaborates with several departments - initially the Nanoscience Center and Electrical Division of the Engineering Department - on projects that, to begin with, are centered on nanotechnology.

Elements of Morph might be available to integrate into handheld devices within 7 years, though initially only at the high-end. However, nanotechnology may one day lead to low cost manufacturing solutions, and offers the possibility of integrating complex functionality at a low price.

For further information, please visit the websites www.moma.org/elasticmind and http://www.nokia.com/A4126514

UPCOMING EVENTS

Singapore

Invited Research Lecture on OLEDs for Displays and Lighting: Materials, Processing and Production
01 September 2009, SIMTech Training Rooms, Level 3, Tower Block, Singapore
http://www.simtech.a-star.edu.sg/simcorp/loadEventDetail.do?id=1.6&currId=1.6.1&cid=4718602&pid=16285700

8th National Healthcare Group Annual Scientific Congress 2009
16 -17 October 2009, Suntec Singapore International Convention & Exhibition Centre http://eastar.eventshub.sg/ems_wb_Details.aspx?CalID=28&EventID=102781

Exploit Technologies Innovation and Enterprise Week
19 - 23 October 2009, Matrix Building, Biopolis, Singapore
http://eastar.eventshub.sg/ems_wb_Details.aspx?CalID=28&EventID=104421

Singapore International Water Week 2010
28 June - 02 July 2010, Suntec Singapore International Convention & Exhibition Centre, Singapore
http://www.siww.com.sg/

Worldwide

NanoBusiness 2009: Revitalizing the Economy through Nanotechnology Innovation
08 - 10 September 2009, McCormick Place, Chicago, USA
http://www.nanobusiness2009.com/

Nanocarbons: from physicochemical and biological properties to biomedical and environmental effects
08 - 13 September 2009, Acquafredda di Maratea, Italy
http://www.esf.org/index.php?id=5254

Asia Nano Camp 2009
28 September - 12 October, Taiwan
http://nano-taiwan.sinica.edu.tw/2009_AsiaNanotechCamp/index.htm

International Conference - cum - Workshop on Nanoscience and Nanotechnology (AIT-Nano 2009)
12 - 16 October 2009, Ansal Institute of Technology, Gurgaon, India
http://www.aitgurgaon.org/nano2/index.html

International Symposium on Nano - Materials, Technology and Applications(Hanoi-NANOMATA 2009)
15 - 17 October 2009, Hanoi, Viet Nam
http://www.coltech.vnu.edu.vn/nanomata2009/

IEEE-NANOMED 2009
18-21 October, National Cheng-Kung University, Tainan, Taiwan
www.nma.org.tw/Seminars/Seminars_more.asp?vrlShodIe7iBxL65kod=

4th International Conference on Surfaces Coatings and Nanostructured Materials (NanoSmat 2009)
19 - 22 October 2009, Rome, Italy
http://www.nanosmat2009.com/

The 2nd International Workshop on Nanotechnology and Application – IWNA2009
12 - 14 November 2009, Vung Tau, Viet Nam
http://www.hcmlnt.edu.vn/index.php?Module=Content&Action=view&id=128&Itemid=393

Nanotech Business Summit
05 - 06 December 2009, Cairo Marriott Hotel, Cairo, Egypt
http://www.nanobus.sabrycorp.com/conf/nanobus/09/index.cfm

IEEE International Nanoelectronics Conference (INEC) 2010
03 - 08 January 2010, City University of Hong Kong, Hong Kong, China
http://www.cityu.edu.hk/ieeeinec/index.htm

The 5th International Conference on Advanced Materials and Nanotechnology
February 2010, Wellington, New Zealand
http://www.macdiarmid.ac.nz

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