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A newsletter about micro and smart systems in India

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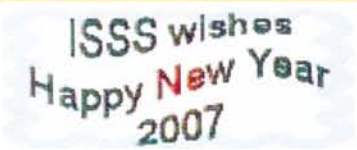
CONTENTS



The 1st National Conference of ISSS

D.V.K. Sastry

The first ISSS National Conference on Smart Structures and MEMS for Aerospace Applications was organized by Research Centre Imarat (RCI), Hyderabad, during 1 – 2 December 2006. Shri S.K.Ray, Director, RCI welcomed the dignitaries, invitees, and delegates to the conference. Prof. P. Rama Rao, former Secretary of DST and chairman of BRNS, Distinguished Professor, ISRO, inaugurated the conference and delivered the inaugural address. Prof. S. Mohan, president of ISSS, briefed about ISSS's activities and declared the opening of ISSS, Hyderabad Chapter. Shri. K.V.S.S. Prasad Rao, Chairman NTRO, Govt. of India, was the guest of honour and addressed the gathering. This was followed by the keynote address by Dr. V.K. Saraswat, Chief Controller, DRDO, who discussed the challenges of MEMS for defence and aerospace applications. On the second day of the Conference, Dr. V.K. Aatre gave the keynote address elaborating on the NPSM initiatives in promoting this emerging technology. Invited talks by eminent scientists and experts on both 1st and 2nd December, were included in the plenary sessions. The invited speakers included Prof. S.K. Koul (IIT-D), Prof. G.K. Ananthasuresh (IISc), Lt. Gen (Dr.) V.J. Sundaram, Shri. S.K. Ray (Director, RCI), Dr. K. Natarajan (BEL), Dr. Bhagirath Rao (Ex-Director, DLRL) and Dr. A.R. Upadhya (Director, NAL). The conference was attended by 200 delegates from 10 academic institutes, seven R&D organizations (CEERI, SAC (ISRO), NAL, NPOL, RCI, etc.) and four public sector undertakings (BEL, SCL, GAETEC, and SITAR) from all over the country. About 50 technical papers covering various topics including MEMS design, devices, smart structures, material processing and device fabrication, testing and characterization, sensors for control applications, inertial sensors, RF MEMS design and simulation, were presented during the conference. There were fruitful deliberations among various groups. The presentations gave a comprehensive idea of the status of this technology and the R&D initiatives at various parts of the country. In this connection, an exhibition was arranged, in which 23 exhibitors including R&D organizations and companies dealing with MEMS related products participated. This was found useful by the delegates.

See p. 2 for highlights of a panel discussion held on the last day of the conference.

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National MEMS Design Centres (NMDCs)

A. Selvarajan

The National Programme on Smart Materials (NPSM) (see Vol. 1, No. 1, 2006, p. 1) funded a project with the objective of enabling education and training of personnel in the use of Computer Aided Design (CAD) tools for Micro-Electro-Mechanical Systems (MEMS). It is expected that the availability of such personnel would enhance the value and utility of MEMS efforts in the country through optimal design and the use of this technology. Because the MEMS technology calls for sophisticated equipment for both processing and characterization, extensive design and optimization are beneficial to save time and money. With this realization, three National MEMS Design Centres (NMDCs) at IISc, IIT-Kharagpur and IIT-Mumbai were set up with the following objectives:

- Facilitating the required design tools and the hardware so that MEMS design expertise in the country could be assured.
- Acting as nodal centers to enable the students, faculty and scientific staff of not only the institution in which the centre is set up but also others from neighboring universities and R&D labs to use the design centers.
- Undertaking in-house novel MEMS designs in a variety of application domains such as inertial MEMS, RF MEMS, optical MEMS and bioMEMS.
- Conducting periodic short-term courses/workshops for the benefit of interested persons in academic, R&D and industrial establishments across the country.

Dr. A. Selvarajan is an emeritus professor of Electrical Communications Engineering at IISc. He can be reached at rajan@ece.iisc.ernet.in.

Furthermore, auxiliary centres were set up at IIT-Chennai, IIT-Kanpur, IIT-Guwahati, SSPL-New Delhi and NPL-New Delhi with MEMS design tools. Several satellite centres were also created at NITs at Surathkal, Calicut, and Trichy and at Pune University and the Karunya Institute at Coimbatore. A few Ph.D and many B.Tech. and M.Tech. projects have been successfully completed using the facilities at the above centres. The centre at IISc has been the nodal point for all the above activities. It has completed the detailed design of devices such as a varactor, resonator, micromirror, RF switch, microphone, gyroscope, accelerometer, pressure sensor, and a micro pump. Some of the above designs have already been prototyped through external foundries.The IISc design centre has conducted more than eight workshops. Each of these were attended typically by about 30 scientists and researchers from academic and research institutions from across the country. It is particularly gladdening to note that a good number of these were engineering college teachers, who in turn are expected to spread the message about MEMS. Several government R&D organizations (LEOS, NAL, ADA, VSSC, ISAC, LPSC, BEL, SITAR, SCL, etc.) have actively participated and later used these facilities for their own design and development activities. Industry participation in the area of MEMS is also gradually increasing in India. Several of the other design centres have also generated substantial interest in the area of MEMS. The NMDC at IIT-Kharagpur, took up the design and analysis of piezoresistive micro-accelerometer, tunneling accelerometer and piezoresistive pressure sensor. IIT-Mumbai focused on biosensing applications. It can be emphatically stated that the decision of NPSM to set up MEMS design centres has stimulated great interest among students, scientists and industry personnel. A good number of trained design professionals are now ready to undertake the development of prototypes and products enabling India to be globally competitive in the area of MEMS.

President's Message

S. Mohan

Dr. S. Mohan is a Professor of Instrumentation in the Indian Institute of Science (IISc), Bangalore. He is also the President of ISSS and a PI of the MCIT project entitled "Centre for Excellence in Nanoelectronics".

In a few months, ISSS is going to have a new Executive Council. During the last couple of years, the present team has continued to contribute to many initiatives started by the past committees and has also initiated some new programs. One of the major efforts where considerable success has been achieved is the human resource development at the engineering college level. The society has been successful in exposing more than 100 engineering college teachers from all over the state of Karnataka. About 100 engineering students drawn from various colleges will be trained during January-February, 2007, in MEMS technology. ISSS has developed the curriculum for undergraduate students and initiated preparation of a text book for this course. About 30 faculty members from six National Institutes of Technology have undergone training in a workshop organized at IISc, Bangalore. This is the beginning of a major effort to extend this activity all over the nation.

The importance of networking academic institutions, R&D Laboratories and industries in India and abroad was reiterated in the recent National Conference organized at RCI, Hyderabad. Major initiatives are planned to form consortia on specific devices – the first one on "gyros" is now being planned at RCI, Hyderabad. I take this opportunity on behalf of all the executive committee members to thank all those who contributed to the activities, and wish the new team success in carrying forward the vision of ISSS.

Panel summary at ISSS MEMS 2006

(Contd. from p. 1)

The panel consisting of Dr. V.K. Aatre, Lt. Gen. V.J. Sundaram, Mr. S.K. Ray, Dr. A.R. Upadhya, Dr. Chandra Sekhar and Prof. S. Mohan recommended the following.

- A strong networking between academia, R&D organization and foundries in India and abroad is essential.
- Consortium groups are to be formed for product development for specific purposes.
- ISSS shall initiate and facilitate the above two activities.
- Two or three micro foundries are to be established to help the microsystems community.

ISSS News

S. Gopalakrishnar

On behalf of ISSS, Research Centre Imarat (RCI) in Hyderabad organized the ***first national conference on Smart Materials, Structures and Systems, ISSS-MEMS 2006*** on December 1-2, 2006. On this occasion, ISSS Hyderabad Chapter comprising more than 30 ISSS life members, was inaugurated by Prof. S. Mohan. On the second day of the conference, four distinguished scientists were honored for their contributions to ISSS. They were Dr. V.K. Aatre, Dr. Kota Harinarayana, Mr. K.V.S.S. Prasad Rao and Prof. B. Dattaguru. ISSS co-opted Mr. Guru Dutt of Bigtec as an Executive Council Member of ISSS as its industry representative. With his induction, the number of ISSS Executive Council members has risen to eight. ISSS partially supported Mr. Rizwaan Ali, a Research Scholar in the Department of Aerospace Engineering, IISc, to attend the SPIE Smart Structures conference in Adelaide, Australia. ISSS also conducted a one week intensive course on ***Micro and Smart Systems*** for the faculty o National Institutes of Technology (NITs) This course was conducted during Decembe 11-16 in IISc, Bangalore. Since the release o last newsletter, 20 new life members hav been inducted into ISSS.

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This newsletter is sent to all ISSS members by postal mail.

To become an ISSS member, download:
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Department of Aerospace Engineering
Indian Institute of Science, Bangalore
560012, India

ISSS admission fee: Rs. 200
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Rs. 200 (annual); Rs. 2,000 (life)
Student member:
Rs. 75 (annual)
Corporate member:
Rs. 10,000 (annual); Rs. 50,000 (life)
Payable to "ISSS, Bangalore".

Industry Watch

Rudra Pratap

It is no secret that India has had little success in the past in creating successful commercial enterprises from new technologies developed in its research laboratories. While several theses can be written on the analysis of this failure, it serves little purpose in analyzing the past because the present scenario is radically different in terms of all relevant parameters. With this backdrop, it is heartening to see several entrepreneurs taking the challenge head-on by starting companies in high-tech areas and trying to build their own technologies, sometimes from the scratch. These companies bring a breath of fresh air to the sensitive nose that has got so used to the smell of borrowed technology or service offerings. A quiet revolution is taking place, at a very small scale, that is likely to have a large impact on India Inc., not on its revenues in the short run but on its psyche, its confidence, its ability to harness scientific research for technology development and economic growth.

The global landscape of mirco and nano technologies is dominated by four or five countries in terms of products, patents, companies, and publications; not surprisingly by the same countries that have invested heavily and continuously in these technologies over the last two decades. India has made a late entry into this technology but this is perhaps the first time in history that the phase lag in entering a revolutionary technology is remarkably small (see Table that shows the number of micro/nano companies). What is even more significant to note is that this is the first time when young entrepreneurs with 'can do' attitude have started their own technology shops. This bodes very well for technological future of the Indian industry.

The number of micro/nano companies

Year	1990	2000	2005
USA	5	100	800
Switzerland	0	20	130
China	0	10	300
India	0	0	10

The micro and nano technology space across the world is filled with small start-ups that are extremely focused and work on niche products or technologies. Although some of the major players are large corporations with major investments in these technologies, some surveys have found that most innovations have come from the focused small companies. Many of these companies have been incubated in university research labs and other similar research centres. In fact, there is a very good correlation between the number of companies in a country and the number of government-funded major research labs or initiatives in that country. The comparison in the table shows the phase lag we have. However, it shows that the phase lag is not too big and that, if the trend continues, we will be well placed in this technological space. Because this experiment is relatively new for India, there are several hurdles that the new companies face. There is no proven tradition of building commercial products or systems from scratch up research. Expertise in systems design is extremely hard to find. It is even harder to keep a team of motivated engineers together on the promise of a good future in a few years when that future, at least financially, is available every minute in the IT industry just around the corner. Finding the required funding for these start-ups is extremely hard because the finance market does not have either the time or the inclination to look beyond the service industry. Under these circumstances, it is very tough going for these companies. However, these very circumstances are also the reason for innovative business solutions. Our start-ups are innovating and finding oxygen for their survival in their ingenious ways. The coming issues of this newsletter will present a profile of the companies that are developing micro or nano systems and technologies.

Dr. Rudra Pratap is an Associate Professor of Mechanical Engineering in IISc. He may be reached at pratap@mecheng.iisc.ernet.in.

Watch for...
BEL
Bigtec
Cranes Software Int'l
QtechNanotech
...in the next issues.

Leaders of ISSS

Prof. Bhagavatula Dattaguru is an outstanding scientist and engineer with deep insight into the complexities of aerospace structures. He is normally referred to as the doyen of aerospace structures in our country. Born in 1942, Prof. Dattaguru has B.Sc. (Physics) from Andhra University; B.E. (Electrical), M.E. (Aero.) and Ph.D. (Aero.) degrees from IISc, Bangalore. He joined the Department of Aerospace Engineering at IISc, Bangalore in 1964 and superannuated in 2004.

Prof. Dattaguru is an outstanding researcher and a well-respected teacher. Under his guidance, more than 25 students graduated with Ph.D. and 50 with Masters. The list of his scientific publications is impressive both in quality and number: over 150 papers that have been frequently cited by other researchers. Prof. Dattaguru has made several contributions towards education and research related to aerospace structures. His individual scientific contributions cover the critical areas of structural integrity including fracture mechanics, damage tolerance, durability and life extension, composite structures technology and smart structures. He is internationally recognized for his scientific contributions in the areas of fracture and life-prediction in high performance structural systems. He is one of those instrumental in establishing the Institute of Smart Structures and Systems (ISSS) and was one of its founding members. He was the first Vice president of ISSS and went on to become President in 2000. As an active member of the B-SMART of NPSM (See Vol. 1, No. 1, 2006, p. 1), he has contributed substantially for the growth of smart systems technology in India.

Prof. Dattaguru has been recognised with several awards. He was one of the earliest to be elected a Fellow of the Indian National Academy of Engineering. He is a Fellow of the Institution of Engineers (India) and the Aeronautical Society of India (AeSI); Member of Indian Society for Non-destructive Testing (ISNT), Indian Society for the Advancement of Materials and Process Engineering (ISAMPE), Materials Research Society of India (MRSI), Indian Society for Theoretical and Applied Mechanics (ISTAM) and current President of the Advanced Computing and Communications Society (ACCS). He is the recipient of the Biren Roy Trust Award (1993) and Excellence in Aeronautical Education Award (1998) both of the AeSI, DRDO Academic Excellence Award (2002), AR&DB Silver Jubilee Award for best sponsored research project (1996), KSIIDC Chair, IISc (instituted by the Karnataka State Industrial Investment and Development Corporation) (2000-2003), Prof. Rustom Choksi Award for Excellence in Engineering Research, IISc (2001). In 2005, Prof. Dattaguru was conferred with the award of Padmasri from the Government of India. We would like all the members of ISSS to join us in applauding Prof. Dattaguru's contributions for the growth of ISSS.

Physical health has always been a basic human concern, and societies across the ages have addressed this in its own way in keeping with its ethos and wisdom. The widespread availability and use of mechanical, electrical and electronic devices in present day society is naturally reflected in their use in the biomedical field for monitoring and intervention. Such trends are now moving in the direction of combining two well developed fields, namely, miniature electronics (mainly silicon based ICs) and relatively larger scale mechanics (sensors, actuators and mechanisms) to obtain Micro-Electro-Mechanical Systems (MEMS) that are multifunctional in nature and are easy to fabricate in large numbers using modified IC processing techniques. Some of the practical devices available in the market today, after much experimentation, are inkjet heads, video projector systems, disposable diagnostic chips, and airbag crash sensors. These are all products based on MEMS technologies. These systems are realized by integrating a MEMS device with electrical, magnetic, chemical, and biomedical elements usually on a single chip. This is known as a system-on-a-chip (SOC) or a system-in-a-package (SIP). There is a characteristic that electronic circuits do not share with MEMS: while electronic circuits are inherently rigid and compact structures, MEMS are mostly freestanding elastically flexible structures. MEMS have holes, cavities, channels, cantilevers, membranes, etc., and in some way resemble 'a mechanical structure'. Polymer based MEMS are emerging to replace silicon based MEMS in view of their even low cost and ease of manufacturing. In the context of biological application of MEMS, polymers are preferable because of their bio-compatibility.

The application of MEMS in the area of biomedicine holds limitless potential and has pervasive influence on the society at large. This is expected to make many of the diagnostic systems, point-of-care systems, and drug delivery systems (all of which are explained later in this article) very cheap in view of the large-scale production. Such a development will put these exotic but life saving systems within the reach of the common man. For instance, a point-of-care system can constantly monitor a few critical physiological parameters and make available to the physician on demand, by which, post-operation stay in hospital could be significantly reduced. Similarly, life-saving drugs could be administered through micro drug-delivery systems while the patient is in his natural environs like home or office. It has been found that such controlled and continuous monitoring and administration of drugs only on-demand by the body system results in better and faster recuperation.

Fig. 1. (From http://www.abbottpointofcare.com/istat/)
A portable clinical analyzer shown along with its cartridges.

A host of MEMS devices serve as the basic building blocks of biological diagnostic systems, infusion pumps and lab-on-chips. Such devices are commonly grouped under BioMEMS (Biological MEMS) and these devices have the advantage of interfacing MEMS components with functional biomolecules to enhance their capability and performance for a variety of healthcare applications. Miniaturized pressure sensors were quick to find their ways in medical equipment for blood pressure test. Since then biomedical application have grown tremendously. The DNA chip and microanalysis system are the latest successes in the list.

Long waits at the clinical laboratory for your blood test results may soon be a thing of the past. Point-Of-Care (POC) systems enable you to get your blood or other body fluid samples analyzed for many parameters in one go in a few minutes in the convenience of your bedroom. The POC systems have evolved as cheaper and truly portable alternatives to the conventional laboratory assaying for various parameters on blood or urine samples. Tests with POC systems could be carried out without technical training and are significantly faster than usual. BioMEMS based POC systems are excellent examples to illustrate the advantages of MEMS technology in biomedical applications. Commonly POC systems have an analyzer and disposable cartridges. Such a cartridge is in reality what is called a "Lab-On-Chip". It usually has a sensor chip, which has an array of sensors capable assaying one parameter each of the sample. Challenge in realizing a portable, fast and cheap clinical test laboratory lies in a paradigm that integrates miniaturized sensors with biosensing molecules and techniques. It is these miniaturized sensors that have been realized with silicon micromachining techniques. BioMEMS have made this all-pervasive technology a reality for the common man. An example of a commercial POC system (www.istat.com) is shown in Fig. 1. The disposable cardridge used here could sense as many as eight blood parameters in a single blood sample – glucose, heamatocrit, sodium, potassium, ionized calcium, pH, pO_2 and pCO_2.

The undeniable benefits for diabetic patients are constant monitoring of blood glucose levels and appropriate insulin dosing, and thus maintaining near normal blood glucose levels at all times. This is known to avoid or at least delay the potential risks of long-term hyperglycemic conditions such as glaucoma. The self-testing, as currently practiced, involves drawing a blood sample by puncturing the skin usually from the finger by a fine tipped needle. Long-term use of this "finger stick" procedure produces calluses, thickening of the skin and loss of sensation in the fingers. The pain and psychological trauma associated with this discourages many patients. A mosquito-bite like skin puncturing would largely be acceptable to most patients and such a device has been made possible with the advent of MEMS based microneedles,

Indian Iniative in BioMEMS

The National Programme on Smart Materials (NPSM) (see Vol. 1, No. 1, 2006, p. 1) had five Project Assessment and Review Committees (PARCs) one of which (namely, PARC 5) focused on biomedical applications. The thrust areas of this PARC were diabetes management, cardiac disorders, diagnostic kits for common deseases and noninvasive physiological monitoring. As many as seven projects were funded under this PARC. It was coordinated by five experts from academia, industry and research organizations. They included Dr. Lazar Mathew (Dean, Biomedical Engineering and Biosciences, Vellore Institute of Technology), Prof. Sujoy Guha (All India Institute of Medical Sciences and IIT-Kharagpur), Prof. Apte (Electrical Engineering, IIT-Bombay), Dr. Makam Ramesh (Director, BEST instituteand reseacrch Centre, Bangalore), and Dr. K. Vijayaraju (Scientist, ADA, Bangalore) .

Some of the accomplishments of the projects funded under this initiative will be featured in the future issues. The authors of this article may be contacted for further details.

Suggested Reading

1) *BioMEMS* edited by Gerald A. Urban, Springer, Dordrecht, The Netherlands.

2) http://mmadou.eng.uci.edu/Classes/Biomems_Winter2007/

3) Manz, A., Vilkner, T., and Janasek, D., 2004, "Micro-total Analysis Systems: recent Developments," *Analytical Chemistry*, 76, pp. 3373-3385.

4) Turner, A.P.F., Karube, I., and Wilson, G.S., 1987, *Biosensors: Fundamentals and Applications*, Oxford University Press, Oxford.

which are similar in size to a human hair (see Fig. 2). While use of such microneedles is an excellent painless way to sample blood, they are also equally good for delivering drugs at the skin level. In fact, an array of such needles would combine effectively the two well-known conventional drug delivery approaches, namely, skin patches and hypodermic needles. In an area of a couple of square millimeters, one could realize a few tens of these microneedles.

Drug delivery could now be made painless and effective with microneedles and a MEMS micropump. A piezo activated silicon diaphragm with micromachined cavities in silicon constitutes a high performance micropump capable of as low a flow rate as 1 ml/min has been realized and aimed at insulin delivery. The pump shown in Fig. 3 is a credit card sized instrument that can be taped on to the body and can be programmed with a wristwatch for controlled drug delivery. In fact, the dream of an artificial pancreas is not far away if these technologies of blood glucose sensing, micro pumps and micro needles could be coupled with feedback control electronics.

The ultimate goal of this technology is to create therapeutic chips that can to go inside the body, feel, diagnose, sense and repair. Such a device is not anymore in the realm of science fiction.

Did you know that Richard Feynman had made a passing reference to "swallow your doctor" idea in his famous lectures in 1959 and 1983?

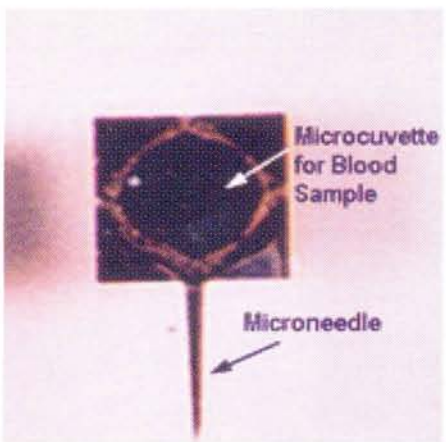

Fig. 2. (From http://www.kumetrix.com/)
Kumetrix, Inc., located in Union City, CA, USA, has developed a hand-held micro sampling and assay device using which blood test can be done painlessly in a single step. This is particularly useful for blood test for new-born babies. The silicon micro needle technology shown above is as painless as the bite of a mosquito.

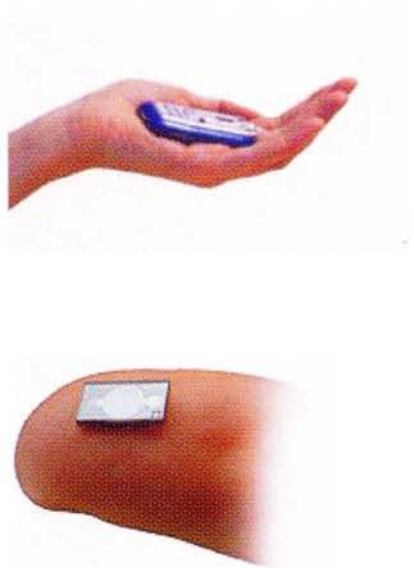

Fig. 3. Debiotech, a company located in Lausanne, Switzerland, has developed a miniature pump for subcutaneous infusion of insulin for diabetes. Its size is 65 mm X 38 mm X 11 mm and it can hold 3 ml of insulin in a detachable part. The silicon chip it uses is much smaller as shown here. (From http://www.debiotech.com/debiotech.html).

Dr. K. Vijayaraju is a scientist in Aeronautical Development Agency (ADA) and Dr. Lazar Mathew is the Dean of Bioengineering and Biosciences, Vellore Institute of Technology. They can be reached at vijay@jetmail.ada.gov.in and dean_bs@vit.ac.in, respectively.

University Buzz: MEMS in NITs

N. Bhat and G.K. Ananthasure

The success of an application oriented field such as Micro-Electro-Mechanical Systems (MEMS) depends on the number of people engaged in in its research and development. Currently, IISc and many IITs have active programmes in MEMS. But it is not enough to produce adequate number of trained individuals in this multi-disciplinary area. Noting this need, Professor A. Selvarajan, Professor Emeritus, ECE, IISc, took the iniative to spread the gospel of microsystems to National Institutes of Technology (NITs). He, with the help of some faculty members of IISc, started a programme to initiate microsystems research in southern NITs as a first step. The National Programme on Smart Materials (see Vol. 1, No. 1, 2006, p. 1) was approached for funding this activity. The project consisted of several components. First, it aimed to establish National MEMS Design Centre (see p. 1) satellites at these institutes. The second was to conduct workshops to introduce aspects of microsystems research to NITs' faculty of NITs of the entire nation and not only southern NITs. The third goal was to enable the faculty of participating institutes to fabricate the prototypes of their microsystem designs. The premise for this last goal is that only design and simulation do not give the full appreciation of the microsystems field, which is focused on practical applications and specific products.

All of the above three goals were achieved by the NPSM-funded project. Four institutes, namely, NITs at Calicut, Surathkal and Thiruchirapalli, and Karunya Institute of Technology, Coimbatore, were given one license of Intellisuite and MEMS-pro software and 30 licenses of COMSOL Multi-Physics to help them set up NMDC satellite centres. Four IISc faculty, one for each institute, worked with coordinators identified at the four institutes. The coordinators were: Mr. Shijo Thomas (Calicut), Dr. G. Umesh (Surathkal), Dr. Umapathy (Trichy), and Mr. Sanjeev Kumar (Karunya).

The faculty and students of the four institutes interfaced closely with the respective IISc faculty and students to develop designs of their own choice. Some of them visited the National MEMS Design Centre (NMDC) at IISc and spent a few days to finalize their designs. They also designed the photolithography mask layouts for the PolyMUMPs (Multi-User MEMS Processes) foundry process. These designs were sent to the foundry and fabricated devices have been received. Some institutes have visited IISc again to test these devices. This exe has enabled the research students and fa at the four institutes to have a first- experience of designing and prototyi MEMS device. Thus, these four institute now well poised to undertake their research in this area. Indeed, several fac members at these institutes are advisi number of students working in this area. also have graduate level MEMS course

The success achieved with four sele institutes motivated IISc faculty and ISS extend this to all NITs in the nation. Tow this, ISSS held a workshop for faculty o NITs from December 11-16, 2006. Abou participants from more than six NITs atter this workshop. At the conclusion of workshop, the NIT faculty expressed inte in starting a network among themselve take this momentum forward to fur enhance their research and educat activities in this important area.

NIT-Calicut

NIT-Surathkal

NIT-Trichy

Karunya

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Conference Announcements

Sayanu Pamidighanta

International Conference on Integration and Commercialization of Micro and Nano-systems, Jan. 10-13, 2007, Sanya, Hainan, China, http://asmeconferences.org/micronanoChina07/

10th International Conference on Modeling and Simulation of Microsystems, MSM 2007, May 20-24, 2007, Santa Clara, California, http://www.nsti.org/Nanotech2007/MSM2007/

20th International Conference on MEMS, MEMS 2007, Jan 21-25, 2007, Kobe, Japan, http://www.conferences.jp/mems2007/

Technology News

G.M. Kamath

Nnanotechnology in the medieval ages. Does it sound like an anachronism? No, says a recent study conducted by German researchers and published in the journal *Nature*. The ancient Damascus swords used by the muslims against the crusaders had extraordinary mechanical properties and an exceptionally sharp cutting edge. High resolution transmission electron microscopic images published by Reibold, et al., (*Nature*, Vol. 444, 16, November 2006, p. 286) indicate that the presence of carbon nanotubes and cementite nanowires may have been the cause of these superior properties. The swords made of *wootz* steel produced in ancient India were forged and annealed using a process whose details have since been lost. The *wootz* steel was produced with ingredients such as wood and leaves from specific plant species in addition to ores taken from particular mines in India. The *Nature* paper uses a sample from a sword made by the famous 17th century blacksmith Assad Ullah. The authors suggest that "by empirically optimizing their blade-treatment procedure, craftsmen ended up making nanotubes more than 400 years ago."

Above: A high-resolution image showing multiwalled carbon nanotubes in a Damascus sabre after dissolution in hydrochloric acid (*Nature*, 444 (16), 2006, p. 286).
Left: Damascus sword with its characteristic pattern on the blade (J. Verhoeven and A. Pendray, *Muse*, 2 (2), 1998, pp. 35-43).

Dr. G.M. Kamath is a scientist in the Advanced Composites Division of the National Aerospace Laboratories, Bangalore. He can be reached at gmkamath@css.nal.res.in. He wishes to acknowledge Prof. P. Rama Rao for bringing this finding to his attention in the inaugural address at the ISSS MEMS 2006 conference.

Accomplishments: CGCRI-Kolkata (Part 1 of 2)

The Central Glass and Ceramic Research Institute (CGCRI) was established in 1950 in Kolkata as one of the constituent national laboratories under the Council of Scientific and Industrial Research (CSIR). During more than five decades of its existence, CGCRI has built up an impressive knowledge-base and expertise and has made significant contributions covering a wide range of applications in the field of optical materials and specialty glasses, advanced ceramics and ceramic coatings, refractory materials and sol-gel derived glasses and ceramic materials.

The Fibre Optics Laboratory at CGCRI, which started its activities in early 1980s, has emerged as the only facility in India where extensive research is being carried out to develop optical fibres for special applications including optical amplification and online measurement of strain in engineering structures. It has the facilities for production and characterization of fibres of lengths up to a few kilometers. Several specialty fibres have been developed at CGCRI. It holds three US patents in relation to erbium doped fibres. Recently, activities have been initiated for the development of silica based holey (photonic crystal) fibres.

Fibre Bragg Grating Facility at CGCRI

Fibre Bragg Grating (FBG) is an important member of the suite of sensors used in a smart structure, wherein they can be used for sensing vibration, acoustic signals, and even temperature (see Vol. 1, No. 1, 2006, p. 5). A complete facility for writing FBG with sophisticated software and precision process control has been set up in CGCRI for the fabrication of grating structures such as chirped, sampled, phase-shifted and Moire gratings. CGCRI, in collaboration with SINTEF (the Norwegian Foundation for Scientific and Industrial Research) and Power Grid Corporation of India Ltd. is developing FBG based sensor technology for real-time monitoring of parameters for capacity enhancement of power transmission lines. In collaboration with some of the defense laboratories, CGCRI is standardizing the application of its embedded FBGs to monitor the development of internal strains generated during the curing process of composite materials. CGCRI is also developing the methodology for the use of in-house developed FBGs for monitoring the strains in concrete structures. A calibration facility has been built for detailed analysis of the sensitivity of the strain measurement in the presence of interference due to temperature changes.

A setup for Fibre Bragg Gratings at CGCRI-Kolkata.

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The next issue will feature the accomplishments of the Sensors and Actuators Section of the same institute.

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