·|| SUKSHMA ||·

A newsletter about micro and smart systems in India

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Micro & Smart Systems Course for VTU

K.J. Vinoy

ISSS, in association with the Indian Institute of Science (IISc), recently organized a two-week course on Smart and Micro Systems Technologies for 66 undergraduate students from various engineering colleges affiliated to the Vishveswaraiah Technological University (VTU), Belgaum. The workshop was held from January 29th to February 9th, 2007, at IISc. This was one of the highlight events of ISSS and was a natural follow-up of the series of workshops ISSS conducted for the teaching faculty of these colleges (see p. 6 Sukshma Vol. 1., No. 1, Oct. 2006). The lectures in this course were given by five IISc Professors G.K. Ananthasuresh, K.N. Bhat, S. Gopalakrishnan, S. Mohan, and K.J. Vinoy. The course began with an inspiring talk by Dr. V.K. Aatre who was instrumental in this initiative by ISSS. Other lectures included Introduction to Micro and Smart Systems, Concepts of several Microsensors and Devices, Scaling Issues in Microsystems, a Review of Strength of Materials, Control Theory, Electronics for Microsensors and Actuators, Microfabrication Technologies, Finite Element Analysis, Modeling of Microsystems, Materials and their Processing, Smart Systems and Devices, Vibration Control, and Integration and Packaging of Microsystems.

Given that the audience consisted of students of different undergraduate disciplines (e.g., mechanical engineering, electronics and communications, and instrumentation) brief overviews of some fundamental topics (which are not usually taught in all the engineering discplines) were included in this course. One of the highlights of this course was a visit to the VLSI facility at Society for Integrated Circuit Technology and Applied Research (SITAR), Bangalore. The cooperation from Dr. P.V.S. Subramanyam and his team in this regard was exemplary. The students also visited various IISc laboratories and facilities. IntelliSuite, the software for the design of such systems was also introduced to the students by a team of engineers from BigTec (*see* p.3). As this course was organized almost one year after the first of the workshops for the VTU teachers, ISSS got ample time for fine-tuning the lectures and the course materials. For example, a book on Smart and Micro Systems Technologies (under preparation by an ISSS team) was used for this course. Feedback from the students will be used for improving the contents of the proposed book. Incidentally, this book will be the main textbook for a proposed course that will be introduced after approvals by VTU's Boards of Studies for regular engineering streams of final year students.

Undergraduate students of the VTU from several Bangalore engineering colleges in a lecture hall of IISc. The lectures were lively as stduents freely interacted with the instructors.

All the instructors of this program felt that the student participation was outstanding during this program. This had a cumulative effect on the overall productivity of the course. As an experiment, two objective type examinations were conducted during this course and the overall performance was good. Mr. Christy Alen Becker Nandan of M.V.J. College of Engineering and Mr. Srinivasa Tantri of R.N.S. Institute of Technology topped the class and were given special gifts from ISSS. Apart from the reading material prepared by the ISSS team, all participating students were given a copy of the book "Introduction to MEMS" by TaiRan Tsu.

The final session of the workshop was attended by several personnel from VTU including the Vice Chancellor Dr. Balaveera Reddy and the Registrar Dr. E.S. Shivakumar. Both were highly appreciative of the efforts of ISSS in introducing this new course for VTU students. Several students were asked to speak about their experiences during this course. The general feedback was positive and useful. The students suggested that the first-year general course on mechanical engineering, which is taken by all branches, should contain some of the background required for an interdisciplinary course such as this. Students' comments on the parts of the book that were made available to them at the time of workshop are being considered seriously by the ISSS/IISc team.

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The closing ceremony. From right to left: Prof. S. Mohan (President of ISSS), Dr. Balaveera Reddy (Vice Chancellor of VTU), Prof. V.K. Aatre, and Dr. E.S. Shivakumar (Registrar of VTU). Prof. Mohan signs the books given to all the students while Prof. Aatre speaks to the students.

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".

I take this opportunity to thank the members of the Executive Council as the current team has completed its term by the end of March 2007. During the last two years, ISSS continued to work closely with the National Program on Smart materials (NPSM) to fulfill its goals listed below.

* Human resources development
* Organization of conferences and workshops
* Quarterly newsletter "SUKSHMA"
* Release of monographs
* Interaction with industry
* Membership drive
* Website creation
* Forum B-Fast
* Chapter formation

Creation of a website and release of the quarterly newsletter are the major achievements of this committee. The ISSS activities have reached a large cross section of people through these two modes.

Thanks to the vision and support of Dr. V.K. Aatre, the founder president of ISSS, and Prof. K. Balaveera Reddy, the Vice-Chancellor of Vishveshwaraiah Technological University (VTU), a large number of VTU faculty and students have been introduced to the exciting area of microsystems and smart materials and systems by ISSS, IISc faculty, and scientists from BEL and NAL. I thank all those who helped in this effort, and in particular, Dr. G.K. Ananthasuresh and Dr. K.J. Vinoy without whose help this effort would not have been a success.

The International Conference organized under the leadership of Dr. A.R. Upadhya, Vice President of ISSS, in July 2005 was a major success. This event was held at J. N. Tata Auditorium, Indian Institute of Science, Bangalore. About 400 delegates from national and international universities and research labs from ten countries participated in the conference. Prof. C N R Rao, Scientific Advisor to the Prime Minister of India delivered the inagural address. The three days of the conference had 8 plenary talks, 30 invited talks and over 100 contributed papers, which were presented in five parallel sessions. The conference was preceded by two single day workshops: (i) An introduction to MEMS conducted by Prof. Apte of IIT Mumbai, Dr. P. Nagasayanu of BEL, and Mr. M.K. Mathur of SCL, (ii) "Bio-MEMS" by Prof. V. K. Varadan of University of Arkansas, USA and Dr. Sang Choi of NASA Langley. Both the workshops were attended by about 100 active scientists.

The committee decided to have annual conferences and it was held at Research Centre Imarat (RCI), Hyderabad, with a specific focal theme in 2006 (*see* Vol. 2, No. 1, p1). In this conference, ISSS honored four distinguished scientists/engineers, namely Dr. V. K. Aatre, the Founder President of ISSS, Prof. B Dattaguru, the Second President of ISSS, Dr. Kota Harinarayana, the former Programme Director of ADA, and Shri K. V. S. S. Prasada Rao, Former Director of RCI. They were honoured for their significant contributions to the smart technology in our country. The decisions taken in the conference to network groups working on specific devices to form consortia have taken off: the first one on RF MEMS is leading to the development of RF devices.

For the first time, ISSS will have its presence abroad by participating in a conference at Harbin, China, during July 2007.

The interaction with industry is not moving at the expected pace, but efforts in this direction are underway. Dr. V. K. Aatre and I are trying to motivate the electronics and information technology (IT) industries to come together by organizing a conference in July 2007. This conference aims to network industries towards the objective of designing and fabricating MEMS based subsystems for automotive applications.

I am happy to announce that the Hyderabad Chapter of ISSS was inaugurated by Dr. P. Rama Rao on December 1, 2006. This inauguration coincided with the inauguration of the first National Conference on Smart Structures and Systems (ISSS-MEMS-2006). The chapter has currently 29 active life members of ISSS.

Prof. S. Gopalakrishnan's contributions in organizing the records and accounts of ISSS, and in coordinating all of its activities deserves special appreciation. Through this message I once again thank all the members of ISSS for giving the outgoing Committee the opportunity to serve ISSS. We wish our successors all the best.

In spite of initiating many new activities and continuing the existing programmes, the Committee has not been very successful in its membership drive. It requires special efforts to mobilise support from the corporate sector and industries. I hope and wish that our successors will be able to realize this goal.

To become an ISSS member, download:
http://www.isss.org.in/membership.html
and send the form with 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)
Payable to "ISSS, Bangalore".

Industry Watch: bigtec

Rudra Pratap

Bigtec is a growing company that is increasingly focusing on bio-MEMS. It was founded in 2000 with broad ideas of developing technologies for bio-medical applications. However, if you happen to visit its website (www.bigtec.org), you are not likely to get any inkling of this effort from the information provided there. Most of the information on the website is about their other business on SAP implementation and training. However, from inside, it is a technology incubator that is trying to bridge the gap between the technology ideas and marketable products in its chosen arena. It is currently involved in the development of prototype bio-MEMS (*see* Vol. 2, No. 1, pp. 4-5) devices and in their validation through clinical trials. The current strength of the company is 135 with expertise in the areas of biology, MEMS and Information Technology.

For both survival and growth, Bigtec provides comprehensive solutions and services for the Micro ElectroMechanical Systems (MEMS) technology sector in India. They have partnered with IntelliSense Software, USA, to provide reliable, real-world, high quality MEMS-specific solutions to their clients in India and Australia. Bigtec leverages its expertise in this field by offering the MEMS specific design tool, IntelliSuite. This popular CAD software is designed to be user-friendly to the diverse group of users who are interested in exploring MEMS design, analysis, and fabrication. It has excellent built-in tools for reducing the need for costly iterations in the design process. Bigtec's expert team, comprising of people with cross-domain expertise in this highly interdisciplinary area of technology, lends support to the MEMS design activities at Bigtec.

Watch for...

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

While Bigtec's IT team works closely with many educational institutions for IntelliSuite promotion and training, its technology team focuses on working very closely with a few select players for technology development. Bigtec is currently collaborating with IISc Bangalore, C-MET Pune, RRL Jammu, and IIT Madras on bio-MEMS projects that are at various stages of development. Although they are not willing to discuss yet the products they are working on, it is heartening to know that they are focused on bio-MEMS.

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Leaders of ISSS

Born on 8 July 1947, Dr. Vikram Kumar did his B.Sc. and M.Sc. (Physics) from the Allahabad University (1965 and 1967, respectively), and M.S. (Elec. Engg). and Ph.D (Elect. Engg.) from Lehigh University, USA, (1971 and 1976, respectively). He served as a Lecturer (1977-82), Assistant Professor (1982-87) and Associate Professor (1987-92) at the Indian Institute of Science, Bangalore, and as the Director of Solid State Physics Laboratory (SSPL) (1992-2003). Dr. Vikram Kumar served as a visiting professor in the Department of Physics, IIT-Delhi, during 1998-2000 and as an INAE Visiting Professor in the Department of ECE, IISc. He has published more than 140 papers in journals and delivered numerous invited talks. He has guided 15 Ph.D. and 11 M.Tech. theses. He is currently the director of National Physical Laboratory (NPL).

Dr. Vikram Kumar is well known in the area of semiconductor materials characterization and device technology. He has worked extensively towards the understanding of electronic defects and interface states in Silicon III-V and II-VI semiconductors. He has made noteworthy contributions towards the development of semiconductor crystals and device technology in India. As a faculty member of the Indian Institute of Science, he had set up world-class facilities for experimental research in semiconductor physics. He received the prestigious Shanti Swarup Bhatnagar Prize in Physical Sciences for the year 1992 in recognition of his scientific contributions towards understanding of deep level defects in semiconductors. He also received the Materials Research Society of India (MRSI) Medal in the same year.

As the Director of SSPL, Dr. Vikram Kumar contributed towards the technology of materials and devices, some of which have reached production stage. He led the team for setting up a GaAs Enabling Technology Centre (GAETEC) foundry for pilot level fabrication of monolithic microwave integrated circuits (MMIC) that has supplied devices to various users. The technology, which utilizes 0.7 micron gate ion implanted MOSFET, was entirely developed at SSPL. Furthermore, 0.5 micron pseudomorphic High Electron Mobility Transistor (HEMT) devices using strained layer AlGaAs/InGaAs/GaAs structures were demonstrated. His team developed the technology for growing single crystals of CdZnTe and GaAs and supplied device quality wafers to users. The CdZnTe technology was transferred to a production agency. The technology for the Long Wave Infrared (LWIR) photoconductive detector array was demonstrated. Several micro electro mechanical systems (MEMS) devices were fabricated in his laboratory at SSPL. He has played a major role in starting the National Programme on Smart Materials, and as chairman of the committee responsible for development of devices, guided the development of MEMS devices in the country. Recently, Dr. Kumar is actively working in the area of polymer electronics. At NPL he has initiated programmes on silicon and polymer based solar cells. Under his guidance, NPL has completed the requirements of the International des Poids et Mesures (CIPM) Mutual Recognition Arrangement. He is playing a key role nationally in nanotechnology as the chairman of the Working Group on Nanotechnology for the Department of Information Technology.

Dr. Vikram Kumar is a fellow of the National Academy of Sciences (NAS) and Institution of Electronics and Telecommunications Engineers (IETE), and a member of several professional societies including MRS (USA), MRSI, IPA, ISTE, SSI, ISSS, APAM, SSD, MSI and ISOI. He has been the president of IWPSD (1997, 1999, 2001, 2005), SSD and Electronic Materials Group of MRSI. He is currently the President of ISOI, MSI and SSI. Other prestigious positions held by him include membership of the Science and Engineering Research Council of DST for 2004-07, Steering Committee on Nano-Science and Technology Initiative of DST, Board of Directors, SCL, Chandigarh (for a few years); Board of Directors, CEL, Sahibabad; Governing Council of C MET, Pune; and Research Council, NPL (for a few years); and Editorial Boards of Bulletin of Materials Science, J. IETE, IETE Tech Reviews, and Indian Journal of Engineering and Materials Sciences. He is currently a member of the Executive Council for the Asia Pacific Metrology Programme (APMP) and the Chairman for the Developing Economies Committee of APMP.

Dr. Vikram Kumar was the President of ISSS for 2003-05. All the members of ISSS express their sincere thanks to him for his contributions to this society and to the micro and nano technologies.

Microfabricated RF Components

K.J. Vinoy and S. Pamidighantam

The market for wireless personal communication devices has expanded so dramatically in the last two decades that the focus of research in the microwave and millimeter wave areas has shifted towards consumer applications from the traditional defense related products. Accordingly, the production volume has increased manifold, and the power handling capacity required in these systems has reduced considerably. These developments paved the way for increased application of microfabricated components including micro-electro-mechanical systems (MEMS) in many current and future microwave and millimeter wave systems. Apart from having the advantages with bulk production and being miniaturized, these can often lead to more efficient systems, compared to the conventional ones.

The need for micromachining and MEMS based components in radio frequency (RF) and microwave systems arise from the inherent limitations of the existing architectures. A communication system shown in Fig. 1 can very well represent a typical microwave system. Although the functions may be slightly different, many of these blocks can also be found in a radar, or any other similar military system. The motivation for incorporating MEMS based fabrication technologies in the microwave and millimeter wave systems is threefold.

First, as the frequency increases, the size of the microwave components becomes small. Thus, for millimeter wave systems, it is imperative that dimensions of most of the components are in the sub-millimeter range. This calls for *high-precision fabrication technologies*. MEMS and micromachining offer a viable route in such cases. The supplementary advantage of this approach is in *system-integration capabilities*. These micromachining based techniques are preferred for frequencies above 30 GHz for the fabrication of components such as filters, directional couplers, etc.

Second, at lower frequencies (wavelength of the order of 1 to 2 cm) efforts have been made towards implementing micromachining techniques to *reduce the effective dielectric constant* of the microstrip substrates. One major disadvantage of using silicon substrates for microstrip antennas is the reduced radiation efficiency due to its high dielectric constant. However innovative means of reducing the effective dielectric constant of the substrate by etching an array of holes, and bulk micromachining have been reported in the literature. This approach not only improves the radiation efficiency of the antenna, but also increases the bandwidth.

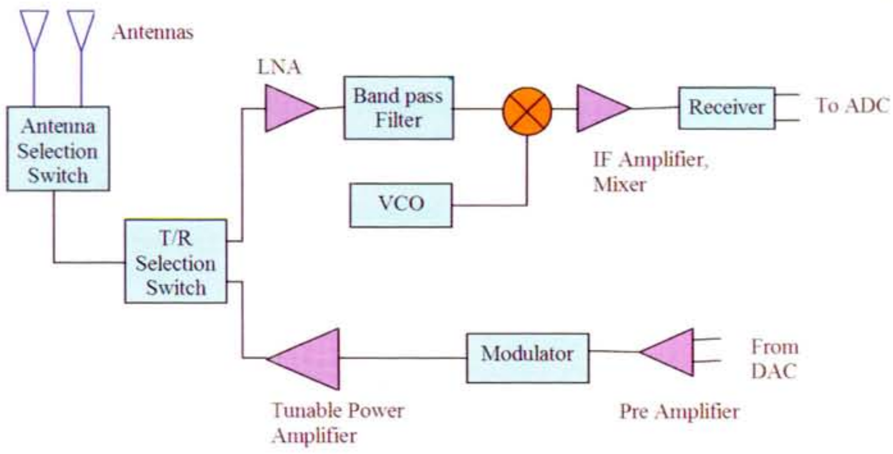

Fig. 1. Simplified block diagram of a super heterodyne transceiver. Most of these blocks can incorporate components fabricated with micromachining-based technologies to reduce size and improve efficiency.

Many MEMS based microwave components are aimed at *reducing the insertion loss and increasing the bandwidth* (*see* the boxes on the next page). This third aspect is valid for surface micromachined devices such as RF switches and inductors. Conventional RF switching systems such as PIN (p-type intrinsic n-type) diodes are very inefficient at higher frequencies. MEMS based RF switches with very low actuation voltages have been reported recently. Although distributed components can be used at microwave frequencies for realizing inductances and capacitors, these are limited to very small bandwidths. Lumped components are therefore preferred for wideband systems. MEMS based inductors and tunable capacitors also lead to the additional feature of integration compatibility. Similarly, micromachined or MEMS based phase shifters can replace existing configurations, which tend to be lossy at high GHz frequencies. It may also be noted that recent advances in micro fabrication technologies help realize high Q micro mechanical filters for frequencies up to 10 MHz, and SAW filters up to 2 GHz. A new area of research has emerged based on these developments, and is generally called RF MEMS. Several new books are presently available on the topic (*see* Suggested Reading box).

Compared with commercial applications, defense requirements are in general more stringent, especially with environmental factors, system life time, and fault tolerance. Proper packaging approaches would address the first aspect to a great extent. MEMS based component are very small; hence, multiple components can be used to introduce fault tolerance. Furthermore, these are produced in bulk and hence are inexpensive. It is an important factor which could offset their relatively shorter life time.

Bulk and surface micromaching techniques including deep reactive ion etching (DRIE) have been used to make RF components. The advancement of the fabrication technologies is the key to the success in the field of micromachined RF systems.

Suggested Reading

1) G.M. Rebeiz, RF MEMS: Theory, Design, and Technology Wiley Interscience, New York, 2002.

2) V.K. Varadan, K. J. Vinoy, and K. A. Jose, RF MEMS & Their Applications, John Wiley, London, 2002

3) H.J. De Los Santos, RF MEMS Circuit Design for Wireless Communications, Artech House, Boston, 2002.

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Figures of merit for RF components

Return Loss (S11): RF power returned back by the device when the switch is ON.
Insertion Loss (S21): RF power dissipated in the device. The power losses may be due to resistive losses, contact loss or skin depth effect.
Isolation (S21): Isolation between input and output when the switch is in the OFF position This is caused by capacitive coupling or surface leakage.
Quality Factor: Ratio of the energy stored in a device to the energy dissipated in a resonant cycle.
Power handling: The RF power the switch can transmit without damaging itself.
Switching Speed: Transition time between ON and OFF states of the switch.
Resonant frequency: The frequency at which the device resonates. This determines the maximum rate at which the switch can be toggled. However, in general, this does not affect the frequency of the signal carried through the switch.
Physical size: The overall size of the device, often constrained by the area requirements, and its effect on the resonant frequency.
Integration Compatibility: MEMS switches can replace solid state switches only if they are compatible with the IC technology.
Life time: Represented as number of ON/OFF cycles the switch can go through before failing due to structural damage, or breakdown. Typically life-time of MEMS components is of the order of hundreds of millions of cycles.

Some micromachined RF components

Antennas: As the frequency increases, the size of the antenna reduces to that of the features realizable with microfrabrication technologies. An additional advantage of a micromachined antenna is its low power consumption making it attractive for satellite applications. Metal-coated polysilicon and pure metal-to metal contacts to construct two- and three-dimensional reconfigurable radiation and wave guiding structures on the surface of devices allows the waves to propagate and be controlled in the air. The emerging monolithic millimeter-wave integrated circuit (MMIC) technology favors planar structures as antennas so that these can be integrated with the associated circuitry.

Transmission Lines: The intrinsic limitations of transmission line structures implemented on Si, GaAs, or InP substrates are overcome through the use of selective removal of material near the transmission lines through the use of bulk micromachining. The advantages of micromachined transmission lines over standard planar transmission line techniques are minimized radiation and dispersion and amenability for integration with other silicon microwave ICs.

Phase shifters: These are used to adjust the relative phase between the elements in an antenna array. At least three different configurations of MEMS based phase shifters are available in the literature. The first is based on sections of transmission line with different path lengths, with MEMS switches between them. By proper choice of switch positions, one can obtain a stepwise variation of phase at the output side. The second is a distributed array of switch capacitances realized with beams periodically placed over a transmission line. The position of the beam changes the capacitance, and thus the phase. The third approach makes use of the phase of the reflected signal on the transmitted signal, with transmission lines of different lengths connected through a Lange coupler in the main line. These have low insertion loss compared with most of the existing configurations, and hence should be preferred for frequencies in Kurtz-under (Ku) band (12-18 GHz) and above.

RF Switches: One of the earliest applications of MEMS technology for microwave applications has been in the area of surface micromachined actuators for the realization of switches with high linearity, low dc standby power, and low insertion loss. The switch design is based on singly- or doubly-supported beams, with electrostatic attraction employed as the mechanism to pull the switch into position (*see* Fig. 2). Such switches can be designed for standard transmission line impedance of 50 Ohms for a broad range of frequencies and nearly as an open/short circuit when there is no connection. Both the cantilever and bridge switches can be designed for less than 1 dB loss from dc to 50 GHz in the ON state of the switch. Apart from electrostatic actuation, other schemes such as thermal and magnetic have also been attempted.

Lumped and Variable Components: Another use of MEMS technology for RF applications is in the area of variable capacitors in lieu of varactor diodes for tuning. Lateral capacitance variation and the parallel-plate capacitance variation are used to reach this goal. The capacitance variation of this structure is over 3:1 making it attractive for wide-band tuning of monolithic voltage controlled oscillators. The measured quality factor is over 30 at 2 GHz. Micromachined igh quality lumped inductors have also been used in RF applications.

Micro Mechanical Filters: High Q filters are widely used in most of the communication systems and in radars. Bulk mechanical filters are common for very low frequencies. Their principles have recently been translated to smaller devices at higher frequencies. These micro devices can be used for frequencies up to 10s of MHz, and can have quality factor (*see* the box above) in 1000s with proper packaging.

Planar Filters: Microwave and millimeter wave planar filters on thin dielectric membrane show low loss, and are suitable for low cost, compact, high performance MMICs. These tunable filters use micromachined cantilever type variable capacitors. By applying a dc bias voltage on these cantilevers, the electrostatic force between the plates increases which pulls the plates closer, resulting in an increase in capacitance. Fabrication limitations restrict the extension of micro mechanical filters for frequencies above 100 MHz. However, SAW filters and resonators can bridge this gap and provide high Q devices for frequencies up to 2 GHz. These planar devices can be accurately fabricated with modern microfabrication facilities.

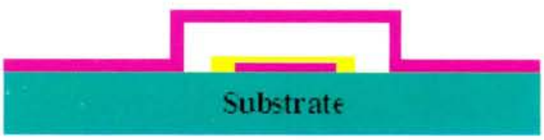

Fig. 2. Two simplified schematics of RF switches

University Buzz: Microsystems@VIT

Lazar Mathew

The Vellore Institute of Technology (VIT) has set up a Micro Electro Mechanical Systems (MEMS) design laboratory primarily for conducting hands-on computational classes for M.Tech. students undergoing courses in the area of Sensor Systems Technology, Mechatronics, Biomedical Engineering, Nanotechnology, and Automotive Electronics. The software available in this laboratory includes: Coventorware (ver. 2006 with Architect, Designer, Analyzer modules for microsystems simulation), Intellisuite (ver. 5.1 for microsystems simulations), ANSYS (ver. 10 for finite element analysis and multi-physics simulation), OptiFDTD (ver 5, a modeling software for photonic bandgap structures), Mentor Graphics (VLSI software), Lab VIEW–8, Ptolemy and Kelper. A team of faculty members (one associate professor, one assistant professor and two lecturers) are specially trained in the above software programs to not only instruct students but also to supervise minor projects at the post-graduate level.

Some of the MEMS projects undertaken at VIT include: micromachined components for sensing humidity, blood glucose, pressure, etc., and devices such as cochlear implants and gyroscopes. The cantilever structure and its capacitive sensing action in a humidity sensor were analysed using Coventorware software. As part of a BioMEMS initiative, a blood glucose sensor was designed by the VIT students and faculty. This design consisted of a reservoir and two electrodes, one a Platinum electrode and the other Silver or Silver Chloride electrode. It uses the capacitive sensing principle to detect the concentration of glucose in the blood. Noting that micromachined cochlear implants can drastically reduce the size and cost, the VIT team has undertaken an effort to model and design cantilever-based cochlear sensor. A gas pressure sensor concept based on PVDF films was investigated. A micromachined gyroscope is another project that was pursued by this team.

The VIT's MEMS research team also conducts sponsored research. For example, a project in the area of Micro Opto Electro Mechanical Systems (MOEMS) is funded by Vikram Sarabhai Space Centre (VSSC) under the RESPOND program. The objective of this ongoing project is to develop a computer aided design and modeling software platform for MOEMS based sensors. An open source framework, called Ptolemy, is utilized in this effort.

VIT's several departments have commenced doctoral programs some of which focus on the MEMS related topics. An experimental lab for testing devices and for demonstrating the MEMS concepts is also set up.

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Vellore Institute of Technology (VIT), located in Vellore in Tamilnadu and known previously as Vellore Engineering College, became a deemed university in 2001. It comprises seven schools offering 17 undergraduate and 28 post graduate programmes. It also offers research programmes leading to M.Phil and Ph.D degrees. It has 400 fulltime faculty members, about 600 administrative staff and about 10,000 students. According to the website of this Institute, "international linkages established by the institute help the students to get global education and training locally and if needed globally also". Additional information can be found at: www.vit.ac.in.

Conference Announcements

SPIE Europe Microtechnologies for the New Millennium 2007, May 2-4, 2007, Gran Canaria, Spain. www.spie.org/conferences/programs/07/emt/

International Conference on Smart Materials and Nanotechnology in Engineering, July 1-4, 2007, Harbin, China. smart.hit.edu.cn/en/frame.htm

10th International Conference on Modeling and Simulation of Microsystems, NSTI Nanotech 2007, May 2007, California, USA. www.nsti.org/nanotech2007/MSM2007/

Smart Structures and Materials, III ECCOMAS Thematic Conference, July, 9-11 2007, Gdansk, Poland. www.imp.gda.pl/ECCOMAS2007/index.html

Within the framework of the IFSA (In-Flight Aircraft Structural Analysis) project, an optical monitoring system has been developed by *Fiber Optic Sensors and Sensing Systems* (FOS&S), Belgium, in co-operation with *Xenics*. The system measures strain and temperature in a distributed way for static and dynamic conditions. The system makes in-flight health monitoring of aircraft structures possible. The system is based on the Fiber Bragg Grating Technology (*see* Vol. 1, No. 1, 2006, p. 5). The first technical objective of the IFSA project is the development of a fibre optical monitoring system that meets the high requirements for structural analysis of aircraft structures. The second and the main objective of the project is the integration of the fibre optic sensor into specified thermo-plastic composite structures of an airplane (*see* figure). This will allow continuous real-time in-flight structural health monitoring resulting in improved safety, design optimization, and reduced maintenance costs. The system can monitor the occurrence and growth of damage in composite elements by monitoring the stress and strain inside the thermo plastic composite structures, which is not possible with the measurement systems available today. The IFSA system will lead to better aircraft performance and in-flight safety, and can substantially advance the scope and scale of future aircraft design. For more information, visit www.fos-s.com.

The composite wing part of A380 built by Airbus is perhaps the largest ever produced aircraft wing for a civil airliner. Its wingspan measures 79.8 m, which is just under the working standard of 80 m to fit in different sections of the airports and runways. The surface area of each wing is 835 m^2. It has more than 25,000 different components and about 7,50,000 fastners!

Accomplishments: CGCRI-Kolkata (Part 2 of 2)

The Sensor and Actuator section of Central Glass and Ceramic Institute (CGCRI), Kolkata, has been actively involved in the development of gas and moisture sensors, and piezoelectric actuators and piezoelectric wafers for a long time. It has successfully developed semiconductor sensors for the detection of methane and carbon monoxide jointly with Central Mining Research Institute (CMRI), Dhanbad. These sensors performed satisfactorily in the mines. Presently, negotiations are underway with potential entrepreneurs for transferring the technology of Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG) leak alarms (including packaging and circuitry) developed at CGCRI (*see* figure). Other than domestic safety, LPG/CNG leakage alarms are going to take a pivotal role in the automobile sector.

LPG leak alarm sensor module along with the package deeveloped at CGCRI

Recently, CGCRI team has developed sulfur dioxide sensors with detection level down to 5 ppm using nanosized powders prepared by sonochemical method. It is also actively pursuing work on low-power MEMS based sensors jointly with CEERI, Pilani. Moisture sensors based on nanoporous alumina have been supplied to Bhabha Atomic Research Centre (BARC), Trombay. These sensors have been performing satisfactorily. A few moisture sensors have also been sold to a private party in UK for their preliminary studies.

Large force generation and stroke, fast response and low operating voltage of multilayered PZT (lead zirconate totanate)-based piezoelectric actuators result in their applications in micro- positioning, vibration cancellation, micro-pumps, etc. Incidentally, PZT wafers are potential candidates for nondestructive evaluation (NDE) of structures in defence, aerospace and industrial sectors, where they can act as both sensors and actuators.

The Sensor and Actuator Section of CGCRI has developed both multilayer piezoelectric actuators and PWAS (Piezoelectric Wafer Active Sensor). The former (*see* the specifications in the table) is almost on par with imported Morgan actuators. Furthermore, the results obtained from NDE studies at IISc, Bangalore, indicate that CGCRI made PZT wafers have excellent sensitivity and are comparable (only 0.3 db less) to conventional imported piezo discs.

Specifications of the multi-layer piezo actuator developed at CGCRI

Sample size: 25 mm x 25 mm x 1.6 mm
Number of layers : 10
Sintered density (in the multilayered form): 96%
Block force: 11 kN
Displacement: 1.6 microns
Excitation voltage: 90 V
Bandwidth (k_p x f_r): 10 kHz (order of magnitude)
d_{33} : 650 pC/N
k_p : 0.61
Dielectric constant: 3,300
Dissipation factor: 0.025
Strength (three point bending): 78-90 MPa
Young's modulus: 47-48 GPa

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The previous issue (Vol. 2, No.1, Jan. 2007) featured the accomplishments of the fibre optics laboratory of CGCRI. This is the second part describing other accomplishments of CGCRI.

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