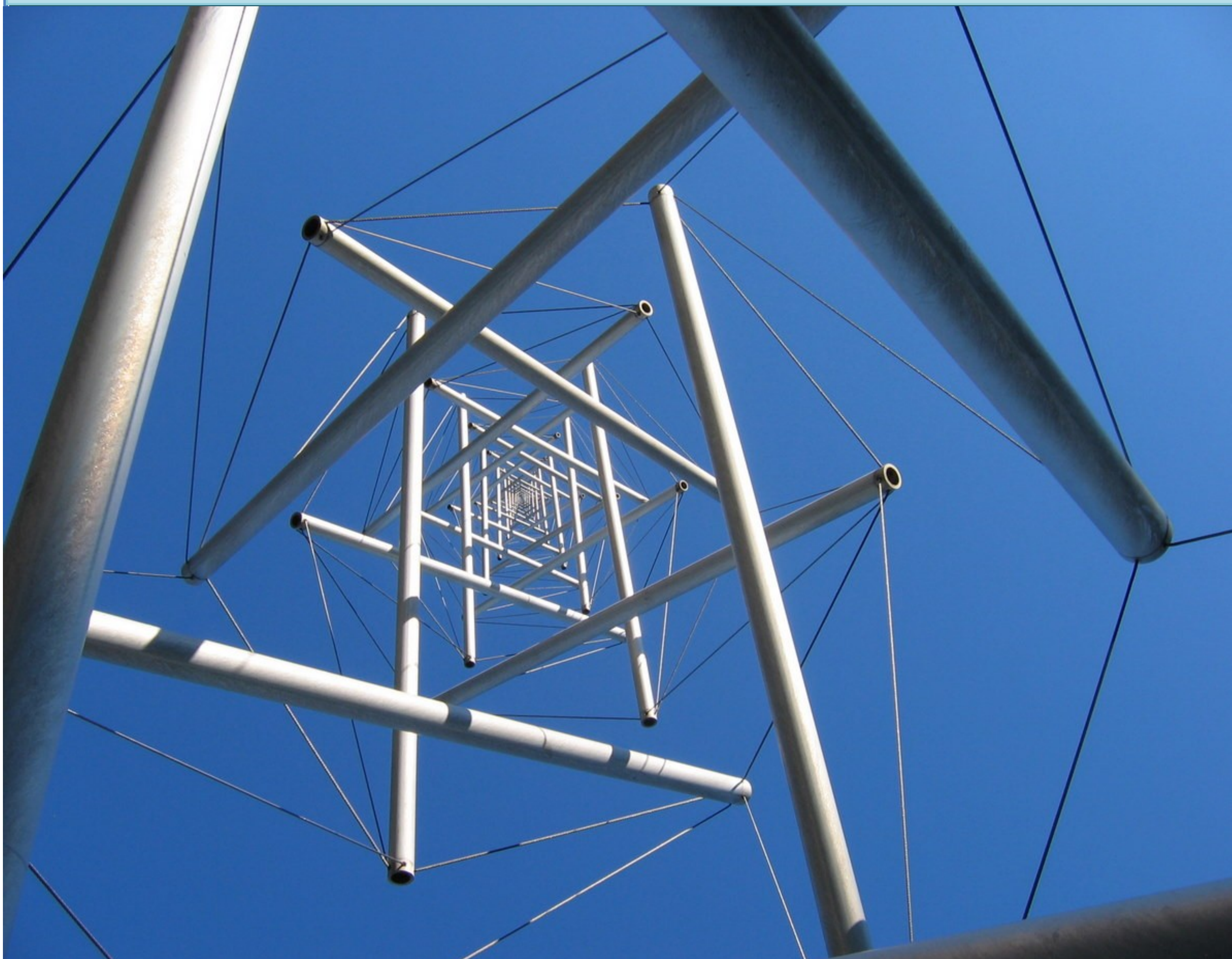
Nanotechnology Newsletter

IEEE nanotechnology Council

June 2010



Inside This Issue

President's Message

Dear IEEE NTC members,

I have been elected as the new IEEE Nanotechnology Council President and will serve the Council from January 1, 2010 to December 31, 2012. Currently I am the John D. Ryder Professor of Electrical and Computer Engineering in the Department of Electrical and Computer Engineering and the Director of Robotics and Automation Laboratory at Michigan State University.

As the president I intend to lead the Council to better serve its members. The major goals I look forward are to enhance the technical spectrum of the IEEE Nanotechnology Council, to increase its industrial participation, and to strengthen the financial standings of the Council. The specific endeavors I strive to complete in the next two years include, further improvement of the publications of IEEE Transaction on Nanotechnology and IEEE Nanotechnology Magazine, working with other IEEE societies to develop more conferences, workshops and symposiums in the areas most representative of nanotechnologies and to develop the nanotechnology lecture series to promote the research, development, and education of the nanotechnology, and to reach out to industries and general public. The success of these efforts will enable the IEEE Nanotechnology Council to be financially viable, and promoting it to become the premier professional organization of nanotechnology in the world.

I welcome you all to provide new ideas and suggestions to improve IEEE Nanotechnology Council and its activities and productivities.

Dr. Ning Xi
2120 Engineering Building
Michigan State University
East Lansing, MI 48824, USA

From the Editor

Welcome to the June 2010 issue of the NTC IEEE Nanotechnology Newsletter. I am John Yeow from the Waterloo Institute of Nanotechnology at the University of Waterloo, Ontario, Canada where I am currently a Canada Research Chair in Micro/Nanodevices and Director of the Advanced Micro/Nanodevices Lab.

I was invited by Dr. Chennupati Jagadish and Dr. Meyya Meyyapan to be the Editor-in-Chief of the NTC IEEE Nanotechnology Newsletter. It is a position I gladly accepted because this position allows me to get in touch with many of you within the nanotechnology community. It is also my role to keep you updated on the latest nanotechnology trends and development, be it commercial or research. Throughout the year, I look forward to working with Dr. Ning Xi who is the current President of the Council in bringing you exciting new issues of the newsletter.

The goal is to provide 4 issues of newsletter annually. I seek your inputs in terms of interesting articles, news, announcements, and commentaries. If you have ideas to share, please email me at jyeow [at] engmail [.] uwaterloo [.] ca

Sincerely,

Dr. John T.W. Yeow

University of Waterloo
200, University Avenue West
Waterloo, ON, Canada

IEEE NMDC 2010

IEEE Nanotechnology Materials and Devices Conference

http://www.egr.msu.edu/nmdc2010/

Monterey, California, USA

The Clement Monterey
October 12-15, 2010

Indexed by SCI, EI, Scopus, and Inspec

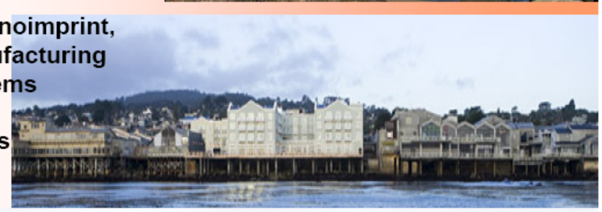
General Chair:
Xiaoping Yun, Naval Postgraduate School
General Co-Chair:
Yoshio Nishi, Stanford Univ.
Program Chair:
Lixin Dong, Michigan State Univ.
Organizing Committee Chair:
King W. C. Lai, Michigan State Univ.
Program Co-Chairs:
Wen J. Li, Chinese Univ. of Hong Kong
Nobuhiki Kobayashi, UC Santa Cruz
Regional Program Chairs:
Parviz Famouri, West Virginia Univ.
Sergej Fatikow, Univ. of Oldenburg
Andy Chung, POSTECH
Financial Chair:
Weihua Sheng, Oklahoma State Univ.
Publication Chair:
Zhidong Wang, Chiba Inst. of Technology
Registration Chairs:
Guangyong Li, Univ. of Pittsburg
Carmen Fung, Michigan State Univ.
Publicity Chairs:
Uchechukwu C. Wejinya , Univ. of Arkansas
Antoine Ferreira, ENSI Bourges, France
Liang Dong, Iowa State Univ.
Arunkumar Subramanian, Sandia National Lab
Local Arrangement Chair:
Wen Li, Michigan State Univ.
Invited Sessions Chair:
James E. Morris, Portland State Univ.
Organized Sessions Chairs:
Stanley Pau, Univ. of Arizona
Stephen M. Goodnick , Arizona State Univ.
Li Zhang, ETH Zurich
Jeong-Soo Lee, POSTECH
Masahiro Nakajima, Nagoya University
Workshops and Tutorials Chair:
Yu Sun, Univ. of Toronto

Conference Scope:

NMDC aims to develop critical assessment of existing work and future directions in nanotechnology research including nanomaterials and fabrications, nanoelectronics, nanophotonics, devices, and integration. This conference will bring together key researchers from all over the world and from every sector of academy and industry in the nanotechnology research field, with a special focus on materials and devices.

Technical Topics:

1. **Quantom dots, graphene, nanowires, nanotubes, nanobelts, nanorings, nanohelices, and other low-dimensional materials and structures**
2. **Quantum mechanics and devices**
3. **Nanoelectronics and devices**
4. **Nanophotonics, photonic crystals, and devices**
5. **Molecular electronics**
6. **Nanomagnetic materials and spintronics**
7. **Nanomechanics and nanomechatronics**
8. **Nanomanipulation and nanoassembly**
9. **Nanoelectromechanical systems**
10. **Nanopackaging**
11. **Nanofluidics, nanofluidic devices**
12. **Nanolithography, nanoprototyping, nanoimprint, and other nanomanufacturing processes and systems**
13. **Bionano devices**
14. **Nanomedical devices**



Important Dates:

- Deadline for submitting two page abstracts: June 15, 2010
- Notice of the acceptance: July 15, 2010
- Deadline for submitting final manuscripts of accepted papers and proposals of organized sessions/workshops/tutorials: Aug. 16, 2010

IEEE NANO 2009: 9th Nanotechnology Conference

IEEE NANO 2009 conference was held in Genoa, Italy. It provided a forum for exchange of ideas, interaction, networking and collaboration for research and development in nanotechnology with special reference to the latest advances in nanotechnology.

The conference was sponsored by the Nanotechnology Council, which was officially formed in 2002 and has since then been the focus of nanotechnology activities in IEEE and the nanotechnology community worldwide.

A session addressed by the conference co-chair, Dr. Toshio Fukuda, at the IEEE Nano 2009 conference.

IEEE Distinguished Lecturer Program

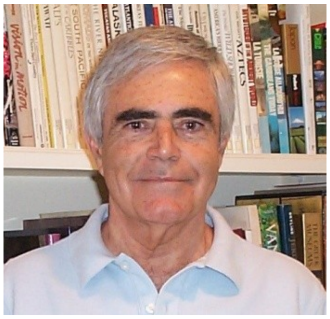
IEEE Distinguished Lecturers are engineering professionals who help lead their fields in new technical developments that shape the global community. These experts:

- specialize in the field of interest of their Society/Council.
- travel to various technical and regional groups to lecture at events.

Talk Title: An Overview and Recent Development in Nanotechnology

Dr. Meyya Meyyappan
Chief Scientist for Exploration Technology,
Center for Nanotechnology,
NASA Ames Research Center,
Mailstop 229-3,
Moffett Field, CA 94035.
Ph: (650) 604-2616
Fax: (650) 604-5244
Email: m.meyyappan@nasa.gov

Talk Title: Nanorobotics



Professor Ari Requicha
Laboratory for Molecular Robotics,
University of Southern California,
Los Angeles, CA 90089-0781 .
Ph: (213) 740-4502
Email: requicha@usc.edu

Talk Title: Manufacturing of Nano Sensors and Devices

Professor Ning Xi
Department of Electrical and Computer Engineering,
Michigan State University,
2120 Engineering Building,
East Lansing, MI 48824-1226.
Ph: (517) 432-1925
Fax: (517) 353-1980
Email: xin@egr.msu.edu

Talk Title: Compound Semiconductor Nanowires for Optoelectronic Device Applications

Professor Chennupati Jagadish
Australian Laureate Fellow and Distinguished Professor
Department of Electronic Materials Engineering,
Research School of Physics and Engineering,
Australian National University,
Canberra, ACT 0200,
Australia.
Ph: 61-2-6125-0363
Fax: 61-2-6125-0511
Email: c.jagadish@ieee.org
Email: Chennupati.Jagadish@anu.edu.au

Research Highlights

Patternable media

Manu Pallapa
Waterloo Institute of Nanotechnology,
University of Waterloo.

"The rate of increase in areal density doubled from 30% per year to 60% per year in the early 1990s, owing to thin-film magnetoresistance (MR) sensors"

Hard Disk Drive (HDD) memory capacity has come a long way since the birth of the RAMAC (Random Access Method for Accounting and Control), built by IBM in 1956. The RAMAC had fifty 24-in-diameter disks with a storage density of 2 kB/in^2, and a total capacity of 5 MB. The rate of increase in bit areal density, which is a benchmark measurement of the progress of magnetic data storage, doubled from 30% per year to 60% per year in the early 1990s, owing to thin-film magnetoresistance (MR) sensors. This upward trend increased to 100% per year in the mid 1990s with the incorporation of the giant MR (GMR) sensor. Today's products range in lateral size from 1.8 to 3.5 inches, have areal densities exceeding 200 GB/in^2, and provide storage capacities as high as 1 TB per device. But it has been observed that the rate of yearly increase in storage density has slowed down to approximately 40% since 2000, due to technological limitations [1].

"The rate of yearly increase in storage density has slowed down to approximately 40% since 2000, due to technological limitations."

The existing HDDs consist of one or more disks for data storage with a reading head for each disk, a motor, signal processing circuitry and feedback and control circuitry. The data storage media on the disks is a highly optimized nanogranular magnetic thin film, which is sputtered onto both sides of the disk substrate. The top of each disk is coated with a few nanometers of a hard diamond-like carbon protective overcoat and lubricant. The reading head is a monolithic slider, which contains a small micromachined electromagnet, and a magnetoresistive sensor sensitive to the changes in magnetic stray field originating from the surface of the media. To facilitate easy reading the magnetic media is oriented along an axis that is either parallel or perpendicular to the plane of the disk.

Limitations of memory storage systems

In GMR sensors, ferromagnetic layers are separated by non-ferromagnetic layers. The alignment of magnetizations between these layers change from parallel to antiparallel, due to the direction of injection of current. This results in an increase in electric resistance due to the flow of current. The existing current in plane giant magnetoresistance (CIP-GMR) sensors are being replaced by current perpendicular to plane tunnelling MR (CPP-TMR) sensors [2] as they possess a higher intrinsic MR ratio and, larger cross section sense current flow resulting in an increase in areal density.

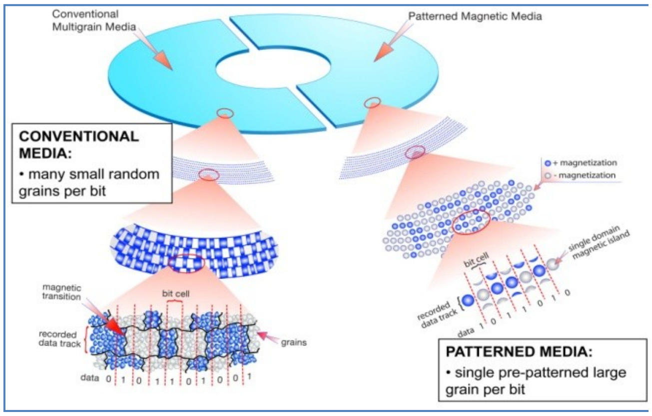


Figure 1: Conventional media versus patterned media *(Source: Dobisz et al., 2008)*

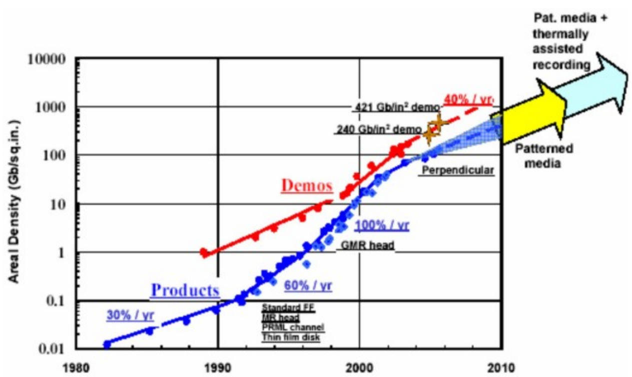


Figure 2: Roadmap of data storage *(Source: Dobisz et al., 2008)*

Current trends indicate that the device will become too resistive with further downscaling and the increased capacitance will cause noise and distort the signal [7].

Increasing bit-areal density without sacrificing the signal-to-noise ratio requires reducing average grain size in the media. Taking this direction leads to the limitation of the grain becoming so small that thermal energy alone can randomly flip its magnetization direction, during the lifetime of the drive. This is known as the superparamagnetic effect. Thermal activation of magnetization reversal occurs when thermal energy *($E = k_BT$)* is comparable with the anisotropic energy of the grains *($E = k_uV_g$)*, where k_B is the Boltzmann constant, T is the absolute temperature, k_u is the uniaxial anisotropic energy per unit volume, and V_g is the grain volume [1].

After a generation or two, it is likely that the device will become too resistive with further downscaling and the

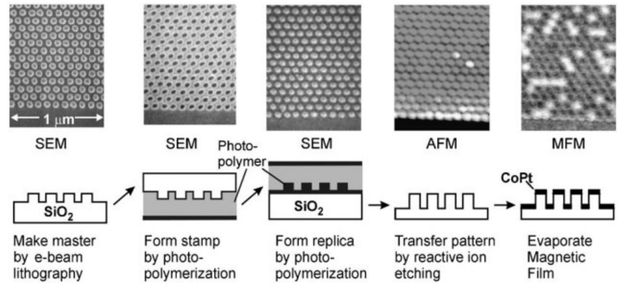


Figure 3: Fabrication process flow of patterned media *(Source: Terris, 2009)*

increased capacitance will cause noise and distort the signal.

Possible approaches to overcome the limitations

Presently there are two main approaches to extending the superparamagnetic limit of the media to 1 TB/in^2 and beyond. An increase in the uniaxial anisotropic energy, K_u by down scaling the grain size by patterning of composite continuous media* results in a higher anisotropic media. This increases the thermal capacity of the media to extend the superparamagnetic limit. But this approach is limited by the insufficient obtainable magnetic field in existing write heads. The second approach is to increase V_g by patterning bits on a disk into single domain magnetically isolated units (islands). Each single domain unit is larger than the grains of the composite media, and is stable owing to the fact that the bit switches as an entire unit in a Stoner Wohlfarth [3].

Unlike conventional composite media, patterned media does not consist non- or weakly magnetic between the grain to control grain coupling further strengthening stability of the bits. Implementation of patterned media calls for an entire paradigm shift in the HDD industry

*Magnetic storage media consists of a composite of sub-10nm magnetic alloy grains separated by ~1nm of non- or weakly magnetic material.

For patterning media the industry must develop an entire new tooling and strategy to fabricate ≥ 1 TB/in^2 islands on disks in a very high-volume manufacturing process. In addition, patterned media requires new strategies for the write/read access, and synchronization, address structure, and data architecture.

Higher storage density demands a lower resolution of lithographic tools. The only established lithographic tools that have demonstrated resolution ≤ 25 nm are electron beam lithography (EBL) [4] and nanoimprint lithography (NIL) [5]. The disk circular symmetry and the pattern placement accuracy eliminate the move and expose operations of X-Y stage exposure tools because the field stitching errors are > 3 nm. Electron beam lithography is a serial writing process and thus very time intensive. It clearly cannot meet disk throughput requirements of hundreds of disks per hour. In addition it also requires the development of a rotator stage tool. NIL is the most likely technology to meet the lithographic specifications in resolution, placement accuracy, and throughput.

The present patterned media disk manufacturing strategy is to write a master disk pattern with high resolution electron beam lithography on newly developed rotary stage toll. The EBL pattern on the master may be enhanced with self-assembled diblock copolymers [6]. The expensive master mold would be replicated into subsequent daughter and grand-daughter molds, which would imprint hundreds of disks per hour. Following the imprint of the disk pattern into the nanoimprint resist on the disk, the pattern is transferred into the disk using a physical and/or chemical etching process.

Though implementation of patterned media comes with the overhead of completely revamping the existing industry standards, the extremely high storage density, high resolution and throughput would bring about a revolution in the world of media storage.

References

[1] E. A. Dobisz, Z. Z. Bandić, T-W. Wu, T. Albrecht . “Patterned Media: Nanofabrication Challenges of Future Disk Drives”, *Proceedings of the IEEE,* vol 96, no. 11, 2008.

[2] Ho M. K., Tsang C. H., Fontana R. E., Parkin S. S., Carey K. K., Pan T., MacDonald S., Arnett P. C., and Moore J. O., “Study of magnetic tunnel junction read sensors”, IEEE transactions on magnetics, vol. 37, no 4, pp. 1691 - 1694, 2001.

[3] E. C. Stone and E.P. Wohlfarth, “A Mechanism of Magnetic Hysteresis in Heterogeneous Alloys”*, Philosophical Transactions of the Royal Society A*, vol 240 pp. 599 - 642, 1948.

[4] J. Fugita, Y. Ohnishi, Y. Ochiai, E. Nomura, and S. Matsui, “Nanometer-scale resolution of calixarene negative resist in electron beam lithography” , *Journal of Vacuum Science and Technology B*, vol. 14, no 6, pp. 4272, 1996.

[5] M.D. Austin, H. Ge, W. Wu, M. Li, Z. Yu, D. Wasserman, S. A. Lyon, and S. Y. Chou, “Fabrication of 5 nm line width and 14 nm pitch features by nanoimprint lithography”*, Applied Physics Letters*, vol 84 , pp. 5299, 2004.

[6] R. Ruiz et al., “Density multiplication and improved lithography by directed block copolymer assembly”, *Science*, vol. 321, no. 5891, pp. 936 – 939, 2008.

[7] B. D. Terris, “Fabrication challenges for patterned recording media, *Journal of Magnetism and Magnetic materials*, vol 321, pp 512-517, 2009.

Research Highlights

NanoElectrodes

Shruti Nambiar
Waterloo Institute of Nanotechnology,
University of Waterloo.

With the advent of nanotechnology, development of nanoelectrodes and arrays/ensembles of these electrodes have opened up new applications in the field of electrochemical studies. Particularly in the areas of biological investigations, nanoelectrodes offer great advantages for fabrication of microchips, single cell studies, and use in biosensors that allow ultrahigh-sensitivity screening and detection of biological analytes [1]. The most commonly used nanoelectrodes are metallic nanowires, carbon nanotubes, magnetic nanoparticles, and metal oxide nanowires [2].

One of the primary advantages of using smaller electrodes is to exploit the enhanced mass transport phenomenon (via diffusion). In theory, as the electrode-size decreases, the radial diffusion becomes dominant which results in very high mass-transport rates. This leads to increased signal-to-noise current ratios and enhanced detection limits. However, as the electrode dimensions become smaller, the diffusion layer becomes thinner, affecting the characteristics of the diffusion-controlled currents within the electrical double layers. The molecules diffusing between the electrical double layers experience solution characteristics different from those of the bulk solution. For example, the double-layer viscosity may become more obvious as the size of the electrodes, the diffusion distance and the thickness of the electrical double layer all become equivalent [3-8].

Another advantage of the nanoelectrodes is that they can be assembled into densely packed arrays which provide scope for multi-modal and massively parallel measurements with high spatial resolution [1]. Figure 1 shows a schematic of a type of carbon nanotube (CNT)-based amperometric biosensor used for multiplexed detection of multiple bioanalytes (redox enzymes). Each of the CNT electrodes is functionalized with single-stranded deoxyribonucleic acid (ssDNA) oligonucleotide such that they bind to the analyte carrying the complementary ssDNA. Electrocatalytic currents measured from the bioanalytes correspond to their concentrations [11].

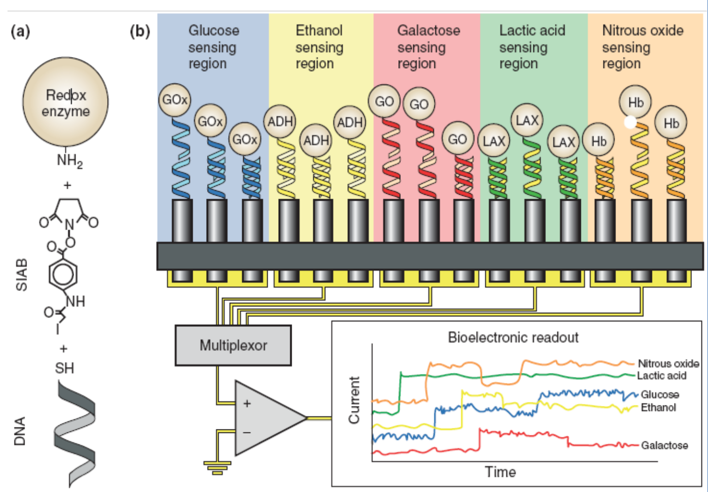


Figure 1: Amperometric biosensor for parallel detection of five distinct enzymes. (a) Enzyme-ssDNA assembly. (b) biosensor set-up. (Source: *Withey GD, Kim JH & Xu J, 2007*)

Robustness and efficiency of the nanoelectrodes can be enhanced through optimal alignment of nanoelectrode arrays by appropriate fabrication techniques. Spatially separated geometry of nanoelectrode arrays have shown to enhance protein immobilization on each electrode [12, 13]. Moreover, high precision linkage between the analyte and the electrodes collectively contribute to enhanced detection limits of the nanoelectrodes in comparison to macro or microelectrodes [2].

Integration of nanostructures into micro-devices is not trivial and requires implementation of innovative strategies for nanomaterial deposition and processing [9]. Moreover, some nanoscale material properties, particularly, the electrical conductivity has been noted to reduce drastically with decreasing size. The inverse correlation between size and conductivity specifically restricts further downscaling of electronic components in applications wherein electrical conductivity is paramount for device performance [9]. Fabrication of nanoelectrodes is one of the greatest challenges faced by researchers [1]. Reduction in electrical conductivity of nanoscale structures, due to increased surface energy barriers and density of boundaries, adds to the challenge especially when they need to be integrated with standard electronic components [9]. Typically, electrodes in micro- and nanosensors are made of dense films that are deposited by chemical vapour deposition, sputtering, screen printing, etc. In general, a functional nanofilm (a sensing material) is deposited between these electrodes, or the electrodes themselves are functionalized to act as nanosensors. The resistive property of the nanofilms is determined by the film composition and the geometry of the electrodes. For these reasons, the minimal resistance of the film is determined primarily by the ratio between the electrode distance and area, both of which are quite restrictive for wide-bandgap semiconductors.

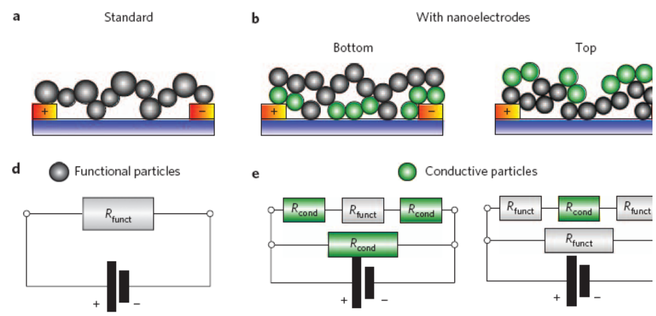


Figure 2: A schematic of layouts for functional nanoparticles with and without nanoelectrodes (Source: *Tricoli A & Pratsinis SE, 2009*).

However, unique electronic devices such as thin films of aligned carbon nanotubes have been shown to have high current-carrying capacity [10].

Recently, a novel concept to control resistance of nano-structured films has been proposed [9]. The authors used two different layouts to integrate metallic and low-bandgap metal-oxide nanoparticles onto the functional nanoparticle film (Figure 2). With this set-up they were able to greatly reduce the total film resistance while the nanoelectrodes served as extensions of bulk electrodes. They demonstrated that the electrical properties of highly resistive nanofilms could be controlled by deposition of conductive domains above or below the films. As a proof-of-concept, they applied their idea to solid-state gas sensors and reportedly achieved a controlled device resistance with ultrahigh sensitivity to ethanol of 20 ppb.

Till date, potential applications of nanoelectrodes have been extensively investigated in the areas of physical electrochemistry, scanning electrochemical microscopy, and micro/nano-electromechanical systems (MEMS & NEMS). Micro- and nano-devices with very high specificity, sensitivity and efficiency can be realised with the development of nanoelectrodes. For these reasons, they offer great advantages in areas of biological investigations, particularly in the design and development of coordinated biosensors.

Future biomedical application of intelligent nanosensors could facilitate a direct, point-of-care clinical device enabling personalized medical care. Innovative strategies to fabricate nanoelectrodes will potentially open up other novel applications.

References

[1] D. W. M. Arrigan, "Nanoelectrodes, nanoelectrode arrays and their applications". *Analyst*, vol. 129, pp. 1157-1165, 2004.

[2] J. I. Yeh & H. Shi, "Nanoelectrodes for biological measurements" *Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology*, 2010.

[3] R. M. Wightman & D. O. Wipf, *"Voltammetry at ultramicroelectrodes"*. Electroanalytical Chemistry, ed. A. J. Bard, Marcel Dekker, New York, pp. 15-267, 1989.

[4] A. M. Bond, "Past, present and future contributions of microelectrodes to analytical studies employing voltammetric detection: a review", *Analyst*, vol. 119, pp. 1R-21R, 1994.

[5] R. J. Forster "Microelectrodes: new dimensions in electrochemistry", *Chemistry Society Reviews*, vol. 23, pp. 289-297, 1994.

[6] C. G. Zoski, "Ultramicroelectrodes: Design, Fabrication, and Characterization", *Electroanalysis*, vol. 14, pp. 1041-1051, 2002.

[7] R. Feeney & S.P. Kounaves, "On-site analysis of arsenic in groundwater using a microfabricated gold ultramicroelectrode array", *Electroanalysis*, vol. 72, pp. 2222-2228, 2000.

[8] K. Stulik, C. Amatore, K. Holub, V. Maracek & W. Kutner, "Microelectrodes. Definitions, characterization, and applications (Technical report), *Pure Applied. Chemistry*, vol. 72, pp. 1483 -1492, 2000.

[9] A. Tricoli & S. E. Pratsinis, "Dispersed nanoelectrode devices", *Nature Nanotechnology*, vol. 5, pp. 54-60, 2010.

[10] S. J. Kang et al. "High-performance electronics using dense, perfectly aligned arrays of single-walled carbon nanotubes", *Nature Nanotech*. vol. 2, pp. 230–236, 2007.

[11] G. D. Withey, J. H. Kim & J. Xu, "Wiring efficiency of a metallizable DNA linker for site-addressable nanobioelectronic assembly", *Nanotechnology*, vol. 18, 424025, 2007.

Vision of Nanotechnology

NanoRobots

Chongxiao Shen
Mechatronics Engineering,
University of Waterloo.

In 1959, Nobel prize winner Richard Feynman gave the famous talk "There's plenty of rooms at the bottom" which inspired advances in nanotechnology. Nanorobotics is an emerging field of nanotechnology that may revolutionize the medical world in the future. Developments in biosensors [17] and nano-kinetic devices [18, 19] have significant impact in the operation and locomotion of nanorobots. Here in this article, the possibility of nanorobot teams working together to assemble biomolecules for medical purposes will be discussed.

Approach

Automation of atoms manipulation is one vital step toward application usage of nanorobots in nanomedicine. To manipulate molecules into special patterns, the traditional approach of using Atomic Force Microscopy (AFM) and Scanning Tunnelling Microscopy (STM) require too much time and produce imprecise work [3]. Cavalcanti et al. proposed the use of artificial intelligence [4], fuzzy logic [5], neural networks [6] and evolutionary techniques [7] to enable automation of atom manipulation.

The concept of nanorobot teams performing coherent work is theoretically possible with the development in bio-computers [8] to carry out logical tasks, and the progression in biosensors [8] and nanokinetic devices [9] [10]. Possible issues related to quantum mechanics, thermal motion and friction has been addressed and resolved [11].

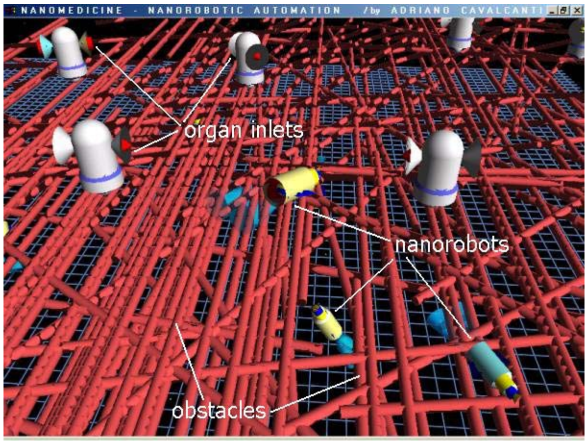


Figure 1: Virtual environment, top camera view *(Source: Cavalvanti A. et al., 2005).*

Applications

Multi-nanorobot teams can potentially perform various medical tasks to process chemical reactions for injured organs, or assist in chemotherapy to battle cancer [12]. Once the teams are equipped with nanosensors, they can be employed to determine glucose demand, which will benefit many diabetic patients [13].

Simulation environment

A computer simulated environment occupied by nanorobots, biomolecules, obstacles and organ inlets was investigated by Cavalcanti et al. (Figure 1). In order to mimic a biological environment, the computer simulation parameters were set to be under water, where gravitational force is not considered, while friction, adhesion and viscous forces dominate[14, 2].

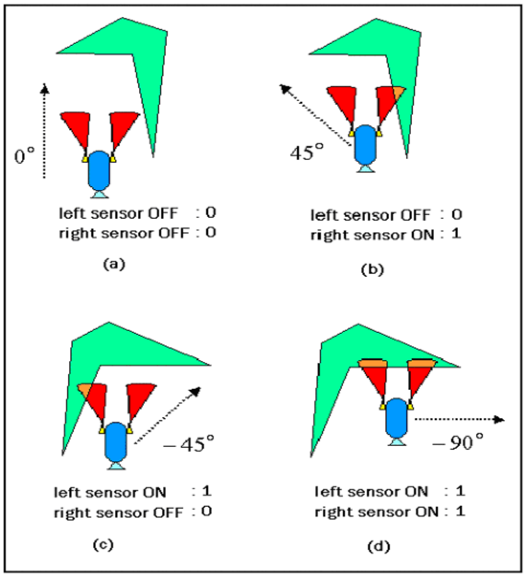


Figure 2: Sensor based navigational behaviour *(Source: Cavalcanti A. et al., 2005).*

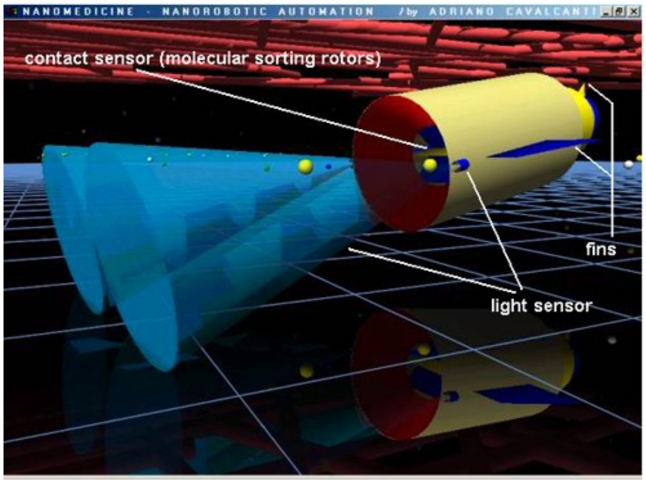


Figure 3: Molecular Identification *(Source: Cavalcanti A. et al., 2005).*

Design of nanorobot

Mechanical parameters such as velocity, acceleration, stoppage time, inertial force, viscous drag force, rotational power, and turning angle all have to be calculated and taken into consideration to design robust nanorobots [3].

In the simulation program reported by Cavalcanti et al., the nanorobot was designed to capture molecules, and assemble them. In order to mimick biological models, the nanorobot was consisted of 3 main parts: molecular sorting rotor, robot arm, and chemotactic sensors used to identify different biomolecules [14]. The dimensions of the nanorobots used were 650 nm in length, and 160 nm in diameter [3]. To avoid adverse immune response, a diamondoid, artificial-glycocalyx surface was chosen as the nanorobot material [15]. A macroponder navigational system assisted with beacons placed outside the human skin may help in real-time identification of the nanorobot location [15]. Implementation of acoustic communication sensors provided an extended network between nanorobot teams. This increased the efficiency of work; however, too many messages sent would result in inefficient energy consumption. One possible alternative suggested in the study was the use of oxygen and glucose which are abundant in the human body [15].

Navigation was conducted using two counter-rotating screw drives for propulsion, and the decision-making was handled by sensors [15]. In a 3D world, the nanorobots need to determine the shortest path displacement while avoiding all obstacles. The feedforward neural network model can help accomplish this with low computational effort and high accuracy [16].

Conclusion

Automating manipulation of atoms in nanomedicine can be made possible by the proposed nanorobot. However, from the simulation conducted by Cavalcanti et al., there are many technical obstacles needing to be address before nanorobots can be applied in the real world such as identification of real time location, and communication between nanorobots. Once these barriers are taken down, the proposed integration of medical engineering and medical science may revolutionize the future of cancer research, and cure severe maladies such as cancer using brand new methods made possible with atom manipulation.

References

[1] Weir N.A., Sierra D.P., and Jones J.F., "A review of research in the field of nanorobotics", *Sandia report, Sandia National Laboratories,* SAND2005-6808, pp. 8 -9, 2005.

[2] R. A. Freitas Jr., "*Nanomedicine, Volume I: Basic Capabilities"*, Landes Bioscience, 1999 R. A. Freitas Jr., "*Nanomedicine, Volume I: Biocompatibility"*, Landes Bioscience, 2003.

[3] A. Cavalcanti, R. A. Freitas Jr., L. C. Kretly, "Nanorobotics control design: A practical approach tutorial", *Robotics Today, SME*, vol. 18, no. 4, pp. 1-22, 2005.

[4] T. T Toth-Fejel, "Agents, assemblers, and ANTS: scheduling assembly with market and biological software mechanisms", *Nanotechnology*, vol. 11, pp 133-137, 2000.

[5] V. Matellan, C. Fernandez, and J. M. Molina, "Genetic learning of fuzzy reactive controllers". *Robotics and Autonomous Systems,* vol. 25, pp. 33-41, 1998.

[6] H. D. Drucker, D.Wu, V. Vapnik, "Support vector machines for spam categorization", *IEEE Transaction on Neural Networks*, vol. 10, no. 5, pp. 1048-1054, 1999.

[7] J.J. Grefenstette, A. Schultz. "An evolutionary approach to learning in robots". *Machine Learning Workshop on robot Learning*, New Brunswick, NJ, 1994.

[8] M. Hagiya. "From molecular computing to molecular programming," *Proc. 6th DIMACS Workshop on DNA Based Computers*, Leiden, Netherlands, pp 198-204, 2000.

[9] J. Sun, M. Gao.,J. Feldmann, "Electric field directed layer by-layer assembly of highly fluorescent CdTe nanoparticles," *Journal of Nanoscience and Nanotechnology*, vol. 1, no. 2, pp. 21-27, 2001.

[10] G. D. Bachand and C. D. Montemagno, "Constructing organic/inorganic NEMS devices powered by biomolecular motors," *Biomedical Microdevices*, vol. 2, pp. 179-184, 2000.

[11] A. Hellemans, "German team creates new type of transistor-like device," *News Analysis, IEEE Spectrum Magazine*, pp. 20-21, 2003.

[12] M. N. V. R. Kumar, "Nano and microparticles as controlled drug delivery devices", *J. Pharmacy Parmaceutical Science*, vol. 3, no. 2, pp. 234-258, 2000.

[13] E. Katz, A. Riklin, V. Heleg-Shabtai, I. Willner and A. F.Bückmann, "Glucose oxidase electrodes via reconstitution of the apo-enzyme: Tailoring of novel glucose biosensors", *Anal.Chim. Acta*., vol. 385, pp. 45-58, 1999.

[14] K. E. Drexler, "*Nanosystems: molecular machinery, manufacturing, and computation"*, John Wiley & Sons, 1992.

[15] R. C. Merkle, "Nanotechnology and Medicine," *Advances in AntiAging Medicine*, Mary Ann Liebert Press, 1, pp. 277-286, 1996.

[16] M. T. Hagan, H. B. Demuth, and O. D. Jesús, "An introduction to the use of neural networks in control systems," *International Journal of Robust and Nonlinear Control*, John Wiley & Sons, vol. 12, no. 11, pp. 959-985, 2002.

[17] J. Sun, M. Gao, and J. Feldmann, "Electric Field Directed Layer-by-Layer Assembly of Highly Fluorescent CdTe Nanoparticles", *Journal of Nanoscience and Nanotechnology*, vol. 1, no. 2, pp. 21-27, 2001.

[18] G. D. Bachand and C. D. Montemagno, "Constructing organic/inorganic NEMS devices powered by biomolecular motors", *Biomedical Microdevices*, vol. 2, 179-184, 2000.

[19] R. Stracke, K. J. Böhm, J. Burgold, H. Schacht, and E. Unger, "Physical and Technical parameters determining the functioning of a knesin-based cell-free motor system", *Nanotechnology,* vol. 11, pp. 52-56, 2000.

Nanotechnology Awards

Pioneer Award in Nanotechnology

Dr Phaedon Avouris
IBM Watson Research Centre
1101 Kitchawan Rd Yorktown Heights,
New York, NY 10598, USA
Email: avouris@us.ibm.com

Dr. Phaedon Avouris is an IBM Fellow and manager of Nanoscience & Nanotechnology at the T. J. Watson Research Center in Yorktown Heights, NY. He received his B.Sc. at the Aristotle University in Greece and his Ph.D. in Physical Chemistry at Michigan State University in 1974. He did postdoctoral work at UCLA and was a Research Fellow at AT&T Bell Laboratories before joining the staff of IBM's Research Division at the Watson Research Center in 1978.

Over the years, he has worked in a wide range of research areas: laser spectroscopy, surface physics/chemistry, scanning tunneling microscopy, atom manipulation and nanoelectronics. His current research focuses on experimental and theoretical studies of the electronic and photonic properties of carbon-based nanostructures. The work also includes the design and study of nanoelectronic and optoelectronic devices based on these materials.

Dr. Avouris has published over 400 scientific papers. He has been elected Fellow of the American Academy of Arts and Sciences, the American Physical Society, the Institute of Physics of the U.K., the Academy of Athens (National Academy of Greece), the IBM Academy of Technology, American Association for the Advancement of Science, New York Academy of Sciences and the American Vacuum Society. He has received many awards including the APS Irving Langmuir Prize for Chemical Physics, the AVS Medard W. Welch Award for Surface Science, the Julius Springer Award for Applied Physics, the Richard E. Smalley Research Award of the Electrochemical Society, the Richard Feynman Nanotechnology Prize, the CNSI Nanoscience Prize and the IEEE John Raper Award. He has also received many IBM Corporation "Outstanding Technical Achievement" awards. He serves or served on the Editorial Boards of a number of journals and book series.

"For pioneering contributions to the science and technology of carbon-based electronics and photonics"

Early Career Award in Nanotechnology

Dr Ali Javey
Dept of Electrical Engineering
and Computer Science
621C Sutardja Dai Hall
University of California, Berkeley
Berkeley, CA 94720, USA
Tel: +1 (510) 643-7263
Fax: +1 (510) 643-7846
Email: ajavey@eecs.berkeley.edu

Dr. Ali Javey received a Ph.D. in chemistry from Stanford University in 2005, and served as a Junior Fellow of Harvard Society of Fellows from 2005 to 2006. He then joined the faculty of the University of California at Berkeley as an assistant professor of Electrical Engineering and Computer Sciences. Effective July 2010, he is promoted to an associate professor.

Professor Javey's research interests encompass the fields of chemistry and electrical engineering, focusing on the integration of synthetic nanomaterials for electronic, sensor and energy applications. His publications have been cited >4500 times with h index of 27. He has received a number of awards, including 2010 Alfred P. Sloan Fellowship, 2010 Mohr Davidow Ventures Innovators Award, 2009 National Academy of Sciences Award for Initiatives in Research, 2009 MIT Technology Review TR35, 2008 NSF CAREER Award, 2008 U.S. Frontiers of Engineering (National Academy of Engineering), and the 2003 Peter Verhofstadt Fellowship from the Semiconductor Research Corporation.

"For creative research on nanomaterials and nanotechnologies for electronic applications" "

IEEE Robotics and Automation Award

Dr Toshio Fukuda
Dept of Micro System Engineering
Nagoya University
Furo-cho, Chikusa-ku
Nagoya 464-8603, Japan
Tel: +81 (52) 789-4478
Fax: +81 (52) 789-3115
Email: fukuda@mein.nagoya-u.ac.jp

Dr. Toshio Fukuda received the B.A. degree from Waseda University, Tokyo, Japan, in 1971, and the M.S and Dr. Eng. from the University of Tokyo, Tokyo, Japan, in 1973 and 1977, respectively. In 1977, he joined the National Mechanical Engineering Laboratory. In 1982, he joined the Science University of Tokyo, Japan, and then joined Nagoya University, Nagoya, Japan, in 1989. Currently, he is Director of Center for Micro-Nano Mechatronics and Professor of Department of Micro-Nano Systems Engineering at Nagoya University, where he is mainly involved in the research fields of intelligent robotic and mechatronic system, cellular robotic system, and micro- and nano-robotic system.

Dr. Fukuda was President of IEEE Robotics and Automation Society (1998-1999), Director of the IEEE Division X, Systems and Control (2001-2002), and Editor-in-Chief of IEEE / ASME Transactions on Mechatronics (2000-2002). He was President of IEEE Nanotechnology Council (2002-2003, 2005) and President of SOFT (Japan Society for Fuzzy Theory and Intelligent Informatics) (2003-2005). He was elected as a member of Science Council of Japan (2008-). He received the IEEE Eugene Mittelmann Award (1997), IEEE Millennium Medal (2000), IEEE Robotics and Automation Pioneer Award (2004), IEEE Robotics and Automation Society Distinguished Service Award (2005), Award from Ministry of Education and Science in Japan (2005). IEEE Nanotechnology Council Distinguished service award (2007). Best Googol Application paper awards from IEEE Trans. Automation Science and Engineering (2007). Best papers awards from RSJ (2004) and SICE (2007), Special Funai Award from JSME (2008), 2009 George Saridis Leadership Award in Robotics and Automation (2009), IEEE Robotics and Automation Technical Field Award (2010), IEEE Fellow (1995), SICE Fellow (1995), JSME Fellow (2001), RSJ Fellow (2004).

"For leadership and pioneering contributions to Intelligent Robotic Systems and Micro and Nano Robotic Systems"

Distinguished Service Award

Dr. Aristides Requicha
Laboratory for Molecular Robotics
Computer Science Department
University of Southern California
Los Angeles, CA 90089-0781, USA
Tel: +1 (213) 740-4502
Fax: +1 (213) 740-7512
Email: Requicha@usc.edu

Aristides A. G. Requicha received the Engenheiro Electrotécnico degree from the Instituto Superior Técnico, Lisbon, Portugal, in 1962, and the Ph.D. in electrical engineering from the University of Rochester, Rochester, NY in 1970. He was a college and high school Valedictorian, and is listed as a highly cited author in the ISI Web of Science for 1980-99. He was awarded the Pioneer in Robotics and Automation Prize of the IEEE Robotics and Automation Society in 2008, the first-ever Pierre Bézier Prize of the Solid Modeling Association in 2007, and the Senior Research Award of the Viterbi School of Engineering of the University of Southern California (USC) in 2006.

Dr. Requicha holds the Gordon Marshall Chair in Engineering and is a Professor of Computer Science and Electrical Engineering at USC. He was the founding director of the Laboratory for Molecular Robotics at USC. His past research focused on geometric modeling of 3–D solid objects and spatial reasoning for intelligent engineering systems. His recent work is on robotic manipulation of nanometer-scale objects using scanning probe microscopes; nanorobot components and nanorobotic system integration; fabrication of nanostructures by robotic self-assembly; sensor/actuator networks; and applications in NEMS and nanobiotechnology. The long-term goals are to build, program, and deploy nanorobots and networks of nanoscale sensors/actuators for applications to the environment and health care.

He currently is the Editor-in-Chief of the IEEE Transactions on Nanotechnology, and recently stepped down as co-chair of the Micro/Nano Robotics and Automation Technical Committee of the IEEE Robotics and Automation Society. He is a member of the AAAI (Association for the Advancement of Artificial Intelligence), AVS (American Vacuum Society) and SME (Society of Manufacturing Engineers). He is a Fellow of the IEEE, of the ACM (Association for Computing Machinery) and of the AAAS (American Association for the Advancement of Science), and a member of Computer Graphics Pioneers and Sigma Xi.

"For leadership excellence as Editor-in-Chief of IEEE Transactions on Nanotechnology"

The Quantum Device Award:

Dr. Chennupati Jagadish
Dept of Electrical Material Engineering
Research School of
Physics and Engineering
Australian National University
ACT 0200, Australia
Tel: +1 (510) 643-7263
Fax: +1 (510) 643-7846
Email: cxj109@rsphysse.anu.edu.au

Dr. Jagadish received the B.Sc. degree from Nagarjuna University, Guntur, India in 1977, the M.Sc(Tech) degree from Andhra University, Waltair, India in 1980 and the M.Phil. and Ph.D. degrees from the University of Delhi, India in 1982 and 1986, respectively. He was a Lecturer in Physics and Electronics at S.V. College, University of Delhi, during 1985-88 and worked at Queen's University, Kingston, Canada, during 1988-90 as a post-doctoral research fellow. He moved to Australia in 1990 and established a major research program in the field of optoelectronics and nanotechnology. He is currently an Australian Laureate Fellow, Distinguished Professor and Head of Semiconductor Optoelectronics and Nanotechnology Group in the Department of Electronic Materials Engineering, Research School of Physical Sciences and Engineering, the Australian National University. His research interests include compound semiconductor optoelectronics and nanotechnology.

Jagadish is a winner of 2000 Institute of Electrical and Electronics Engineers, Inc (USA) (IEEE) Third Millennium Medal and a Distinguished Lecturer of IEEE Nanotechnology Council (NTC), IEEE Lasers and Electro-Optics Society (LEOS) and IEEE Electron Devices Society (EDS). He has published more than 580 research papers (390 journal papers), 5 US patents assigned, co-authored a book, co-edited a book and edited 12 conference proceedings. Jagadish has served as President of the IEEE Nanotechnology Council (2008 and 2009) and Associate Vice-President (Membership and Regional Activities- Asia-Pacific) of the IEEE Lasers and Electro-Optics Society (2008). He served as an elected member of EDS AdCom (1999-2004), and as Chair of Optoelectronic Devices Technical Committee of EDS (1998-2003) and Vice-President (Publications) of the IEEE Nanotechnology Council (2004-2005) and served as a member of the nanotechnology technical committee of EDS (2003-2005) and Chair of the NTC Nano-Optoelectronics, Nano-Optics and nano-photonics technical committee (2003-2006) and Chair of the NTC Awards Committee (2006-2008). He is a Fellow of the Institute of Electrical and Electronics Engineers, Inc. (USA), the American Physical Society, the Materials Research Society, the Optical Society of America, the Australian Institute of Physics, the Institute of Physics (UK), the Institute of Nanotechnology (UK), SPIE-the International Society for Optical Engineering, Electrochemical Society, the Institution of Engineering and Technology, American Association for Advancement of Science, American Vacuum Society, the Australian Academy of Technological Sciences and Engineering and the Australian Academy of Science. Jagadish served as an Associate Editor of the Journal of Nanoscience and Nanotechnology (2001-2005) and as an Associate Editor of the IEEE/OSA Journal of Lightwave Technology (2003-2008). He is currently serving as an Editor of the IEEE Electron Device Letters (2008-), an Editor of Progress in quantum Electronics (2008-) and an Editor of the Journal Semiconductor Technology and Science (2009-). He is a member of editorial boards of 12 journals. He is the Convener of the Australian Research Council Nanotechnology Network and ACT Node Director of the Australian National Fabrication Facility. He chaired many conferences (Program Chair of IEEE NANO2003, San Francisco, Co-Chair ICONN 2006, Brisbane, Co-Chair, IEEE NMDC 2006, 2008) and served on many international professional society committees. He advises high tech industries in Australia and overseas in the field of photonics and nanotechnology and collaborated with researchers from 20 different countries. He received Peter Baume Award (ANU's prestigious and highest award) for excellence in research and research leadership. He has also been awarded Australian Federation Fellowship (2004-2009) by the Australian Research Council and Distinguished Professor position (since 2009) by the Australian National University.

"For pioneering and sustained contributions to compound semiconductor quantum structures and optoelectronic devices"

Editor-in-Chief: Ian Akyildiz (Georgia Institute of Technology, Atlanta, GA, USA)

E-mail: nanocomnet@ece.gatech.edu

Submit on line at: http://ees.elsevier.com/nanocomnet/

Nano Communication Networks Journal is an international, archival and multi-disciplinary journal providing a publication vehicle for complete coverage of all topics of interest to those involved in all aspects of nano-scale networking and communications. Theoretical research contributions presenting new techniques, concepts, or analyses, applied contributions reporting on experiences and experiments, and tutorials are published.

Nano Communication Networks is a part of COMNET (Computer Networks) family of journals within Elsevier. The family of journals covers all aspects of networking except the nano-scale communications subject which is the target for this newly proposed journal.

1. Architectures and Systems for Nanocommunications
2. Novel Information Theory Aspects of Nanocommunications
3. Communication Protocols for Nanonetworks
4. Nano-addressing and Nano-coding for Communications
5. Molecular Communication aspects such as Ion Signaling, Molecular Motors, Flagellated Bacteria, Nanorods, Pheromones, Axons, Light Transducers, Capillaries
6. Quantum Theory and its Application on Nano-Communication Networks
7. Modeling and Simulation of Nano-Networks
8. Automata Models for Nanonetworks
9. Graph Theory Aspects of Nano-Networks
10. Nano-Sensor Networks: Architecture and Communication Protocols
11. Bio-nano Applications: Bio-micro/nanoelectronics, molecular scale chemical and biosensors, bio-MEMS technology, data and power management
12. Networks-on-Chip (NoC): Network architectures and topologies, NoC performance and trade-off analysis, Energy efficiency and power management, CAD flows for NoCs and MP-SoC platforms, Fault tolerance and reliability issues
13. Innovative System Interconnects: Nano-technologies and devices for on-chip interconnects (CNTs, semiconductor, metallic and DNA-templated nanowires), Molecular, optical and wireless interconnects, Interconnects for non-charge-based devices
14. Electro-Magnetic Communication for Nanonetworks (Nanoscale Electromagnetics, Carbon Nanotubes, Propagation models for nanoscale communications, planning and optimization, nano-radios, nano-batteries, nanoscale antennas, nano-arrays, EM aspects at nanoscale, reconfigurability issues)
15. Nanonetworks in Tera-hertz band
16. Applications of Nano-Networks

IEEE NTC Members

Selective Available Positions

Member Representative, Solid State Circuits (SSC) – odd-year appointment	**Member Representative, Circuits & Systems Society (CAS)** – odd-year appointment
Member Representative, Communications Society (COM) – odd-year appointment	**Member Representative, Computer Society (C)** – odd-year appointment
Member Representative, Components, Packaging, & Manufacturing Technology Society (CPMT) – odd-year appointment	**Member Representative, Computational Intelligence Society (CI)** – odd-year appointment [Formerly Neural Networks Society]
Member Representative, Control Systems Society (CS) – odd-year appointment	**Member Representative, Reliability Society (R)** – even-year appointment
Member Representative, Electromagnetic Compatibility Society (EMC) – odd-year appointment	**Member Representative, Engineering in Medicine & Biology Society (EMB)** – even-year appointment
Member Representative, Magnetics Society (MAG) – odd-year appointment	**Member Representative, Electron Devices Society (ED)** – odd-year appointment
Member Representative, Instrumentation & Measurement Society (IM) – odd-year appointment	**Member Representative, Systems, Man, & Cybernetics Society (SMC)** – odd-year appointment
Member Representative, Antennas & Propagation Society (AP) – even-year appointment	**Member Representative, Robotics & Automation Society (RA)** – odd-year appointment
Member Representative, Ultrasonics, Ferroelectrics, & Frequency Control Society (UFFC) – odd-year appointment	**Member Representative, Microwave Theory & Techniques Society (MTT)** – odd-year appointment
Member Representative, Industrial Electronics Society (IE) – odd-year appointment	

Executive Committee

Position Title	2010
President	**Ning Xi**
Vice President of Conferences (elected in even years)	**Marc Cahay**
Vice President of Finance (elected in even years)	**Jean Eason**
Vice President of Publications (elected in odd years)	**Xiaoping Yun**
Vice President of Technical Activities (elected in even years)	**Parviz Famouri**
Secretary	**Marc Apter**
Awards Chair	**James Morris**
EIC Transactions on Nanotechnology	**Aristides Requicha**
EIC of Nanotechnology Magazine	**Wen J. Li**
Past-President	**Chennupati Jagadish**

For more information visit:
http://ewh.ieee.org/tc/nanotech/nanoadcom.html

NTC AdCom Member Election

At NTC AdCOM meeting in Seoul, Korea, the NTC AdCom voting members will be electing the following three NTC Officers:

One Position for a 3 year term (1 January 2011 to 31 December 2013):

President- Elect
(President Elect will serve as President of the Council during 2012 and 2013)

Two positions for a two year term (1 January 2011 to 31 December 2012):

Vice-President for Finance
Vice-President for Conferences

Please send proposed nominees, including self-nominations, to Chennupati Jagadish (c.jagadish@ieee.org), the NTC N&A Committee Chair. Please include with each proposed nominee a statement of the candidate's agreement to serve if elected, a short bio (200 words maximum), a short candidacy statement (optional), list of IEEE affiliations and involvements, IEEE membership number and grade, before the deadline.

The Criteria for Office: The AdCom shall elect the Vice-President for Conferences and the Vice-President for Finances from its current members or from those past members who have served as Member Society-appointed or ex-officio AdCom members within the previous three years. The AdCom shall elect the President-elect from its members who have served as Officers of the Council within the previous four years. If a candidate for President-elect cannot be found who meets this criterion, then candidates for President-elect may be chosen from the current Society-appointed members of AdCom or among those past members who have served as Society-appointed AdCom members within the previous three years.

Nominations (Bio and position statement) will be circulated to all the voting members prior to the AdCom meeting where election will takes place.

All nominations are due by 15 July 2010.

This conference is the sequel to meetings held in Maui (2001), Washington (2002), San Francisco (2003), Munich (2004), Nagoya (2005), Cincinnati (2006), Hong Kong (2007), Arlington (2008) and Genoa (2009). Specifically, this conference will be held at Seoul, Korea in the conjunction with Nano Korea 2010 supported by the Korean government.

Under the slogan of 'Nanotechnology for Green World', 14 technical sessions and other variety programs are prepared to cover the most important, current, and emerging topics in the field. This conference will offer a unique opportunity to have comprehensive overview and prospects of nanoscience and nanotechnology, from basic research to application.

Seoul, this year's conference venue, is the capital of Korea with over 600 years of history. It is the heart of Korea's culture and education as well as politics and economics. Seoul is the 2nd largest metropolitan area of the world with over 10 million people and has numerous amenities and shopping districts. It is unique in that historical sites such as Gyeongbokgung Palace and modern cultural facilities coexist.

http://ieeenano2010.org/

Student's Corner

Popular News Sites

Electronics Manufacturing

Nano News & Technologies

Nano Tech Web

World of Microarrays & Microfluidics

Euro Asia News

MEMS Investor Journal

Animations!!

Learn more about nanotechnology:

IEEE nanotechnology Council virtual community:
https://www.ieeecommunities.org/ntc

IEEE nano publications
http://ewh.ieee.org/tc/nanotech/nanopubs.html

National Institute for NanoTechnology
http://www.nrc-cnrc.gc.ca/eng/ibp/nint.html

Nanotechnology basics, news, virtual labs, games & more!
http://www.nanoed.org/
http://www.trynano.org/
http://www.nanotech-now.com/
http://www.azonano.com/
http://www.nanoyou.eu/
http://www.nanooze.org/

"The best way to teach somebody something is to have them think they're learning something else."

- *Randy Pausch*

Learn more about Microelectromechanical Systems (MEMS)

http://www.allaboutmems.com/

http://www.csa1.co.uk/discoveryguides/mems/overview.php

http://home.earthlink.net/~trimmerw/mems/tutorials.html

Upcoming Events

The Eighteenth Annual International Conference on Composites/nano Engineering (ICCE - 18)
Date: July 4–10, 2010
Venue: Alaska, USA
More info: http://myweb.polyu.edu.hk/~mmktlau/ICCE/ICCE_Main.htm

SPIE NanoScience + Engineering symposium
Date: August 1–5, 2010
Venue: California, USA
More info: http://spie.org/nanoscience-engineering.xml

IEEE NANO 2010
Date: August 17–20, 2010
Venue: Seoul, Korea
More info: http://ieeenano2010.org/

Third International NanoBio Conference 2010
Date: August 24–27, 2010
Venue: Zurich, Switzerland
More info : http://www.nanobio.ethz.ch/

NMDC Nanotechnology Materials and Devices Conferences
Date: October 12-15, 2010
Venue: Monteresy, California, USA
More info: http://www.egr.msu.edu/nmdc2010/

IEEE Sensors 2010 Conference
Date: November 1–4, 2010
Venue: Hawaii, USA
More info: http://www.ieee-sensors2010.org/

International Conference on Solid-State and Integrated Circuit Technology
Date: November 1–4, 2010
Venue: Shanghai, China
More info: http://www.icsict2010.com/index.htm

IEEE International Conference on Microelectronics (ICM)
Date: December 19–22, 2010
Venue: Cairo, Egypt
More info: http://www.ieee-icm.com/

June

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

July

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

August

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

September

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		