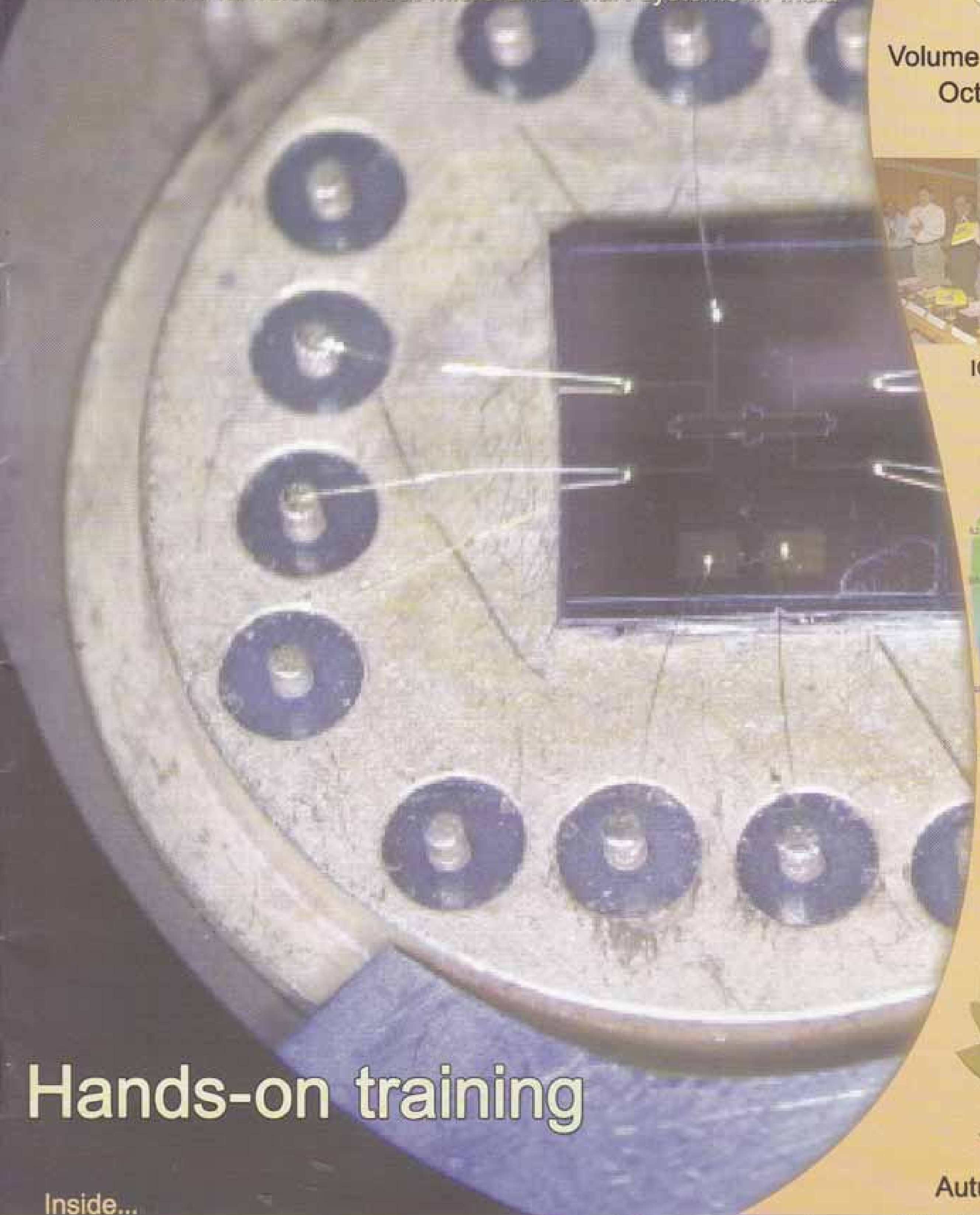
|| SUKSHMA ||

The ISSS newsletter about micro and smart systems in India

Volume 4 : Number 4
October 2009



ICASM-2009

LED Chromaticity

Hands-on training

Autumn Issue

Inside...

To

ISSS Governing Council

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Vice-president: K. Natarajan, BEL
Secretary: K. Vijayaraju, ADA
Treasurer: K.J. Vinoy, IISc
Joint Secretary: Guru Dutt, Bigtec
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J. Gurudutt, bigtec
G.M. Kamath, Tata Adv. Materials
K.J. Vinoy, IISc

Art Design: G. Bharathi

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President's Message

P.D. Mangalgiri
prakash.mangalgiri@gm.com

Friends,

It is with a sense of humility and gratitude that I take over as the President of our Institute of Smart Structures and Systems. I recall the meeting in a small conference room at the ECE department of IISc during the monsoons of 1998 with participation of a handful of interested people led and inspired by Dr. V.K. Aatre which resolved to form this professional body in order to bring together scientists, engineers, technocrats, managers and practitioners working in the smart technology area to promote the growth of this new technology in the country. At that time, there were already a few initiatives being formulated to develop tools and devices of the smart technology. While one stream of activities focused on the development of microsystems and MEMS-based devices, the other stream was looking at various applications at the system level such as structural health monitoring, vibration control and others requiring significant actuation to manipulate mechanical systems. The first international conference in Dec. 1996 at IISc had created not only an awareness of the potential of the smart technology but also brought home the multi-disciplinary nature of the work involved. This also brought about a need to synthesize the two streams of activities. The atmosphere was ripe for the creation of ISSS. Since then, the Institute, diligently and without much fanfare, has been not only growing its membership but also contributing very significantly to the national effort in promoting smart technology. The Institute has been fortunate to have been guided by former Presidents – Prof. B. Dattaguru, Prof. Vikram Kumar, Prof. S. Mohan and Dr. A.R. Upadhya – who have vigorously pursued the goals of the Institute and set course in the right direction in its activities. They continue to be actively involved in the working of the Institute. While I strive to follow in their footsteps, I look forward to their guidance.

Over the decade of its existence, the ISSS has done well and we as its members can take some legitimate pride in the working of the Institute. The series of triennial international conferences that ISSS has been conducting has come to be recognized as a significant event in the smart technology and has seen growing international participation. Our initiative to hold annual national conference is now well set with the success of the first two conferences in Hyderabad and Pilani. We shall now be holding the third national conference in Kolkata in October 2009. The Institute has also taken cognizance of the need to recognize the role played by key individuals in the smart technology area in the country and has instituted a tradition of honouring a few amongst such select individuals at its national conference.

The Institute's participation in the National Programmes in Smart Materials – earlier, NPSM and now NP-MASS – has helped the Institute develop strong bonds with several key institutions and individuals in the smart technology area. Many of our members are playing key roles and form the core of activities in the smart materials work in the country. Specifically, ISSS is working closely with NP-MASS in Human Resource Development in the microsystems and smart materials area. The workshops in the form of short term courses are playing a significant role in not only creating awareness but also in enabling the teachers in the academic institutions to impart training in this new area to their students. ISSS has also taken initiatives towards creating textbooks and laboratory kits.

The growth of ISSS in various geographical areas of the country has led to formation of Chapters of the Institute in various areas. The ISSS now has chapters in Delhi and Hyderabad and we are working towards having Chapters in Coimbatore, Pune, and Kolkata. To facilitate smooth functioning of the Chapters, the Institute formulated and adopted Chapter Bye-laws last year. The Governing Council of the ISSS will continue to provide guidance and support to all the Chapters.

Our newsletter – Sukshma – is doing well and I compliment Prof. G.K. Ananthasuresh and his team for their efforts to bring out the issues of Sukshma on a regular basis with interesting content.

Underlying the achievements of ISSS is the hard work put by several of our members, too numerous to mention here. I appreciate their efforts and thank them all. While much has been done, much more remains to be done. The Institute's efforts need support from all of its members. I take this opportunity to invite all the members to participate vigorously in this great endeavour and help the Institute in achieving its goals. I look forward to your continued cooperation.

AGM Report

S. Gopalakrishnan
krishnan@aero.iisc.ernet.in

The Annual General Meeting (AGM) was held on July 24, 2009 at the KTMD seminar Hall, NAL, Bangalore at 5.00 pm. Nearly 50 members attended the meeting. The Meeting began with technical talks given by Dr. K. Vijayaraju, Project Director, NPMASS, ADA, and Prof. K.N. Bhat, Visiting Professor, Dept. of ECE, IISc. Dr. Vijayaraju spoke about the activities of the National Program on Micro and Smart Systems (NP-MASS), while Prof. Bhat spoke on the nanoelectronics activities of IISc.

The AGM started at around 6:30 PM with secretary's report read by Prof. S. Gopalakrishnan, Secretary, ISSS. In his report, he outlined the activities undertaken by ISSS in 2008-09. The AGM approved the secretary's report with Prof. B. Dattaguru proposing the approval and Dr. T.M. Naidu seconding it.

After the secretary's report, the treasurer's report was presented by the Treasurer of ISSS, Dr. G.M. Kamath, wherein he indicated various income and expenditure details. The questions that were raised during the AGM regarding the budget were answered by the ISSS, Auditor Mr. G. Rangarajan. The AGM approved the treasurer's report with Dr. R.V. Krishnan proposing the approval and Prof. T.S. Ramamurthy and Dr. K. Natarajan seconding it.

The AGM was later addressed by the President, Dr. A.R. Upadhya, wherein he outlined the efforts taken by ISSS in the past two years in promoting the smart technology in the country and he specially complimented the efforts of Dr. V.K. Aatre, the Founder President of ISSS, in enabling the start of a new elective course on Micro & Smart Systems in colleges affiliated to VTU. He later complimented the efforts of the editorial team of Sukshma for printing the newsletters every quarter and rated the magazine as the best he has seen. He thanked all the Governing Council Members and the members of ISSS for extending cooperation and wished the incoming team all the very best.

The President's address was followed by the election of new office bearers for ISSS to handle the society's activities for the next two years. The ISSS Governing Council nominated Prof. B. Dattaguru to conduct the elections. The outgoing committee nominated the following :

Dr. P.D. Mangalgiri, GM-R&D, for President

Dr. K. Natarajan, BEL, for Vice President

Dr. K. Vijayaraju, ADA, for Secretary

Mr. J. Gurudutt, bigtec, for Joint Secretary

Dr. K.J. Vinoy, ECE, IISc, forTreasurer

Prof. B. Dattaguru informed the AGM that the election notice was issued on 23rd June 2009 inviting nominations from the members for the above posts and informed the AGM that no other nominations were received within the stipulated time period. He later invited nominations for all the above posts on the floor of meeting but no nominations were proposed on the floor. He then declared the above people elected for the respective posts unopposed. He then closed the elections.

The election event was followed by an address by the incoming President Dr. P.D. Mangalgiri, who outlined the activities he has planned for the next two years. He urged all the members to make the best effort to increase the membership-base of the Institute. He thanked the outgoing Governing Council members and the former President of ISSS for putting the Institute on solid foundation and vowed to continue their good efforts.

The AGM ended with the formal vote of thanks proposed by Dr. K. Vijayaraju.

ICASM-2009: Conference Report

M. Mahendran
manickam-mahendran@tce.edu

An International Conference on Active/Smart Materials (ICASM-2009) was held at Thiagarajar College of Engineering (TCE) in Madurai from 7th to 9th January, 2009. It was organized by Dr. M. Mahendran, the Department of Physics, TCE and inaugurated by Dr A. Sivathanu Pillai, Chief Controller for Research and Development, Ministry of Defence, Bangalore. Karumuthu T. Kannan, correspondent, TCE, who presided over the function, said that teaching institutions should graduate to the levels of advanced research because "mundane activity of day-to-day teaching alone is not sufficient". Dr. V. Abaikumar, Principal, delivered the welcome address. J.M. Barandiaran, Basque university in Bilbao, Spain, released an abstract book on smart materials at the inaugural function. Dr. M. Mahendran, convener of this conference and associate professor in the department of physics, explained that the international conference aimed at exploring the field of material science. The conference organizing committee invited more than 50 scientists from the reputed institutes around world to present their work. Nearly 400 delegates from many countries participated and presented papers. 350 abstracts were accepted in this conference. The session-wise topics covered in the conference included multifunctional material systems, nano-materials and composites, shape memory alloys, computational methods, smart sensors and structural health monitoring, new materials and applications.

On the third day of the conference, the valedictory address was given by Prof. Dr. S. Kaliappan, vice chancellor, Anna University, Tirunelveli. Lastly, Dr. Y. Kawazoe, professor, institute for materials research, Tohoku University, Japan, and Dr. Madangopal Krishnan, Scientific officer 'H', BARC, Mumbai, gave concluding remarks on the conference. Dr. M. Mahendran gave the vote of thanks. The best awards of the poster/oral presentation were distributed to the selected delegates. The conference showcased the research areas and applications to real-life problems in this recently emerging field.

The conference received overwhelming response from around the globe, as a result, the delegates including the invited speakers suggested that a similar conference be organized again. Therefore, it is planned to organize '2nd International Conference on Active/Smart Materials' in 2011.

Lab Tour

Functional Quantum Structure Lab, IISc; Part 1 of 2

S.B. Krupanidhi
sbk@mrc.iisc.ernet.in

The Functional Quantum Structure lab in the Materials Research Centre at the Indian Institute of Science, Bangalore, runs under the supervision of Prof. S. B. Krupanidhi. The lab was established in 1995. It has contributed nearly 300 research articles in several high-impact peer reviewed international journals to its credit and has produced 15 PhDs and 6 masters graduates. Currently, there are 12 PhD students and two scientists from the Bharath Electronics Limited (BEL) in this lab.

Our main activity is in the development of quantum structures of compound semiconductors and also complex oxides. Quantum structures are configured in both quantum wells and quantum dots while their combinations are used for the device development. A state-of-the-art MBE (Molecular Beam Epitaxy) facility, has been established at MRC for this work.

Quantum Wells-based IR Detectors

Long-wavelength infrared (LWIR) detectors are important in many applications. One major problem with producing LWIR detectors is that they must be made with a material with an energy band gap small enough to allow electrons to be excited from the valence band to the conduction band by the infrared radiation. However, the lowest band gap of the III-V material family is InSb (Eg = 0.174 eV @ 300 K), which corresponds to a wavelength of about 7.1 µm. This makes it impossible to build a long-wavelength (8-14 µm) detector from a bulk III-V material. One way to get around this hurdle is to make use of quantum wells (QWs) grown in the III-V material family. A QW is created when a thin layer of small band gap material (called the well) is sandwiched between materials that have a higher band gap (called barriers). If the well is thin enough and deep enough, then instead of a continuum of allowed states such as those in the conduction band of a bulk semiconductor, a few discrete states are formed in the well. These discrete states can be engineered by adjusting material and growth properties so that the energy distance between them corresponds to the LWIR region. With this motivation, a project on the development of QWIP linear array (8x8) has been launched at MRC, IISc, by collaborating with BEL and successfully demonstrated the IR response in a 8x8 array. With the success accomplished in this project, work was extended to establish the technology of 320 x 256 array QWIP device for the actual use in an IR camera.

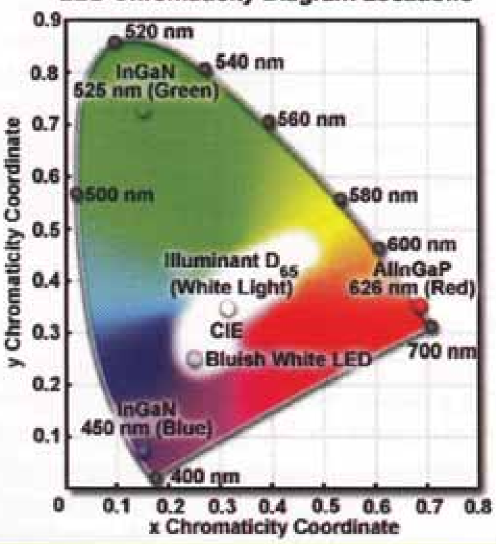
Quantum Dots

Quantum dots (QDs) are formed either by the freely located self aligned fashion or also controlled by either high resolution e-beam lithography or straining the surface of the substrate and/or the wetting layer. A novel approach of organized quantum dots is based on semiconductor QDs grown by MBE in a droplet epitaxy mode. The QDs are formed on the substrate prior to growth using lithography methods. Epitaxial growth on the patterned substrate then yields arrays of QDs, each placed at a different pyramid. The characteristic crystal growth dynamics on such non-planar substrates yields highly uniform QDs with reproducible energy level structure. The fact that each dot is attached to a pyramid directly provides precise control of the position of the dots. Moreover, the structure surrounding each dot grows in such a way that efficient injection of electrons and holes into the dot becomes possible. The special features of this growth method and the resulting QD structures thus provide the essential ingredients for making an efficient solid-state single photon emitter. These QDs may be embedded in a multilayered super-lattice structure of the devices, e.g., single photon emitters and also quantum dot infrared photodetectors (QDIPs).

III-N based LED Technology

Another major research programme launched in the lab is a concerted effort of developing an alternate solid-state lighting for offering green energy by its conservation. The solid state lighting is now well poised to dominate the world market due to the following virtues of the Light Emitting Diodes (LEDs): unprecedented efficacy, extremely low power consumption, wide ranging off grid applications, tuneability of light emission quality for improved human visual experience, long life, stability due to the solid-state, etc. The III-V compound semiconductor based inorganic LEDs have the potential of replacing the conventional incandescent and fluorescent lamps in the near future, with variable color rendering, as shown in the figure below. LED light engines are fully dimmable and can be controlled by something as simple as a switch or as sophisticated as a computer linked via the Internet. Existing lamp technologies simply cannot compete with the huge number of design, control and display possibilities available with LEDs. The potential of fabricating white LEDs with more than 700 lm/watt using the GaN and related alloys offer bright industrial prospects. In contrast, current commercial products use devices that give 30-40 lm/watt. To replace fluorescent tubes (80 lm/watt) and incandescent bulbs (60 lm/watt), a quest is on for reliable and commercially viable LEDs of at least 150 lm/watt. The possible quantum efficiency of GaN, suggests not only the opportunity, but also the need for a synergic effort between science and technology. (More in the second part in Jan., 2010.)

LED Chromaticity Diagram Locations



In the second part...
third generation solar cells and oxide super-lattices

Tools of the Craft
Electron Beam Lithography

K. Sangeeth
sangeeth@ece.iisc.ernet.in

Electron Beam Lithography (EBL) refers to a lithographic process that uses a focused beam of electrons to form the circuit patterns needed for material deposition on (or removal from) the wafer, in contrast with optical lithography, which uses light for the same purpose. Electron lithography offers higher patterning resolution than optical lithography because of the shorter wavelength possessed by the 10-50 keV electrons that it employs.

Given the availability of the technology that allows a small-diameter focused beam of electrons to be scanned over a surface, an EBL system does not need masks to perform its task unlike optical lithography, which uses photo masks to project the patterns. An EBL system simply 'draws' the pattern over the resist wafer using the electron beam as its drawing pen. Thus, EBL systems produce the resist pattern in a 'serial' manner, making it slow as compared with the optical systems.

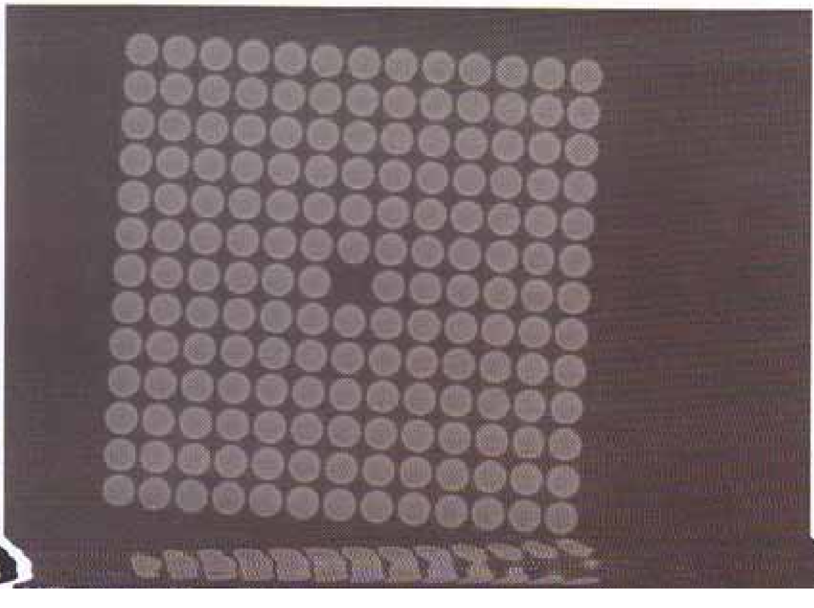
A typical EBL system consists of the following parts: (i) an electron gun or an electron source that supplies the electrons; (ii) an electron column that 'shapes' and focuses the electron beam; (iii) a mechanical stage that positions the wafer under the electron beam; (iv) a wafer handling system that automatically feeds wafers to the system and unloads them after processing; and (v) a computer system that controls the equipment.

Raith e-LiNE is an electron beam lithography tool (Fig. 1) with a 100 mm by 100 mm travel range. It uses thermal field emission filament technology (W/ZrO_2) for lower energy spread and enhanced brightness. It has a laser-interferometer-controlled stage for accurate position addressing. The column voltage varies from 100 eV to 30 keV and the laser stage moves with a precision of 2 nm. There are six apertures on the system: 7.5, 10, 20, 30, 60, and 120 um. The electron beam current is controlled by selecting the appropriate aperture. The system is equipped with a load lock, and an automatic height-sensing. Typically, large-area patterns are divided into small writing fields that are stitched together. The writing fields can vary from 500 nm to 2 mm. The individual fields are written one by one by scanning the beam within the field. The e-LiNE system has 10 MHz DSP-controlled high-speed pattern processor. Finally, three comprehensive software packages for proximity effect corrections, 3-D lithography, and metrology complete the tool.

The specifications of a commercial product, the Raith eLiNE is shown in the table below. The key applications of Raith e LiNE include: nano-scale fabrication by electron beam lithography (Fig. 2); ultra-high resolution, electron-beam imaging, with rotate and tilt module; integrated gas injectors for beam-induced deposition and etching, precise, electron-beam metrology to measure critical dimensions; and electrical testing and sample manipulation by integrated mechanical nano-probes.

Specifications of Raith eLiNE

Filament	Schottky TFE
Beam size	Less than 2 nm @ 20 keV
Beam current range	5 pA - 20 pA
Minimum line width	Less than 20 nm
Import file format	GDSII, DXF, CIF, ASCII, BMP
Detector	Inlens, Everhart Throley (secondary electron detector)
E-beam resists	PMMA 950K, PMMA 495K, EL9, SU8 2002 (negative tone)



Hands-on Training in CEERI (CSIR)-Pilani

The making of a micromachined pressure sensor

Jamil Akhtar
jimmyakhtar@gmail.com

Micro and smart technologies are in the air in many academic institutions in India today. Numerous workshops organised by the ISSS members and others through sponsorship by the National Programme on Smart Materials (NPSM; *see* Vol. 1, No. 1, p. 1) and other programmes have helped in good measure to spread the gospel of the small technologies. Many colleges and universities have design centres to help young students and eager faculty members to get to know this field. This, in most places, until now was limited to computer simulations and design. Hence, the National Programme on Micro and Smart Systems (NP-MASS; *see* Vol. 3, No. 3, p. 1) has begun the next step of giving an opportunity for hands-on training in microfabrication to small groups of MEMS-enthusiasts. This is an account of the first such hands-on training conducted by Central Electronics Engineering Research Institute-Pilani.

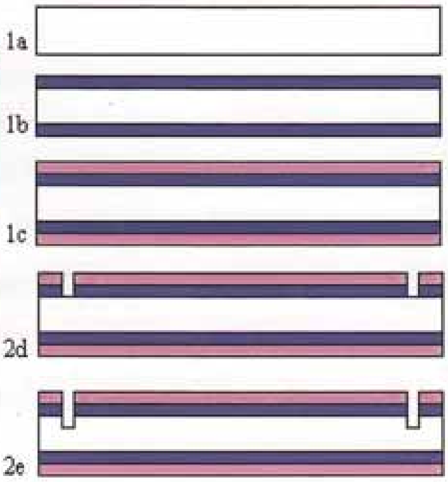
- Editor

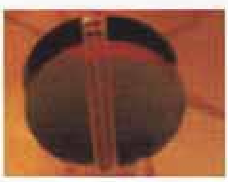
Under the sponsorship of NP-MASS, CEERI (CSIR)-Pilani conducted the first hands-on training programme on MEMS technology in its three-inch facility during May 11-22, 2009. The objective of this programme was to provide an in-depth laboratory exposure and hands-on training on the technological processes of microfabrication. The programme had a specific goal of fabricating a polysilicon piezoresistive pressure sensor on a two-inch diameter silicon wafer, packaging it, and then characterizing it through testing.

The 10-day programme, coordinated by Dr. J. Akhtar, also included technical lectures by Dr. Chandra Shekhar (Director, CEERI-Pilani), Dr. R.K. Nahar, Dr. J. Akhtar (process overview), Dr. G. Eranna (chemical cleaning), Mr. R.N. Soni (photolithography), and Mr. B.C. Joshi (reactive ion ion etching). It also included lab-visits: SEM/EDS and RF-MEMS (Dr. K.J. Rangra), nanotechnology (Mr. A. Kumar), and six-inch MEMS (Dr. V.K. Khanna). We present below

Wafers in a carrier

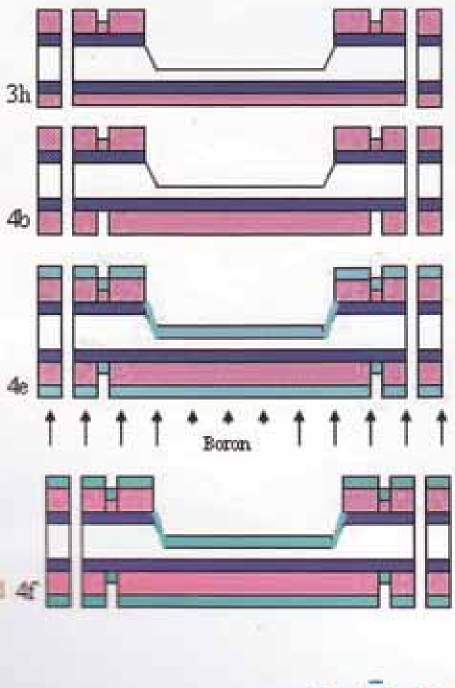
Nitride deposited wafers





Wafers with the grid pattern in the nitride

Wafers with patterned cavities



Day 1

Begin with a two-inch diameter p-type (100) silicon wafer that is polished on both the sides.

1a) Chemical cleaning: degreasing, RCA1, RCA2, Piranha clean followed by HF dip and DI water rinse.

1b) Thermal oxidation: standard thermal oxidation to get 0.5 um thick oxide.

1c) LPCVD Si3N4 deposition: Standard silicon nitride deposition.

Day 2

2a) Photolithography 1: using photoresist S 1813, spin-coat at 4,500 rpm on both sides and pattern.

2b) RIE of Si3N4: delineate the hole pattern in the nitride layer.

2c) BHF etching of SiO2: delineate the hole pattern in SiO2.

2d) Remove the photoresist.

2e) KOH etching 1: etch silicon up to the required diaphragm thickness at the location of the holes.

2f) DI water rinse: rinse thoroughly in de-ionized water.

Day 3

3a) Photolithography 2: Coat S 1813 at 4,500 rpm and pattern the grid.

3b) RIE of Si3N4: etch the grid pattern by partial etching (300 Angstrom).

3c) DI water rinse

3d) Photolithography 3: Pattern to define the cavity.

3e) RIE of Si3N4: delineate the cavity pattern in Si3N4.

3f) BHF etching of SiO2: delineate the cavity pattern in SiO2.

3g) Remove the photoresist.

3h) KOH etching 2: etch silicon to get through holes in the hole pattern.

3i) D I water rinse.

Day 4

4a) Photolithography 4: pattern the grid on the back side.

4b) RIE of Si3N4 to define the grid pattern.

4c) PR removal: remove the photoresist.

4d) DI water rinse.

4e) LPCVD polysilicon deposition up to 1 um thickness.

4f) Boron doping of polysilicon for required sheet resistance.

Hands-on Training in CEERI(CSIR)-Pilani

The making of a micromachined pressure sensor

Jamil Akhtar
jimmyakhtar@gmail.com

Day 5

5a) Photolithography 5: spin-coat and pattern the photoresist for discretisation of polysilicon.
5b) Wet etching to define polysilicon islands.
5c) DI water rinse.
5d) Photolithography 6: spin-coat and pattern photoresist for delineating the polysilicon piezoresistors.
5e) Wet etch polysilicon to realize piezoresistor lines.

Day 6

6a) Metallization: Ti/Au of 300/2000 Angstrom using e-beam evaporation.
6b) Photolithography 7: spin-coat and pattern photoresist for delineating the metal lines.
6c) Wet etch gold and titanium to get metal lines and pads.

Day 7

7a) PECVD: passivate the back side with silicon nitride.
7b) Photolithography 8: Spin-coat and pattern for delineating the pads.
7c) Dry etch PECVD nitride for opening the pads.

Day 8

8a) Coat photoresist and mount for dicing.
8b) Dice the wafer into pieces.

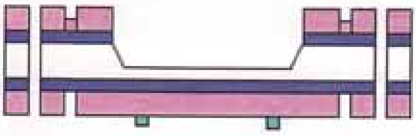
Day 9

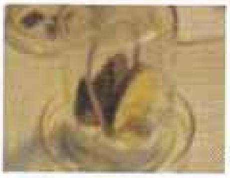
9a) Chip bonding: bond the diced chip to TO-8 header.
9b) Wire-bonding: ball to edge bonding from the chip to the header.

Day 10

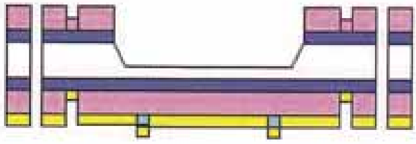
10) Packaging and testing on LabVIEW-based measurement set-up.

5e

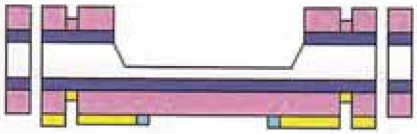




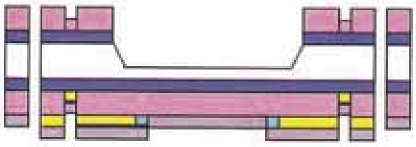
6a



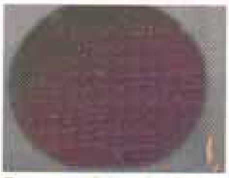
6c



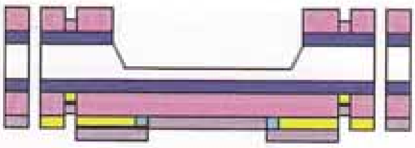
Metal lines



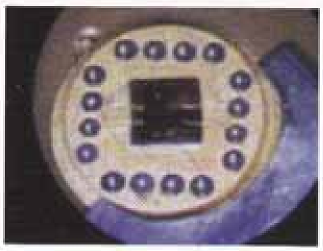
7a



Sensor chips before dicing



7c

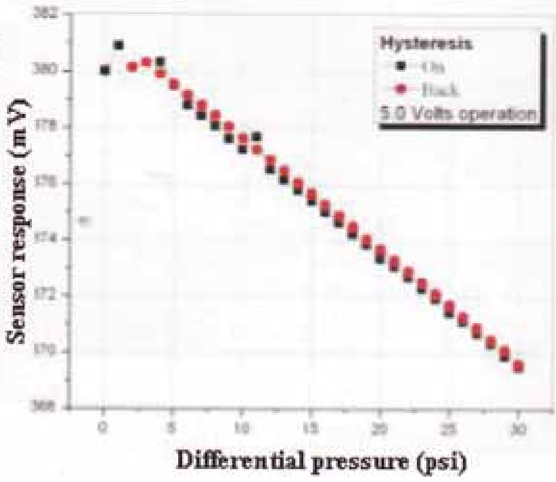


Sensor chip with wire-bonds on a TO-8 header

9b

Ball to wedge bonding.

10 Packaging and testing
Left top: In-house LABView-based test set-up.
Left bottom: Sensor jig for connection in gas line.
Right: Measured performance of the sensor.



The trainees: V.K. Abraham, S.D. Jayavathi, B. Nataraj, V. Ramanatha Prabhu, K.C. Sriharipriya, and K. Thangaraj.
The process team: Surajit Das, Prateek Kothari, Prem Kumar, and Aravind K. Singh.
Head: SNTG: Dr. R.K. Nahar.
Coordinator: Dr. J. Akhtar.
Others in the CEERI team: Jitendra Bhargava, Surajit Das, A.K. Gupta, Sanjeev K. Gupta, B.C. Joshi, Prateek Kothari, Prem Kumar, Satish Kumar, Banwari Lal, Hardwari Lal, Gopi, Negi, B.C. Pathak, R.S. Shekhavat, Aravind K. Singh, and R.N. Soni.

The people
(i) The trainees
(ii) The process team
(iii) The entire group on the last day of training.

Upate **INUP**

Vijay Mishra
vijay.m@ece.iisc.ernet.in

This is another update on the Indian Nanoelectronics Users Programme (INUP) coordinated by the Centers of Excellence in Nanoelectronics (CEN) at Indian Institute of Science, Bangalore, and the Indian Institute of Technology-Bombay. Details about the INUP program can be found at http://www.inup.org.in.

Hands-on training workshop

As part of the INUP activities, a hands-on training program was organized for 12 researchers from all across the country in August 2009 in IISc. The 12 participants were divided into four batches each consisting of three members. Four different modules were assigned to the groups on the lines of their submitted proposals. All four batches went through respective fabrication training modules in parallel. The different fabrication modules designed for this training were: atomic force microscope (AFM) tips, micromachined cantilevers, MOS capacitors and diffused resistors. These devices were fabricated by the participants in association with experienced technologists of CEN at IISc and characterized for exposure to various processes such as RCA cleaning, oxidation, etching, thermal and RF sputtering, and photolithography. Most of the participants were research scholars pursuing their doctoral degree in their respective institutions. Another such hands-on training is scheduled to take place at IISc in December 2009.

INUP also conducts two general awareness workshops every year, one each at IISc and at IITB. Two such 'general awareness' workshops were organized under this program in the first year. More than 250 participants benefited from these.

Research Proposals in INUP-IISc

About 40 short- and medium-term proposals were submitted under this program and some of the approved ones have started the execution of their research at CEN-IISc. These proposals were spread across various domains of micro and nano technologies. About 17% were in nanoelectronics, 25% in materials processing and characterization, 25% in solar cells and sensors, and the remaining 33% in microsystems.

Around 12 short/medium term proposals were approved under this program at IISc-CEN and a few more are under review. Approval process for a submitted proposal is fast: in most cases, it is less than a week. Recently, a research scholar from IIT-Guahati spent more than a month at IISc to successfully fabricate a "hard polymer high aspect ratio structures on SAW resonators". A doctoral student from S.S.N. College of Engineering, Chennai, completed the first phase of "MEMS-based widely tunable photonic band gap filter".

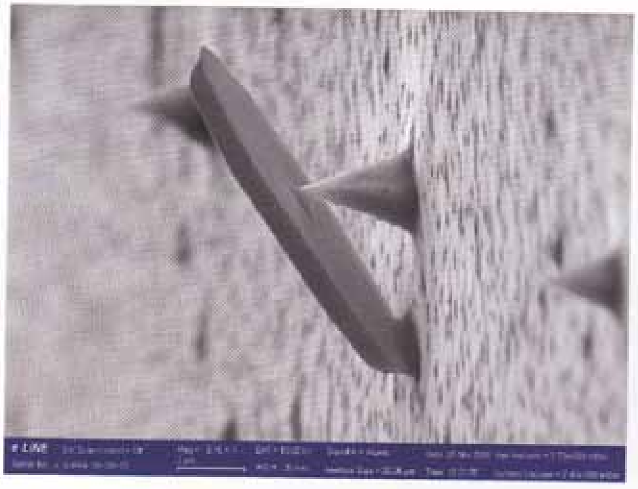


Fig. 1. AFM tips fabricated by the hands-on workshop participants

Fig. 2. Participants with CEN-IISc facility technologist

The third ISSS National Conference
on
MEMS, Smart Structures and Materials

October 14-16, 2009

Venue: Meghnad Saha Auditorium
Central Glass & Ceramic Research Institute (CGCRI)
Kolkata-700032

Organised by CGCRI, Kolkata and IIT-Kharagpur.

Campus Buzz

Micro and Nano Tunes in Thiagarajar College of Engineering

M. Mahendran
manickam-mahendran@tce.edu

Thiagarajar College of Engineering, Madurai, has set up many research laboratories for micro and nano scale research. Some of the activities are described here.

Smart Materials

The smart materials lab in the Department of Physics, Thiagarajar College of Engineering was inaugurated by DST Secretary Dr.T.Ramasamy. In this lab, synthesis of various classes of smart materials and their applications areas investigated. Ferromagnetic Shape Memory Alloys (FSMAs), Ni-Mn-Ga (Smart Materials & Structures, 14, 1-7 (2005); Synthesis & Reactivity In Inorganic, Metal-Organic & Nano-Metal Chemistry, 36, 83-88 (2006)), are known for their higher field induced strain and actuation. These alloys in polymer composites (polyurethane, PU) have potential applications in the areas of actuators and energy absorbers (Applied Physics Letters; Advanced Materials Research, 52, 87-94 (2008)). The mechanical energy absorption analysis in Ni-Mn-Ga/PU polymer composites is in progress. These studies have been carried out using an indigenous acoustic setup specially made for this work. Acoustic energy absorption in Ni-Mn-Ga/PU alloys and composites have been analyzed (see Fig. 1).

The development of FSMA embedded with Magnetorhelogical Fluids (MRF) to study the viscosity of the composites in response to the application of the magnetic field is underway. An investigation on Ferromagnetic Clusters at nano-level using superparamagnetic model has been carried out (Scripta Materialia, 42, 715 (2000); Journal of Physics & Chemistry of Solids, 66, 977-983 (2005)) Active research work is in progress on wide band gap semiconductors like GaN, GaAs, GaAlAs, GaAlN quantum dots and superlattices for the applications of single electron transistor and solar cells (Physica E, 40, 649 (2008)). Presently, Dr. M. Mahendran (manickam-mahendran@tce.edu) and his group are working on the sponsored research projects supported by DST, CSIR, ISRO and DRDO.

Nano-materials

Unique properties of Carbon nanotube (CNT) and other nanostructures (GaN, AlN, BN, ZnO etc.,) are investigated by Dr. V. Gayathri (vgphy@tce.edu) and her group through simulation and analytical methods. The effect of material parameters such as chirality and size of the tube are analyzed on the electrical, electrochemical and electromechanical properties of these nanostructures for the applications in the field of smart systems, hydrogen storage, gas sensors and nanoelectronics. The facilities available are Materials studio, Math lab, Workstation Clusters, Photo acoustic setup. Recent research findings include Strong effect of chirality on doped single walled carbon nanotubes (Physica Scripta, 2009). Semiconductor to metal transition in strictly two dimensions – a comparative study on GaAs and carbon nanotubes (Phase Transitions, 2009). Hydrogen adsorption in defected carbon nanotubes (International Journal of Adsorption, 2007).Thermal properties of the carbon nanotubes (CNTs) and nitride nano materials are being investigated through Photoacoustic technique by the generation of acoustic waves in the presence of pulsed radiation. This research is funded by DRDO, DST, CSIR and MNRE.

Fig. 1. New Experimental Setup to Study Acoustic Attenuation in Ferromagnetic Shape Memory Alloy Polymer Composites

Thin-films

Thin Film Materials Laboratory is carrying out investigations on the synthesis of anode, cathode and dielectric material in powder form for thin film Micro battery application. Development, characterization, integration and testing are carried out by Dr. N. Sankarasubramanian (nssphy@tce.edu) and his group for Lithium ion based thin film micro batteries, micro sensors for gas detection (toxic gases, highly inflammable gases and humidity sensors) and high temperature pressure sensors. Synthesis, characterization and testing have been done on Thermal barrier coatings for heat engine and aerospace applications and on three reinforced metal matrix nano composites for aerospace applications. Preparation and characterization of II-VI semiconducting and TCO thin films for optoelectronic device applications.

RF MEMS

Academic research on MEMS based RF switches on Coplanar waveguide and Elevated Coplanar waveguide platforms were initiated in 2000. Subsequently, a research project on design and development of MEMS based RF phase shifter to work at Ku band was carried out with support from RCI, Hyderabad. The design was customized for fabrication at SCL, Chandigarh. The research group has also focused on MEMS based tunable filter, Micromachined filter for W-band, Dual band mixers for wireless applications. Presently, the group headed by Dr.S.Raju (rajuabhai@tce.edu) is working on meshless numerical methods for the analysis of Micro and Nano structures including nano transmission lines.

Forthcoming Events

Department of Physics organizes National Conference on "Nano Materials for Energy Harvesting" (NaMEH '09) during December 2-4, 2009 (Convener Dr. V. Gayathri; vgphy@tce.edu)

The magnetic society of India and Thiagarajar College of Engineering (Department of Physics) organize National Conference on "Magnetics" during January 20-21, 2010 (Convener Dr. V. Chandrashekaran, DMRL and Co-Convener Dr. M. Mahendran, TCE (manickam-mahendran@tce.edu).

Journal publications by Indian Researchers...

Ranjan Ganguli
ganguli@aero.iisc.ernet.in

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

Title: Performance characteristics of smart-materials based on lead zirconate titanate ; Author(s): Khanna PK, Kumar N, Singh A, Shekhar, C, Jain Y K, Pandey H C; Source: **MATERIALS LETTERS** Volume: **63** Issue: **22** Pages: **1958-1960** Published: **SEP 15 2009**

Title: Vibration and damping characteristics of beams with active constrained layer treatments under parametric variations ; Author(s): Kumar N, Singh SP; Source: **MATERIALS & DESIGN** Volume: **30** Issue: **10** Pages: **4162-4174** Published: **DEC 2009**

Title: Room-temperature gas sensing studies of polyaniline thin films deposited on different substrates; Author(s): Deshpande NG, Gudage YG, Devan RS, Ma YR, Lee YP, Sharma R; Source: **SMART MATERIALS & STRUCTURES** Volume: **18** Issue: **9** Article Number: **095010** Published: **SEP 2009**

Title: TEOS based water repellent silica films obtained by a co-precursor sol-gel method ; Author(s): Latthe SS, Hirashima H, Rao AV; Source: **SMART MATERIALS & STRUCTURES** Volume: **18** Issue: **9** Article Number: **095017** Published: **SEP 2009**

Title: Interaction of the primary anti-symmetric Lamb mode (A(o)) with symmetric delaminations: numerical and experimental studies ; Author(s): Ramadas C, Balasubramaniam K, Joshi M, Krishnamurthy CV; Source: **SMART MATERIALS & STRUCTURES** Volume: **18** Issue: **8** Article Number: **085011** Published: **AUG 2009**

Title: Multi-Objective Optimization of Piezoelectric Actuator Placement for Shape Control of Plates Using Genetic Algorithms ; Author(s): Kudikala R, Kalyanmoy D, Bhattacharya B Source: **JOURNAL OF MECHANICAL DESIGN** Volume: **131** Issue: **9** Article Number: **091007** Published: **SEP 2009**

Title: Assessment of third order smeared and zigzag theories for buckling and vibration of flat angle-ply hybrid piezoelectric panels ; Author(s): Dumir PC, Kumari P, Kapuria S; Source: **COMPOSITE STRUCTURES** Volume: **90** Issue: **3** Pages: **346-362** Published: **OCT 2009**

Title: Review: environmental friendly lead-free piezoelectric materials Author(s): Panda PK Source: **JOURNAL OF MATERIALS SCIENCE** Volume: **44** Issue: **19** Special Issue: **Sp. Iss. SI** Pages: **5049-5062** Published: **OCT 2009**

Title: Nonlinear free vibration of piezoelectric laminated composite plate ; Author(s): Dash P, Singh BN Source: **FINITE ELEMENTS IN ANALYSIS AND DESIGN** Volume: **45** Issue: **10** Pages: **686-694** Published: **AUG 2009**

Title: Active control of geometrically nonlinear vibrations of functionally graded laminated composite plates using piezoelectric fiber reinforced composites Author(s): Panda S, Ray MC Source: **JOURNAL OF SOUND AND VIBRATION** Volume: **325** Issue: **1-2** Pages: **186-205** Published: **AUG 7 2009**

Title: Vibrations of porous piezoelectric ceramic plates ; Author(s): Vashishth AK, Gupta V; Source: **JOURNAL OF SOUND AND VIBRATION** Volume: **325** Issue: **4-5** Pages: **781-797** Published: **SEP 11 2009**

Title: Layer-wise modelling of magneto-electro-elastic plates ; Author(s): Phoenix SS, Satsangi SK, Singh BN; Source: **JOURNAL OF SOUND AND VIBRATION** Volume: **324** Issue: **3-5** Pages: **798-815** Published: **JUL 24 2009**

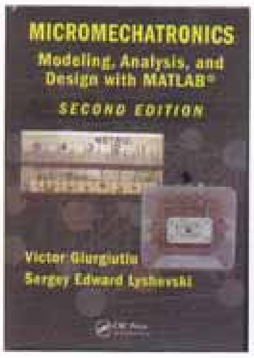
Title: Effect of Mn4+ substitution on thermal, structural, dielectric and impedance properties of lead titanate; Author(s): Shukla A, Choudhary RNP, Thakur AK; Source: **JOURNAL OF MATERIALS SCIENCE-MATERIALS IN ELECTRONICS** Volume: **20** Issue: **8** Pages: **745-755** Published: **AUG 2009**

Book Review

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

Micromechatronics: Modeling, Analysis, and Design with MATLAB, Second Edition

Authors: V. Giurgiutiu and S.E. Lyshevski
CRC Press 2009
ISBN: 978-1-4200-6562-6
Price: US$ 119.95 as published online.



The expectation from printed books is not merely information but also insights and perspectives on the subject matter. In today's information overload, which is abundantly available at our finger tips on the Internet, the bar is higher for the printed books than ever before. Only a few technical and scientific books seem live up to this expectation today. The book by Victor Giurgiutiu and Segey Edward Lyshevski with the title "Micromechatronics: Modelling, Analysis and Design with Matlab" contains information--a lot of it--but does not focus on providing insight into the subject. And hence, it does not differentiate itself from the information that can be found on many a website. A strength of this book, like any other book of this kind, is the systematic organization of the collected information.

The information contained in this book is organized into 13 chapters. Amusingly, in the preface, the authors give a list of 10 courses that they think can be taught using this book. The titles of those courses are synonyms of the titles of the chapters of this book.

Chapter 1, "introduction to mechatronic systems", gives an indication to the readers that there is not much about micro aspects (as in microsystems) in this book. In a lot of words, this chapter says that mechatronics is a subject that integrates mechanical and electronics--nothing new by any means. The second chapter ("electromagnetic and electromechanics fundamentals") sprinkles some well-known equations (including Maxwell's equations and Hamilton's principle) without giving much insight into them. Perhaps, since the title of the book includes Matlab, a few routine problems are cursorily solved using Matlab.

Chapters 3-6 cover electrostatic and electromagnetic actuators, mostly of the macro-scale type, in great detail. Again, the presentation is information-oriented. Power electronics and control are routinely described in Chapters 7 and 8.

In Chapters 9 and 10, the authors extensively describe numerous smart (active) materials and actuators. This information is useful for those who want to quickly know some basic aspects of this topic. Piezoelectric sensors and their applications are painstakingly compiled into more than 170 pages in Chapter 11. More than 150 pages of Chapter 12 amount to a refresher on microcontrollers. The last chapter, "Fundamentals of Microfabrication" is an add-on because the title of the book ostensibly includes the qualifier "micro" for "mechatronics".

Overall, one can see, even in this short book review, that this book is a grab-bag of a number of seemingly related topics. However, it is a reference book using which a few sound bytes about the topics can be quickly garnered.

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ılore - 560012

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