||sūkshma||

The ISSS newsletter about micro and smart systems in India

Volume 4 : Number 1
January 2009

ANUPAMA

IISc in NIT-K

BESU

SCL's Packaged Flow Sensor

Winter Issue

Inside...

To

This newsletter is published quarterly by the Institute of Smart Structures and Systems (ISSS) and is sent to all its members of by postal mail.

To become an ISSS member, download:
http://www.isss.in/membership.html
and send the form with the payment to:
Institute of Smart Structures and Systems
Department of Aerospace Engineering
Indian Institute of Science, Bangalore 560012, India

ISSS admission fee:	Rs. 200
Member:	Rs. 200 (annual); Rs. 2,000 (life)
Student member:	Rs. 75 (annual)
Corporate member:	Rs. 10,000 (annual); Rs. 50,000 (life)
Institutional member:	Rs. 25,000 (life)

Please send a cheque payable to "ISSS, Bangalore".

Editorial

A dozen pages, many opportunities

G.K. Ananthasuresh

This is the tenth issue of Sukshma whose first issue came out in the last quarter of 2006. To mark this occasion, the editorial team has decided to adorn this newsletter of ours with a new look. Two other significant changes are made. First, from now on, by following the tradition of magazines, Sukshma will feature a different image on its cover in each issue. So, if someone does not like the cover of the n^{th} issue, the chances are (s)he might like the $(n+1)^{st}$ issue. Second, we now have 12 pages, a leap from eight pages that we have had so far. The quantum of growth for Sukshma is four pages for the simple reason that it is currently stapled by folding double-sided A3 sheets into two A2 sized sheets resulting in four pages. More pages imply more opportunities to fill the newsletter with more content. Therefore, you will find new features in this issue. Some are regular features such as the existing ISSS news, Industry Watch, Campus Buzz, Accomplishments, and Technology News while others are specific to an issue.

A new regular feature is a list of papers published by Indian researchers in selected journals in the broad areas of micro, nano, and smart systems science and technology. This feature is in line with a goal of Sukshma in spreading the news of micro, nano, and smart happenings in India. The selected journals will vary from issue to issue and papers published in those journals in the last three months will be included in the list. The purpose of this feature is to showcase the scientific and technological contributions from India in these areas.

Another new regular feature is the Book Review. Ironically, or perhaps not, the number of printed books is increasing in this era of easy access to digital information. Micro, nano, and smart fields are no exception. In view of this, Sukshma will include a review of the new books released in these areas. ISSS members and others are hereby requested to submit their book reviews along with an image of the cover of the book and book's complete citation information.

Space fillers are saviors for the editorial team when it scrambles for tidbits of information to fill the gaping holes in the pages at the time of the layout. ISSS members can help by sending short e-mails about any relevant information to sukshma@mecheng.iisc.ernet.in and copying the message to suresh@mecheng.iisc.ernet.in. Letters to the Editor can also be considered. It will be the delight of the editorial team to know that Sukshma is being read and enthusiastically discussed.

Opportunities do not always come without challenges. A challenge that Sukshma now faces is collecting the necessary information to fill its dozen pages once every three months. This also translates to sustaining the current activities of ISSS and doing much more.

ISSS wishes
all its members and their families
a joyous 2009.

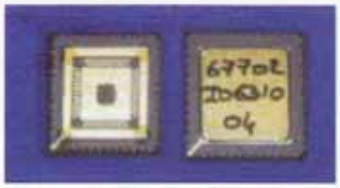
ANURAG

K.D. Nayak

ANUPAMA – 32 bit RISC Microprocessor with internal interrupt controller, Serial and Parallel I/O, programmable timers

ABACUS SoC-V1, A system on chip based o Abacus 32 bit RISC processor core, supporting on-chip Ethernet MAC and 1553B bus controller

ANUSANCHAR – An SoC for communication applications with three DSP cores and several on-chip peripherals



Sigma-Delta ADC

Advanced Numerical Research and Analysis Group (ANURAG), a constituent laboratory of Defence Research and Development Organisation (DRDO), was established on 2nd May 1988 in Hyderabad with the mandate to work on advanced computing concepts in hardware and software. Since inception, the main thrust of ANURAG's activities has been directed towards self-reliance in the area of computing, VLSI designs, and technology. To overcome twin challenges of obsolescence and denial of supply, ANURAG ventured into VLSI design field. Starting with design of a mathematical coprocessor, ANUCO in 1991, ANURAG designed and realized a numbers of ASICs, over the years, for various DRDO applications.

With the realization of ANUPAMA in 1998, ANURAG achieved the distinction of designing a 32-bit general purpose RISC-like processor for the first time in India. ANUPAMA is mainly targeted for real-time embedded applications and has interrupt controller, serial and parallel I/O, single precision floating point arithmetic unit, and programmable timers–on-chip. In 2004, ANURAG came out with microprocessor design that was enhanced to handle desktop applications. Named ABACUS, this 32-bit processor has memory management unit, double precision floating point arithmetic unit on-chip in addition to peripherals ANUPAMA supports on-chip. Since then, ANURAG went on to design faster microprocessors and system-on-chip (SoC) designs based on these cores. Significantly, ANURAG developed complete system software suite for these indigenous processors; this includes, Compiler suite, Linux operating system, and many flavours of real-time operating systems (RTOS) for embedded applications.

ANURAG is also working in DSP line. In 1998, ANURAG developed ANUSIG, a 16-bit fixed point DSP. In 2006 ANUDSP, a 16-bit fixed point DSP with on chip peripherals was realized. ANURAG developed ANUSANCHAR and ANUVANI, baseband transceiver chips, on-chip targeted for Satallite and RF communication applications respectively. These SoCs integrate three ANUDSP cores and peripherals such as DDC, Viterbi Decoder, Galois Field coprocessor, etc., on-chip.

Today, ANURAG's portfolio of over 40 designs includes, indigenous microprocessor-based SoCs, DSP based SoCs, and many ASICs and peripherals.

ANURAG has a dedicated group working on analog design. This group has already designed, realised and tested a data transceiver for Mil. Std 1553B, Sigma Delta ADC, and Pipelined ADC devices. Many more designs are in the advanced stages of implementation.

VLSI chips developed by ANURAG are used in many systems developed by DRDO laboratories. ANURAG is also exploring the commercial application of processors developed indigenously. In the process, prototypes for highly usable products such as hand-held computer, GPS based Navigator, Mobile computing platform, Vocoder based on ANURAG's processors would be realized.

Dr. K.D. Nayak is the Director of ANURAG. He can be reached at kd_nayak@anurag.drdo.in.

Journal publications by Indian Researchers...

... in the following journals in the last three months:

Journal of Micromechanics and Microengineering,
Journal of Microelectromechanical Systems,
Sensors and Actuators A Physical,
Smart Materials and Structures,
Nanotechnology,
Nanoscale Research Letters, and
Journal of Intelligent Material Systems and Structures.

Experimental investigations of the large deflection capabilities of a compliant parallel mechanism actuated by shape memory alloy wires
Author(s): Sreekumar M, Nagarajan T, Singaperumal M, SMART MATERIALS & STRUCTURES, Volume: 17, Issue: 6, Article Number: 065025, DEC 2008.

A semi-analytical model for squeeze-film damping including rarefaction in a MEMS torsion mirror with complex geometry
Author(s): Pandey AK, Pratap R
Source: JOURNAL OF MICROMECHANICS AND MICROENGINEERING Volume: 18 Issue: 10 Article Number: 105003, OCT 2008.

The effect of concentration in the patterning of silica particles by the soft lithographic technique
Author(s): Singh A, Malek CK, Kulkarni SK
Source: SMART MATERIALS & STRUCTURES Volume: 17 Issue: 6 Article Number: 065031, DEC 2008

Active vibration control of beams with optimal placement of piezoelectric sensor/actuator pairs
Author(s): Kumar KR, Narayanan S
Source: SMART MATERIALS & STRUCTURES Volume: 17 Issue: 5 Article Number: 055008, OCT 2008

All-fiber optic sensor for measurement of liquid refractive index
Author(s): Nath P, Singh HK, Datta R, et al.
Source: SENSORS AND ACTUATORS A-PHYSICAL Volume: 148 Issue: 1 Pages: 16-18 Published: NOV 4 2008

Fabrication and transverse piezoelectric characteristics of PZT thick-film actuators on alumina substrates
Author(s): Sivanandan K, Achuthan AT, Kumar V, et al.
Source: SENSORS AND ACTUATORS A-PHYSICAL Volume: 148 Issue: 1 Pages: 134-137, NOV 4 2008

Vertical ordering and electronic coupling in bilayer nanoscale InAs/GaAs quantum dots separated by a thin spacer layer
Author(s): Chakrabarti S, Halder N, Sengupta S, et al.
Source: NANOTECHNOLOGY Volume: 19 Issue: 50 Article Number: 505704 Published: DEC 17 2008

Spray deposition and characterization of nanostructured Li doped NiO thin films for application in dye-sensitized solar cells
Author(s): Joseph DP, Saravanan M, Muthuraaman B, et al.
Source: NANOTECHNOLOGY Volume: 19 Issue: 48 Article Number: 485707 Published: DEC 3 2008

Fabrication and Properties of Ethylene Vinyl Acetate-Carbon Nanofiber Nanocomposites
Author(s): George JJ, Bhowmick AK
Source: NANOSCALE RESEARCH LETTERS Volume: 3 Issue: 12 Pages: 508-515 Published: DEC 2008

Influence of Surface Modified MWCNTs on the Mechanical, Electrical and Thermal Properties of Polyimide Nanocomposites
Author(s): Singh BP, Singh D, Mathur RB, et al.
Source: NANOSCALE RESEARCH LETTERS Volume: 3 Issue: 11 Pages: 444-453 Published: NOV 2008

Substrate atom enriched carbon nanostructures fabricated by focused electron beam induced deposition
Author(s): Tripathi SK, Shukla N, Kulkarni VN
Source: NANOTECHNOLOGY Volume: 19 Issue: 46 Article Number: 465302 Published: NOV 19 2008

INUP update

V. Venkataraman

The Indian Nanoelectronics Users Program (INUP) has been launched by the Centers of Excellence in Nanoelectronics at IISc and IIT-B with generous support from the Ministry for Communications and Information Technology (MCIT). The main purpose of this program is to create awareness among the scientific community about the advanced semiconductor processing and characterization facilities established by MCIT at the IISc and IITB Centers (*see* Vol. 3, No. 3, p. 4-5). Under this program, research students, teachers and scientists from academic institutions, industry, and government R&D establishments will be educated and trained to use these facilities for their research work. This program originated during the discussions that preceded the establishment of the Nanoelectronics Centers at the two institutions. In order to expand nanoelectronics research in the country as well as utilize sophisticated equipment more efficiently, both MCIT and IISc/IITB were convinced about the need for a program aimed at spreading awareness and training a large pool of researchers across the country. The idea further crystallized during a discussion meeting held in April 2007 at the Indian Institute of Science where nearly 100 potential users in the Indian nanoelectronics community presented their views (*see* Vol. 2, No. 3, p. 1). A draft proposal was prepared that was further revised in consultation with MCIT. The final INUP proposal was approved for funding and the program officially began in October 2008.

Over the next few years, IISc and IITB will announce a series of awareness workshops and training programmes. INUP envisages three levels of interaction with external users. At the most basic level, about 50 participants per year will be exposed to the facilities available at the Nanoelectronics Centers through one- or two-day awareness workshops. Depending on their background and involvement, about 20 of these participants will be given intensive one or two weeks of hands-on training to use the processing and characterization tools. At the most advanced level, trained users can submit short-term (four to six months) collaborative research proposals to the Centers for supporting the fabrication of a complete device, for example, a MEMS-based sensor or actuator. A limited number of such proposals, depending on their merit and feasibility, will be selected by the INUP committee for support. Information about the facilities and expertise available at the IISc and IITB Centers are available on their websites which is periodically updated as more facilities are added. Some common facilities such as photolithography, direct laser writing, electron beam lithography, thin film deposition and etching, electrical and optical characterization, and others will be available at both the Centers.

A unique aspect of INUP is the pattern of funding. It has been recognized that a primary impediment for potential users from smaller academic institutions and research centers is the paucity of funds. To mitigate this problem, INUP will support travel and local hospitality for all participants who do not have alternate sources of funding. Furthermore, the cost of training selected participants in terms of equipment time, operator time, consumables, spare parts, etc., will be borne by INUP. Finally INUP will also support the cost of executing the short-term collaborative projects initiated by academic and government institutions.

Professor V. Venkataraman is in the Physics department at the Indian Institute of Science. He can be reached at venki@physics.iisc.ernet.in.

Industry participation is most welcome on a shared cost basis.

Further information is available at www.nano.iisc.ernet.in/inup.htm and www.ee.iitb.ac.in/~nanoe/inup.html.

Continued from p. 4...

Passive Damping Characterization of Parabolic Composite Reflectors with Hybrid PZT-Coated Layers
Author (s): B.S. Munjal, H.V. Trivedi and P.V.B.A.S. Sarma
Source: JOURNAL OF INTELLIGENT MATERIAL SYSTEMS AND STRUCTURES, Volume: 19, Issue: 11, Pages: 1281-1294, Published: 2008

Low-temperature wet-release process for low stiffness structures
Author (s): Jaibir Sharma and Amitava DasGupta
Source: INTERNATIONAL JOURNAL ON MICRO/NANOLITHOGRAPHY, MEMS, AND MOEMS, Volume: 7, Article Number: 043007 Published: 2008

Extraction of Young's modulus and residual stress of structural materials through measurement of pull-in voltage and off-capacitance of beams
Author (s): Jaibir Sharma and Amitava DasGupta
Source: INTERNATIONAL JOURNAL ON MICRO/NANOLITHOGRAPHY, MEMS, AND MOEMS
Volume: 7 Article Number: 043020 Published: 2008

MEMS Orchestra by IISc in NIT-K

Rudra Pratap

In the afternoon of a typical workday at the Indian Institute of Science, a few members of the research team at the CranesSci MEMS Lab were sitting at the lunch table indulging in the usual lunch-time chat. On my way out for lunch, I happened to stop by and join them. Somehow the discussion turned to organising a much delayed picnic of the entire research group. Ideas about having a picnic at some beach appealed to everyone. In the meantime, I got a phone call from the National Institute of Technology-Karnataka (NIT-K), Surathkal, to give a talk in a workshop organized for faculty members of engineering schools in the area. I had been wishing to visit NIT-K for the last eight years but could not manage a visit. One of the students sitting at the lunch table, Abhay, happened to be an alumnus of NIT-K who had joined our lab recently. He lost no time in connecting the invitation from NIT-K to the possibility of having a lab outing on the beach. He proposed to organize the whole trip and we readily agreed, in principle, to go to NIT-K, Surathkal.

That night, as I went to bed thinking about the proceedings of the day, an idea struck me—an idea of a unique experiment. I thought of the MEMS activities at NIT-K and the enthusiasm of both the students and faculty of NIT-K that we have seen over the last couple of years about working in the area of MEMS. At IISc, we had organized a couple of workshops on MEMS in which students as well as faculty from NIT-K had participated. We also saw the result of this interaction in terms of expanding MEMS activities at NIT-K. The time seemed just right for a focussed workshop at the NIT-K campus for the energetic undergraduate students. The idea of a workshop conducted by all the research students of the lab seemed like a win-win proposition—a good opportunity for research students to talk about their research and their experience in a semi-formal environment, and an opportunity for undergraduate students to listen to and interact with young researchers they could easily relate to. If it went right, they could easily ask questions to these presenters, which would otherwise remain unasked due to intimidation if the presenter were to be a professor. I proposed the idea to my students the next day—one complete day of hard work at the workshop and the next day of complete fun at the beach! It wasn't hard to sell this idea. I rang up Professor Umesh of NIT-K who graciously agreed to host the entire team. The workshop was to be held on August 23rd, 2008, a Saturday. It could not have been any better; the following day was ideal for fun and frolic in and around Surathkal.

Our team comprised of 14 members, a mix of PhD and Masters students along with a couple of professional engineers and project staff. We took the overnight train from Bangalore to Mangalore. This train journey along the Western Ghats was a perfect beginning to a memorable journey. As the morning light broke out, I heard excited voices from my group members—someone calling out for me, waking me up and inviting me to come down from my upper berth and see what I was missing. As I looked out of the window, my pupils (no pun intended) just dilated to soak in the panaromic painting of Nature. The splendid green cover in the valleys and on the slopes of the magnificent hills, the low cloud covers providing a contrast of white and grey with the surrounding greens, the occasional appearance of gorgeous gorges playing hide and seek with us as the train chugged along the serpentine track with 50 or so tunnels on the way. The landscape was so enchanting that it reminded me of my graduate school days at Cornell University located on a hill-top in the beautiful surroundings of the Finger Lakes area of the state of New York. I secretly wished to see a university set up on one of these hills in the Western Ghats.

On Saturday morning, most team members started their day by strolling on the beautiful beach that belongs to NIT-K! The day started with inspirations from the Arabian Sea. We quickly got ready and marched to the workshop venue where approximately 40 bright undergraduates from various branches of engineering awaited our arrival. All those students had registered for the workshop on their own. It was a MEMS Workshop organized under the Technical Education Quality Improvement Programme (TEQIP).

We had organized our presentations in three broad categories: Design and Simulation; Fabrication and Testing; and Electronic Interface and System Integration. We had a few talks in each category. Some of the talks were on general methodology that we use in the lab and some were focussed on specific applications. It was heartening to see that the audience got completely involved in the talks and several rounds of discussions took place. I had given very clear instructions to my team that they should present things based on their work experience and not things that are available in books or on the internet. They followed the script and it worked really well. Students got the first-hand account from the foot-soldiers and were not hesitant to ask for the gory details.

There were three talks on MEMS design. Each talk concentrated on a particular MEMS device and discussed the details of the design. A MEMS microphone, a MEMS ultrasound transducer, and a MEMS gas sensor were discussed in fair detail and the required analysis was presented at a level that was accessible to the participants of the workshop. The presenters encouraged students to interrupt

Babar Ahmad discussing the details of an ultrasound MEMS device design.

Professor Rudra Pratap is in the Mechanical Engineering department at the Indian Institute of Science. He can be reached at pratap@mecheng.iisc.ernet.in.

and ask questions. They also presented a couple of slides on advanced analysis and told the students that although it looked complicated, it was not that hard once they learnt the basic tools. These talks were followed by a deeper research oriented topic of energy dissipation and damping at various length scales. This talk covered both micro and nano devices and brought out the need for a new area of investigation—multiscale modelling. Of course, damping in MEMS devices is something that my research group has investigated very vigorously over the last six years.

A free-flowing discussion at lunch.

One of the professional engineers in the group gave a talk on fabrication, using most of the designs presented as example structures. This talk was full of first-hand accounts and discussed problems associated with various fabrication processes in a real lab environment. This talk, naturally, invited many questions from students who had no exposure to fabrication at all. Another professional engineer in my research group, in-charge of dynamic characterization of MEMS devices, gave a detailed talk on this topic, covering the fundamentals of laser vibrometry, micro-motion analyser, in-plane and out-of-plane dynamic measurements, and experimental extraction of several structural parameters. With that we broke for lunch providing a perfect setting for a free and informal discussion between the presenters and listeners.

After lunch, it was time for electronics integration that was covered very well by another professional engineer who talked about low-level signal measurements, noise mitigation and issues with very low capacitance sensing. This talk was followed by a presentation on system integration. The speaker discussed system integration first on an abstract level by defining a system and subsystems as blocks, and then followed it up with a very concrete example—a MEMS-based load cell developed in my lab. To round it all up, the last presentation was given by the Administrative Executive of our lab, Ms Manjula, who showed her MBA skills in a holistic presentation on 'management of a MEMS research group'. She has been the pillar of our lab, keeping track of accounts, funding, purchase, hiring, and public relations. It was indeed engaging to see what all it takes to run a modern lab successfully. The session was wrapped up by comments from NITK faculty members, Prof. Umesh and Prof. Desai, who had made this workshop possible.

A session in progress at the workshop.

The reward after the work: the picnic.

At the end, I personally felt incredibly good about the workshop. As an observer in the audience, I realized that this workshop was a lot more useful than we had imagined. The sheer breadth of coverage and the interplay among the presentations was something that will be very hard to find in a workshop pitched at the level of undergraduate students. It was to me a MEMS orchestra of my own and I was overwhelmed at the success of this unrehearsed piece of music.

Professor Umesh of NITK recently informed me that there are at least 10 undergraduate students this year who have signed up to take up MEMS projects. We would like to think that we had a small part–perhaps a very small part–to play in their decision to pursue MEMS.

Acknowledgments: I thank Prof. H. Saha from Jadavpur University for encouraging me to write about this unique experiment and submit to *Sukshma*.

Accomplishments

M.M. Nayak
mmnayak@gmail.com

Semi-conductor Laboratory, SAS Nagar near Chandigarh

Semi-Conductor Laboratory (SCL, which was formerly known as Semiconductor Complex Limited that was established in 1983) is now a Society under the Department of Space, Govt. of India, with the main objective to undertake, aid, promote, guide and coordinate Research & Development in the field of semiconductor technology, microelectromechnaical systems (MEMS) and process technologies relating to semiconductor processing.

SCL, through its in-house R&D efforts has developed 3 micron, 2 micron, 1.2 micron and 0.8 micron CMOS technologies as well as specialized technologies such as EEPROM and CCD. SCL has over the years developed and supplied a number of key VLSIs, majority of which have been Application Specific Integrated Circuits (ASICs) of high reliability for industrial applications.

The vision of SCL is to

- create a strong R&D base and transform SCL as a centre of excellence in the country.
- meet the microelectronics requirement of the strategic sector
- design and develope of devices in the cutting edge technology
- manufacture VLSI and MEMS based systems and subsystems.

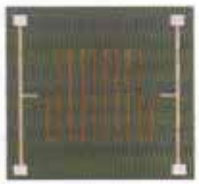
SCL has a state-of-the-art manufacturing facility for producing MEMS devices in 6" wafer size and has the capability of designing, fabricating, packaging and testing. The design activities are taken up for the development of RF MEMS, temperature sensor, piezoresistive pressure sensor, etc. Designers work closely with process engineers and produce production-ready designs.

Built with the state-of-the-art MEMS Technology, SCL's silicon pressure sensors offer a better performance, reliability and repeatability over the conventional electro-mechanical sensors. These pressure sensors have high sensitivity, wide pressure range, linear response, small size, and rugged packaging. The Sensors are available in various pressure ranges and packaging options for use in a variety of applications (see below). SCL's MEMS temperature sensor, SCT01, uses thin film platinum as the sensing element. Its small size provides a response time of less than 1 s and can measure in the range of - 90°C to + 55°C. It is available in CoB package which is directly mountable in electronics circuits. This sensor is useful in many applications in the fields of industrial automation, automotive electronics, medical electronics, weather measurement, climate control, etc. SCL is also engaged in the development of many other MEMS products including flow sensors, RF MEMS, shock tubes, etc. For details, please contact director@sclchd.co.in.

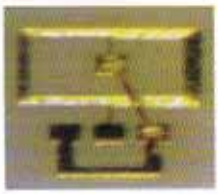
	SCP01	SCP02	SCP03	SCP04	SCP11	SCP12
Application	Digital pressure gauges, pressure transmitters, automotive, industrial automation, medical applications.	Digital pressure gauges, digital tyre pressure gauge/inflators, general gauge pressure applications.	Digital pressure gauges, pressure transmitters, industrial automation, medical applications.	Digital pressure gauges, pressure transmitters, automotive, industrial automation, medical applications.	Digital pressure gauges, pressure transmitters, industrial automation, medical applications.	Digital pressure gauges, pressure transmitters, industrial automation, medical applications.
Pressure Range	0-10 Bar	0-10 Bar	0-1 Bar	0-10 Bar	0-1 Bar	0-1 Bar
Type	Absolute, Gauge, Differential.	Absolute, Gauge.	Absolute, Gauge.	Absolute, Gauge.	Absolute, Gauge, Differential.	Absolute, Gauge.
Package	 TO-8	 Nozzle	 4.5mm Tube inlet with Grip Nut	 ¼ NPT Thread Male	 TO-8	 ¼ NPT Thread Male

Specifications subject to change owing to continuous improvement.

MEMS-based pressure sensors developed by SCL. Typical input excitation of these sensor variants is 3 V DC / 1.5 mA. They have a full scale output of 30 mV (SCP03, SCP11, and SCP12) and 240 mV (SCP01, SCP02, SCP11). The offset is typically 35 mV. The nonlinearity and hysteresis are both less than 1%. Overload and burst pressures are at 2X and 3X respectively.



Temperature sensor



Spiral inductor

Packaged flow sensor

SCL's some more MEMS products

Campus Buzz

C. RoyChaudhuri

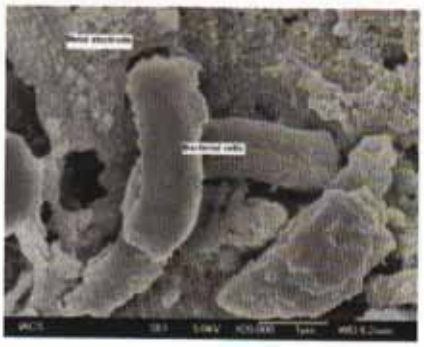
Micro and Nano Bytes from BESU, Shibpur

Bengal Engineering and Science University (BESU), Shibpur, is a budding university. Its department of Electronics and Telecommunication Engineering (ETCE) is recently engaged in a number of research activities related to micro and nano sensor development in collaboration with other departments of the University as well as with other institutions. The major activities are listed below.

Electrical Detection of Bacteria by Simple and Cost-effective Microcellular Trapping Channel Platform

The objective of this work is to develop a simple and cost effective electrical platform for low-level bacteria detection in food and human analytes. The commercially available techniques for bacteria detection are time-consuming and suffer from low resolution. Electrical technique based on impedance measurement that changes after bacteria-absorption is presently considered to be the most efficient and reliable technique by the *Association of Analytical Communities*.

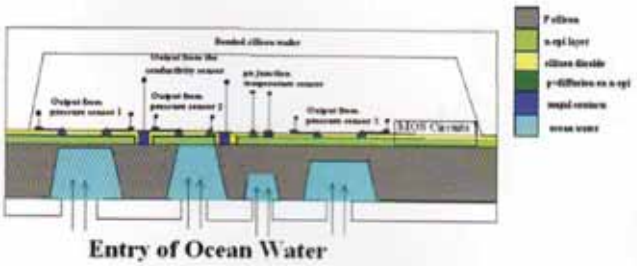
We are in the process of developing a novel low-cost and field-deployable electrical platform of macroporous silicon for detection of bacteria using impedance measurement. Macroporous silicon which is formed by electrochemical etching of silicon in hydrofluoric acid (HF) and dimethylformamide (DMF) solution results in the formation of regular array of pores of 1-2 μm diameter. These pores act as microcellular trapping medium for capturing the bacteria. The porous structure is oxidized for ensuring electrical insulation of the metal contacts from the underlying silicon substrate followed by silanisation and specific antibody-coating for target bacteria. The preliminary reports show that a 2 mm by 1 mm electrode structure with a spacing of 1 mm, was able to detect down to 10^3-10^7 colony-forming units per milli litre (CFU/ml) of *Salmonella Typhimurium* using this microcellular trapping medium at a significantly lower processing cost. This detection is comparable to more sophisticated impedance measurement. The work has started from 2007 with a Department of Science and Technology's (DST), Sensor and Instrumentation Committee project. Prof. A.Mondal of the Department of Chemistry and Prof. N.R. Bandopadhyay in School of Materials Science and Engineering of our University actively participate in this project. There are also external collaborators in this project, namely, Prof. H. Saha of IC Center at Jadavpur University (*see* Vol. 2, No. 3) and Dr. S. Das of the Indian Institute of Chemcial Biology, Kolkata.



SEM of trapped Salmonella Typhimurium cells in macroporous silicon.

Silicon MEMS Based CTD Sensor for Oceanographic Applications

The primary objective of this work is to develop miniaturized, integrated MEMS-based conductivity-temperature-depth (CTD) sensor for continuous and reliable monitoring of ocean water. The existing sensor systems are bulky and have to be coupled with separate data loggers since they lack the advantage of miniaturization through circuit integration. In this project, we design a piezoresistive pressure sensor array with separate bulk-micromachined diaphragms of different dimensions on the same substrate for sensing a wide range of pressure with improved resolution and linearity. Initial results of the multiple diaphragm pressure sensor shows a resolution of 0.05 mbar measurement of water pressure. The temperature sensor will be designed by using a p-n junction temperature sensor. The p-n junction will be fabricated on a micromachined membrane to minimize the thermal mass and improve the speed of response. The conductivity sensor can be realized on silicon by observing the change in the impedance between the two metal contacts deposited on the p type substrate on two sides of a membrane.



A MEMS-based conductivity-temperature-depth (CTD) sensor.

The work has started from February 2008 as a design project sanctioned by Naval Physical and Oceanographic Laboratory (NPOL), DRDO, Govt. of India.

A new DST-sanctioned project on nanocrystalline zinc oxide based gas sensor entitled "Development of Silicon MEMS Based atmospheric monitoring system in underground coal mines" will be starting soon under Dr. P. Bhattacharya of Dept of ETCE and Prof. H. Saha of Jadavpur University.

In addition to these, ETCE department along with the School of VLSI of this University is actively involved in the chip design project through the SMDP II project. The group publishes a number of articles in reputed international journals and conference proceedings.

Professor C. RoyChaudhuri is in the Electronics and Telecommunication Engineering department at Bengal Engineering and Science University. She can be reached at chirosreepram@yahoo.com.

IUTAM Symposium 2008

B. Dattaguru
datguru@gmail.com

International Union for Theoretical & Applied Mechanics (IUTAM) symposium on "Multi-Functional Material Structures & Systems" was held at the Indian Institute of Science (IISc) between December 10-12, 2008. The symposium was organized by Profs. B. Dattaguru and S. Gopalakrishnan from the Department of Aerospace Engineering as Chair and Co-chair. Dr. V.K. Aatre, former Scientific Advisor to Defence Minister, Govt. of India and currently Visiting Professor, IISc was the chairman of the International Steering Committee. The venue for the symposium was Satish Dhawan Auditorium, IISc. The symposium organizing committee invited 70-80 scientists from around the world to present their work. 52 Abstracts (31 from outside India and 21 from India) were accepted. There was an enthusiastic participation from local academic institutions, research laboratories, and industries.

The inaugural session was chaired by Dr. V.K. Aatre and the symposium was inaugurated by Prof. N. Balakrishnan, Associate Director, IISc. Dr. Aatre has been responsible in enthusing Scientists in India in the past decade to work in this area and develop technology of sensors and structural health monitoring through National Programs NPSM and NPMaSS. He and Prof. Balakrishnan held the first SPIE International Conference in India on Smart Materials & Structures in 1996 and it was nice to see them both inaugurate this symposium. The session-wise topics covered in the symposium included multifunctional material systems, nano-materials and composites, shape memory alloys, computational methods, functionally graded materials, smart sensors and structural health monitoring, new materials and applications. The symposium showcased the research areas and applications to practical problems in this newly emerging field.

The symposium was sponsored by IUTAM, Indian National Academy of Sciences (INSA), Institute of Smart Structures and Systems (ISSS) and Aeronautics R&D Board (ARDB).

Faculty Development Programme on MEMS
at Karpagam College of Engineering, Coimbatore.

Muniraj Rajagopal
njmuniraj@yahoo.com

A three-day Faculty Development Programme on MEMS was conducted by the Electronics and Communication Engineering department of Karpagam Engineering College in Coimbatore from 26th to 28th December, 2008. It was sponsored by ISSS and National Programme on Micro and Smart Systems (NP-MaSS). About 50 participants from different colleges in and around Coimbatore attended. They represented a broad range of institutions in the public as well as the private sector and brought to the conference a valuable mix of experiences and perspectives. The topics discussed in the programme included: Overview of micro and smart systems (Dr. V.K. Aatre), microfabrication (Prof. K.N. Bhat), MOEMS (Prof. T. Srinivas), MEMS packaging (Dr. K. Natarajan), scaling issues and inertial sensors (Prof. G.K. Ananthasuresh), bio-MEMS (Mr. Chandrashekhar), aerospace applications of MEMS (Dr. K. Vijayaraju), RF MEMS and electronic interfaces for MEMS (Prof. Navakanta Bhat). The speakers were from the Indian Institute of Science, Bangalore, ADA, BEL, and BigTec. There was also a hands-on demonstration of MEMS CAD software by BigTec. At the end of the programme, Professor Navakanta Bhat and Dr. K.Vijayaraju described a two-week hands-on training programme that will be conducted in CEERI, Pilani, Rajasthan, under the sponsorship of NP-MaSS. It was noted that the participants of this programme will not be charged for taking part in this hands-on training programme.

Book Review

Comprehensive Microsystems Vol. 1 - 3

G.K. Ananthasuresh
suresh@mecheng.iisc.ernet.in

Comprehensive Microsystems, Vol. 1 - 3.

Elsevier, Amsterdam.
ISBN: 978-0-444-52194-1
Price: US$ 1,750 as published online.

Editors-in-chief:
Yogesh Gianchandani, Osamu Tabata, Hans Zappe

Vol. 1: Materials, Fabrication and Packaging, and System Design.
Vol. 2: Actuation Mechanism, Physical Sensing, and Chemical and Biological Systems
Vol. 3: Optical Systems, Industrial Applications, Emerging Topics, and Index.

The microsystems technology, or microelectromechanical systems (MEMS) as it is widely known, is a field that is here to stay. This area of research began in 1970s in academic and industrial research labs in the United States of America, got recognition as a field in its own right in late 1980s, grew exponentially since then, and has given rise several products in the market today. Capturing all these advances surely warrants a comprehensive treatment of this multi-disciplinary subject. To that end, the three-volume "Comprehensive Microsystems" is a commendable effort as it covers a wide range of topics.

The content of the three volumes is arranged in such a way that a novice can begin with the first chapter in the first volume and move on while an experienced microsystems engineer or a researcher can look up a specific chapter for an in-depth discussion. The chapters related to materials illustrate this point very well. The first chapter begins with the crystal structure and properties and processing of silicon and its compounds—ideal for a novice. The subsequent chapters describe the same for metals and polymers as well as such advanced issues as materials for biocompatibility and for harsh environment—a great resource for an experienced reader. Microfabrication related chapters too start off with the basics and move onto the state-of-the-art up to self-assembly and practical issues such as packaging and low-cost MEMS technologies. Also included in the first volume are detailed descriptions of circuits, simulation, design, testing, and calibration. In this sense, the first volume is a comprehensive account of what can be called "the principles of microsystems".

The second and third volumes cover a number of applications of MEMS. The chapters on actuation are justifiably limited to electrostatic, magnetic, and thermal effects. In this sense, this book is not thought of as a grab-basket for every micro-actuation that is out there; instead, it focuses on three widely used actuations and does a good job of it. Similarly, the sensors and systems chosen for the second and third volumes are the ones that have shown or show commercial potential. The five chapters included in 'industrial applications' section are particularly good because this is the information that is not easily available in research publications. In keeping with the current trends in the field, the last few chapters cover such emerging areas/markets as MEMS atomic clocks, oscillators, fuel-cells, tissue engineering, and molecular machines.

One can of course think of a few important topics that should have been covered in this book. The microsystems field is ever-expanding and what is important and what is not is decided in due course. So, the editors have used their discretion in selecting the topics for inclusion. It appears that this book is meant to be a reference resource rather than as an educational aide. Consequently, the focus is on 'knowledge inclusion' and not on analytical thinking. Therefore, it is hard to imagine its use in a class-room setting. It is also true that by reading a chapter in this book, a reader cannot become an expert in designing that component or system. The book informs the reader on what has been done rather than what could be done if one follows a systematic approach. Such a systematic approach, I think, emerges slowly in a field. Simulation and design are still in their infancy in this field. 'Principles', if any, of microsystems technology are yet to be enunciated.

A refreshing change in this MEMS book is the thoroughness with which each topic has been dealt with by its contributors. We see MEMS books coming by the dozen lately. Many of them tend to be cursory compilations of "others' work" and lack insights. As one reads this book, it becomes apparent to the readers that each contributor is an expert on that topic and has the first-hand knowledge of the subject matter. The three editors, 22 distinguished members who served on the editorial board, and its more than 110 contributing authors are to be complimented for their efforts in bringing this book for the benefit of the microsystems researchers around the world. A downside to this book is that the set of the three books carries a heavy price tag and is beyond the affordable limit of most individuals. Hence, it is suitable for acquisition by libraries of the institutions that want to promote microsystems research and education in their organisations.

Have you come across a new book in the areas of micro, nano, and smart systems? Read it up, write a book review, and send it to sukshma@mecheng.iisc.ernet.in with a copy to suresh@mecheng.iisc.ernet.in.

S Ū K S H M A
Institute of Smart Structures and Systems
Department of Aerospace Engineering
Indian Institute of Science
Bangalore - 560012
India