·|| SUKSHMA ||·

A newsletter about micro and smart systems in India

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CONTENTS

INUP Awareness Workshop

S. A. Shivashankar

The Centres of Excellence in Nanoelectronics at IIT-Bombay and IISc-Bangalore, funded by the Ministry of Communication and Information Technology (MCIT), are taking shape. Both will be national laboratories equipped with the capability to fabricate devices with fine geometries, which will be made available to researchers from around the country. To make known the planned capabilities of the two facilities to the potential user community, both from the academia and the industry, and to seek the input of the intended users, a two-day workshop entitled, Indian Nanoelectronics Users' Program (INUP) Awareness Workshop, was held on the IISc campus, Bangalore, on April 9-10, 2007. Researchers active in the field of nanotechnology, nanomaterials, electronic device physics and technology, as well as those intending to enter these fields were invited to participate in the Workshop. It is an encouraging sign that more than 60 participants from around the country attended the Workshop. The significance of the facilities being established was underlined by the fact that the Directors of IIT-B and IISc, as well as Dr. Phadke of the MCIT, were present at the opening session. The Workshop was inaugurated by Prof. P. Balaram, Director, IISc, who pointed out that the IISc was committing significant resources to the program through the funding of a new building to house the fabrication facility. Prof. A. Mishra, Director, IIT-B, noted that a most significant input into such programs was the recruitment and retention of talented researchers, and that it would be very advisable and necessary to make academic positions more remunerative. He also added that a new building will be constructed at IIT-B to house the program, in addition to the space being provided in an existing structure. Dr. Phadke of MCIT outlined the research programs and initiatives that the Ministry intended to support, and pointed out that there would be no dearth of support for well-considered and technically significant proposals.

The opening session was followed by detailed presentations on the facilities being created at IISc and IIT-B. Prof. S. Mohan of IISc described the program evolving at IISc with some 45 faculty members from various departments to be involved in the Centre, which will be housed in a brand-new building measuring 90,000 sq.ft, of which 10,000 sq.ft. will be the clean room fab. Prof. V. Ramgopal Rao described the facility being built at IIT-B, highlighting the participation of researchers from a number of disciplines. He detailed the facilities already available at IIT-B, and noted that IIT-B would be setting up a cluster tool being donated by Applied Materials, Inc of the USA. Both Prof. Mohan and Prof. Rao noted that, in keeping with the proposal made to the MCIT, many of the facilities will be common, and wherever possible, fab tools would be procured from the same vendor. This provides redundancy/backup, apart from providing a better bargaining position with vendors. The teams at IIT-B and IISc are in constant communication and consultation with each other, and will continue to be so, underlined a MoU being signed by IIT-B and IISc in this regard. (*See* a related report on p. 7).

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CSIR Network Program in MEMS

Chandra Shekhar

Council of Scientific and Industrial Research (CSIR) undertook a networked R&D Project (multi-laboratory coordinated R&D project) on MEMS during the 10th Five Year Plan of the government of India. The project involved nine CSIR laboratories (*see* box below), which pooled their expertise in multiple disciplines to achieve common objectives of developing MEMS-based microsensor structures, development of sensing materials including novel nanomaterials, development of prototype sensors for different applications, and their evaluation and characterization.

The MEMS and microsensor platforms developed under the programme include: (a) ISFET: ion-sensitive field-effect transistor, (b) microhotplate device, (c) Micro-channel electrophoretic device, (d) micro-cantilever-based device, and (e) polymer gas sensor device. Utilizing these platforms and specialized materials and techniques developed under the programme, following prototype microsensors have been developed: pH sensor, glucose sensor, triglyceride sensor, potassium and calcium ion sensors (all using ISFET platform), smoke sensor and carbon monoxide sensor (using hybrid microcircuit hotplate), ammonia, hydrogen sulphide and carbon monoxide sensors (using polymer-based gas microsensor), cholesterol biosensor using SPR, dopamine sensor (using micro-channel electrophoretic device including electro-chemical sensing electrodes), methane and LPG sensors (*see* Vol. 2, No. 2, p. 7) using ceramic wire-wound heaters.

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Nine Networked CSIR Laboratories for the Program

1. Central Electronics Engineering Research Institute (CEERI), Pilani.
2. National Physical Laboratory (NPL), Delhi.
3. Indian Institute of Chemical Technology (IICT), Hyderabad.
4. National Chemical Laboratory (NCL), Pune.
5. Central Electro-chemical Research Institute (CECRI), Karaikudi.
6. Regional Research Laboratory (RRL), Bhopal.
7. Centre for Cellular and Molecular Biology (CCMB), Hyderabad.
8. Central Glass and Ceramics Research Institute (CGCRI), Kolkata.
9. Central Mechanical Engineering Research Institute (CMERI), Durgapur.

The programme had a duration of five years ending on March 31, 2007, and a total outlay of Rs.31.71 crores. Under the programme, the MEMS laboratory at CEERI has also been equipped with 6" wafer processing facilities including oxidation and diffusion furnaces, anodic bonding facility, deep reactive ion etching facility, double spindle dicing machine, chem-mech lapping and polishing machine, acoustic imager, surface profiler and gas sensor characterization facilities. These facilities complement the earlier existing facilities of LPCVD, metallization and photolithography to make a complete R&D MEMS laboratory for 6" wafer size.

President's Message

A.R. Upadhya

Dr. A.R. Upadhya is the Director of National Aerospace Laboratorie (NAL), Bangalore. He can be reached at director@css.nal.res.in.

I feel happy and proud to be taking charge as the President of the Institute of Smart Structures and Systems. The out-going Executive Council, under the able leadership of Prof. S. Mohan, visionary guidance from Dr. V .K. Aatre, Founder President, and with the whole-hearted support and cooperation from the members, has done an excellent job of strengthening the society, expanding the scope of its activities to the educational sector (with full support from Dr. K. Balaveera Reddy, the erstwhile Vice Chancellor of VTU), and introducing new elements of communication with the community such as this newsletter "Sukshma" and the website, opening a dialogue with the user industry on MEMS, etc. We need to build on these initiatives and move forward with renewed vigor and commitment to meet the objectives and goals of ISSS.

Thanks to major national initiatives such as NPSM (*s ee*Vol. 1 No. 1, p. 1) and DISMAS, and active and enthusiastic participation of the community in these initiatives, the country has made good progress in this vital and strategically important area. The technology of smart materials, structures and systems, including micro-systems, has matured today to move from R&D in the laboratories to industry specific products such as micro-sensors (pressure, gas, acceleration, RF, vibration, rotational rate, etc.) and piezo and SMA actuators, and applications at a practical level such as Structural Health Monitoring, Vibration and noise control , Shape control, Mechanisms, etc. This opens up new and exciting possibilities in design, particularly in aerospace and bio-medical sectors apart from innumerable applications in automotive, chemical, food, and environment and other sectors. It is practical applications in these sectors that the next phase of the national initiative from the Government, in final stages of consideration and approval, plans to target in the next five years. The strategic and social benefits of such technologies must be exploited to the fullest extent, and ISSS has a major and important role to play here. I am happy to be leading a young (yet tremendously experienced!) and enthusiastic team who are committed to the goals of the society and love their work. Our tasks in the coming two years are clear cut;

(i) *Help in the efficient and effective implementation of national initiatives by active participation in their planning and implementation.*

(ii) *Organizing the next international conference on Smart Materials, Structures and Systems (IC-SMSS 2008) in 2008. I am glad that the Management of Bharat Electronics Ltd., Bangalore, which is a leading institution in the area of microsystems development, has come forward to lead this activity with support from IISc and NAL in their Centenary and Golden Jubilee years respectively.*

(iii) *Expand the base of the society by strengthening the existing chapters at Delhi, Bangalore and Hyderabad and opening more chapters where a nucleus of activity exists; membership drive to be taken up with increased emphasis.*

(iv) *Human Resource Development: build on the already initiated activity with VTU on faculty training and introducing new curriculum on smart and micro systems and help spread the concept to other universities and institutions.*

(v) *Promote interactions with Industry through Industry Federations to spread awareness and increased application of 'Smart' products and technology in their products.*

(vi) *Information Dissemination: Bring out publications such as Monograph on Active Vibration Control and other such publications, Conference proceedings, Continuous Website upgrading, support Newsletter, Organize national level events (workshops, seminars, etc.)*

(vii) *Bring in Nano technology activity into the Society's fold as a logical extension of micro-systems technology*

(viii) *Support out-of-box-thinking and ideas; after all 'smart' is nothing but innovation!*

The Executive Council seeks your support and cooperation in our endeavors. Let us take ISSS to greater heights together.

ISSS News

S. Gopalakrishnan

ISSS Annual General Body Meeting (AGM) for the year 2007 was held on April 5th, 2007 at NAL, Bangalore. The meeting was preceded by three technical talks on some emerging areas in smart technology from three speakers, two from the National Institutes of Technology (NIT) at Trichy and Surethkal, and the third from the IISc. Dr. Umapathy from NIT-Trichy, Dr. Hegde from NIT Surathkal, and Dr. D. Roy Mahapatra from IISc made presentations. This was followed by the AGM, which was presided over by the President of ISSS, Prof. S. Mohan. In his welcome address, Prof. Mohan, highlighted the achievements of the outgoing committee especially, in the area of Human Resource development, resurrection of the newsletter and in increasing the membership. After the presentation of the secretary's and treasurer's reports, AGM elected the new team (*s ee*below under "ISSS Executive Council") to carry on the activities of ISSS for the next two years. The election was conducted by Prof. B. Datatguru, the past president of ISSS. Some new members were also inducted into the Executive Council. After taking over the mantle from Prof. Mohan, Dr. Upadhya placed on record his deep appreciation for the work done by the last committee and emphasized the need to continue some of the activities initiated by the outgoing committee. He spelled out his priorities and vision for the new committee especially in regard to increasing the membership, starting of many local chapters, initiating many new monographs, and also to make a foray into nanotechnology.

Editorial Team

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

ISSS Executive Council

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Members: S. Mohan, J. Gurudutt, G.K. Ananthasuresh, and the presidents of Hyderabad and Delhi chapters

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: Cranes Software Intl. Ltd.

Rudra Pratap

Cranes Software International Limited (CSIL) is a publicly listed company that makes and sells scientific software packages all over the world. With a very humble beginning in the early nineties in Bangalore as a tiny company distributing third party software products such as MATLAB, it now consists of more than 700 people, 15 shrink-wrapped products (including SYSTAT, SigmaPlot, and NISA), and 15 offices worldwide. Naturally, it has been recognized as one of the fastest growing companies in Asia with award winning business process innovations. This, however, is only part of the story. The company is fully committed to research driven innovations and products. In fact, it is surprising to see a company of such small size making commitments for long-term research. But, that is precisely what this company did by establishing the CranesSci MEMS Lab in March 2003, in joint collaboration with the Indian Institute of Science (IISc), Bangalore. CranesSci MEMS lab was conceived as the first such lab in the country in the area of MEMS, funded largely by a private company. With this lab, CSIL embarked upon an ambitious but cautious plan to incubate and nurture micro and nano technologies with a product focus. The chief mandate of the CSIL team working in this area is intellectual property generation for MEMS products and technologies.

From its inception in 2003, the CSIL team's projects at CranesSci MEMS Lab are selected to build competencies required to complete a typical product development process in the MEMS domain. CSIL already holds a joint patent with IISc on a MEMS microphone design. The team is now focused on developing system integration capabilities for MEMS products. In a related development, the lab has built a considerable knowledge base while working on MEMS based load cell for high weight applications. This work allowed the engineers to mesh multiple knowledge and functional domain competencies to overcome numerous engineering challenges in the design and development of a MEMS load cell system. The figure on the left shows the complete integrated module on which characterization has been carried out. In yet another related development, CSIL has created a wireless display system that can be interfaced with MEMS sensors (*see* p. 7 under Technology News).

The CSIL team of engineers enjoy an unprecedented freedom in terms of their pursuit of creative work and innovative ideas. Such initiatives from companies like CSIL have potential of nurturing a whole generation of a new breed of engineers.

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Leaders of ISSS

Dr. Sangineni Mohan, currently a Professor in the Department of Instrumentation, Indian Institute of Science (IISc), is also the Principal Investigator of a major programme, "Centre of Excellence for Nanoelectronics" at IISc, and the Chairman of the Alumni Cell of IISc. He was the Chairman of the Department of Instrumentation in IISc during 1995-97, the Director of Central Scientific Instrument Organisation (CSIO), Chandigarh, during 1997-99, the Chief executive of the Society for Innovation and Development (SID) in IISc during 2001-2006, the President of the Instrument Society of India during 1998-2006, and the President of ISSS during 2005-2007. In these and other capacities, he took exemplary leadership role in initiating numerous new activities and fostering networking among the academia, industry and government R&D organizations.

As the Chief Executive of SID, he has been responsible for not only setting up interaction for IISc faculty with industries in areas such as Information Technology, Biotechnology, Micro and Nano, and Automotive technologies but also networking with various R&D institutions and industries from within the country as well as from abroad. As the Director, CSIO he was responsible for networking CSIO with other R&D institutes, academic institutions, and industries, and executing challenging projects such as Head-up display for light combat Aircraft (LCA). He was also responsible for transferring technologies developed at CSIO to various industries. As the co-chairman of core group of automotive research (CAR), he is playing an active role in bringing academia, industry and resource persons from abroad together and preparing a status report for the future of transport industry in India. The successes of this activity has resulted in his interaction with the machine tool industry, which needs innovation for its survival. As the President of ISSS, he helped expand the activity in the area of Microelectromechanical Systems (MEMS) in the country and foster international collaboration, and help start MEMS industry in India. As a member of Instrumentation committee formed by INSA, he has contributed to a report that gave a vision for R&D in instrumentation activity in the country. His leadership has helped spread the instrumentation culture in the country.

Professor Mohan's accomplishments in research compete with his successes in leadership and networking. He has been working in the area of thin-film technology for almost four decades. Novel methods of thin film deposition, modeling of thin film growth, process parameter–property–structure correlation, and fabrication of multilayer thin film devices are some of the highlights of his research. This work has enabled him to get into the Round Robin of Optical Society of America on TiO_2 coatings in 1985. He continued to be an active participant in the Laser Damage Annual Symposia held at Boulder, Colorado, USA. During the period 1985-1992 he was closely interacting with Air Force Weapons Laboratory, Albuquerque. He has handled a number of challenging R&D projects on the development of thin film synthesis techniques and devices. His major contribution to defence is the development of Head-Up Display System For Light Combat Aircraft (LCA) for which his group has been awarded CSIR Technology award by the Honorable Prime Minister. He was a Visiting Professor at Forschung Centrum, Julich, Germany (1990), Pennsylvania State University (1994), RMIT, Melbourne (1998) and University of Arkansas (2005-06).

Professor Mohan has also contributed to technical education in the country. As a member of the vision committee of Visweshwaraiah Technological University (VTU) he is helping VTU set up a centre of excellence in Bangalore in the Society model to bring the multinational companies to impart training to faculty, students of all engineering colleges in the state and industries in Bangalore. During his tenure as the President of ISSS, a major effort to introduce an undergraduate course on Micro and Smart systems in VTU was taken by ISSS.

ISSS thanks Professor Mohan for his leadership and contributions in research and education.

Shape Memory Alloys (SMAs) are materials that have two (or sometimes several) crystallographic phases for which reversible transformations from one to the other occur through diffusionless transformations (the so-called "reversible martensitic transformations"). Two remarkable effects are related with this phase change: the shape memory effect and the superelasticity. The shape memory effect (SME) refers to the ability of the material, initially deformed in its low-temperature phase (called "martensite"), to recover its original shape upon heating to its high temperature phase (called austenite or "parent phase"). The SME is a macroscopic effect of thermally induced crystallographic phase changes. The superelasticity occurs when the martensitic phase transformation is stress induced at a constant temperature. The transformation is characterized by a plateau and a hysteresis upon unloading. The magnitude of reversible 'pseudoelastic strain' can be as high as 8% or even more for single crystals. These phenomena are illustrated in Fig. 1.

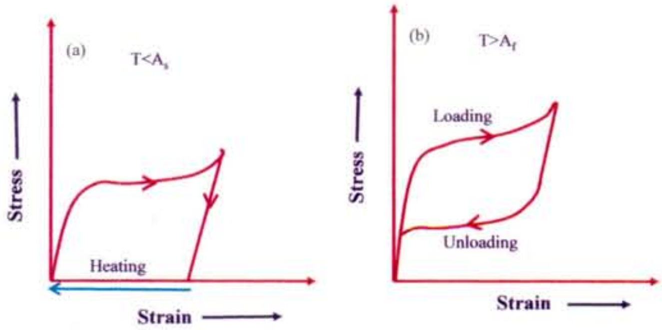

Fig. 1. Schematics showing (a) shape memory effect and (b) pseudo-elasticity.

The physical performance of the NiTi alloy made it a landmark discovery in 1962, and the range of commercially viable applications that have been found for this class of materials is a proof of the importance of the nickel-titanium (NiTi) shape memory alloys. But the discovery may have been a happy accident. Rumour has it that William Buehler, who was working with high nickel-bearing alloys for gas turbine components, left a small ingot of NiTi alloy made in a vacuum melt furnace on a desk in direct sunlight. When Buehler and his colleagues came back from lunch, they noticed the ingot's shape had changed. Now known as Nitinol (derived from Ni-Ti Naval Ordinance Laboratories, a part of the US Department of Defence), the name has become one of the commonly used titles for the SMAs emanating from Buehler's laboratory.

The nickel-titanium alloy has some of the most useful characteristics in terms of its active temperature range, cyclic performance, recoverable strain and relatively simple thermal processing. NiTi and other alloys have two generic properties, namely, the thermally induced shape recovery and super- or pseudo-elasticity. The latter means that an SMA in its elastic form can undergo a deformation approximately ten times greater than that of a spring-steel equivalent, and full elastic recovery to the original geometry may be expected. This may be possible through several thousand cycles. The energy density of the alloy can be used to good effect to make high-force actuators. A modern DC brushless electric motor has a mass of 5-10 times that of a thermally activated NiTi alloy, to do the same work.

The success of NiTi SMAs in engineering applications is due to the unique combination of properties that they posses. Recoverable strains up to 8% and recovery stress up to 800 MPa are possible if appropriate processing methodology is adopted. These compare to just 4% and 200 MPa respectively in Cu-base alloys (Table 1). The other decisive factors for the choice of NiTi SMAs over other SMAs are superior mechanical properties, durability in terms of structural and functional fatigue, and corrosion resistance. The ductility of these alloys is remarkable among many intermetallics, which are usually brittle. Ductility values more than 50% in martensite phase and 20% in austenite phase can easily be obtained in NiTi SMAs. This makes the processing of these alloys from cast ingots to semi-finished products to finished products relatively easy compared to other intermetallic alloys.

The first industrial application of NiTi SMAs in aeronautics was demonstrated with the Cryofit connector for F-14 airplane hydraulic circuits in late 1960s. Hydraulic coupling (Fig. 2) remains one of the earliest, yet, the most successful engineering application and accounts for the largest tonnage usage of NiTi SMAs till date. The other applications include fasteners, electrical connectors, actuators and sensors, release mechanisms, triggering devices, fuel injection, ventilation control etc. Superelastic applications such as foldable antennas for cellular phones, eyeglass frame are also quite popular in recent times.

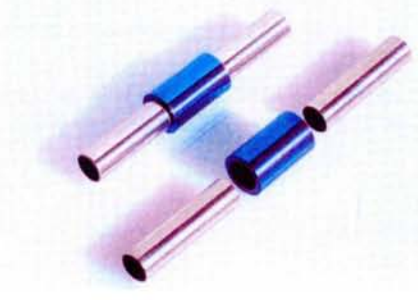

Fig. 2. Shrink ring made of NiTi SMA for hydraulic coupling

The concept of smart structures has thrown altogether a new and exciting field for NiTi SMA applications. Extensive multidisciplinary research is being pursued worldwide in this regard. It has been demonstrated that the shape recovery force generated by NiTi SMA actuators, owing to the capability of adapting their reaction to the given environment, can be effectively utilized for buckling and shape control of flexible structures. Sincere efforts have been made during the past two decades to integrate the functional properties of SMAs to obtain structural response more like a biological system. So far, success in this regard has been very limited and efforts are on to make it a reality. Once this is achieved, the use of NiTi SMAs is bound to show an unprecedented growth in the field of engineering applications. The development of so-called adaptive, multifunctional, smart or intelligent structures with NiTi SMAs as the smart element is likely to dominate the future structural technology.

Conventional actuating principles used at the micro-scale do not scale down favourably from a manufacturing as well as from an efficiency viewpoint. It requires actuating principles that can be easily integrated and miniaturized and that can generate enough power input. Microactuators fabricated with NiTi take advantage of this material's large energy density (~5-10 joules/cm^3) and high strain recovery (~8%). Microelectromechanical Systems (MEMS) devices designed with these actuators can serve as biosensors, micro-fluidic pumps or optical switches.

Though the success story of NiTi SMAs began with engineering applications, the nonlinear stress-strain behaviour of the material was found to be very advantageous for medical applications. Once the biocompatibility of NiTi was proven and accepted, NiTi SMAs opened up new opportunities for innovative devices and procedures in medicine. The higher cost of NiTi SMAs when compared to conventional

Table 1. Properties of some commercially important SMA materials

Propery	NiTi	CuAlNi	CuZnAl	FeMnSiCrNi
Yield strength (MPa)	200-700* 70-140**	350* 80**	400* 130**	1100
Tensile strength (MPa)	900-1900*	600	500-800	1600
Elongation to failure (%)	5-50	~15	~15	30
Recovery strain (%)	8.5 (max)	4	4	3
Recovery stress (MPa)	up to 800	~200	~200	300
Corrosion resistance	Poor	Poor	Poor	Good
Cost	High	Fair	Fair	Low

* Austenite ** Martensite

medical grade stainless steels such as the 304 and 316 did not prevent successful commercialization of these products because of the balance between the benefit to the patient, the host response, and the lifetime of the components.

There are a number of examples where NiTi SMAs have replaced the use of stainless steel and titanium alloy in biomedical implants. Also, minimally invasive surgery has been possible with the use of devices made of superelastic NiTi SMAs. These include guidewires for catheters, stents and various filters, actuators for artificial heart and kidney pumps, orthodontic wires for dental braces, and implants. There is a growing market for NiTi SMAs in clinical instruments as well. These include biopsy forceps, tissue ablators, hingeless graspers, and retrieval baskets for laparoscopy, to name a few. The applications of NiTi SMAs in medicine are expanding at a rapid rate and today, they account for the maximum market share in terms of money. A couple of applications are described next.

The property of thermally induced elastic recovery can be used to change a small volume to a larger one. An example of a device using this is a stent (Fig. 3), either in conjunction with a dilation balloon or simply by self-expansion, can dilate or support a blocked conduit in the human body. Coronary artery disease, which is a major cause of death around the world, is caused by a plaque in-growth developing on and within an artery's inner wall. This reduces the cross-section of the artery and consequently reduces blood flow to the heart muscle. A stent can be introduced in a "deformed" shape, in other words with a smaller diameter. This is achieved by passing through the arteries with the stent contained in a catheter. When deployed, the stent expands to the appropriate diameter with sufficient force to open the vessel lumen and reinstate blood flow.

The same technique can be employed in many of the body's conduits, including the oesophageus, trachea, biliary system and urinary system. The technology of self-expansion or balloon-assisted expansion is used for many millions of these stents each year and the numbers are steadily increasing.

Another commercially important biomedical application is the use of superelastic and thermal shape recovery alloys for orthodontic purpose. For many years, archwires made of stainless steel have been in use as a corrective measure for misaligned teeth. Owing to the limited "stretch" and tensile properties of stainless steel wires, considerable forces are applied to teeth, which can cause a great deal of discomfort. When the teeth succumb to the corrective forces applied, the stainless steel wire has to be re-tensioned and requires frequent visits to the orthodontist during the initial stages of treatment. Superelastic SMA wires are now used for these corrective measures. Owing to their elastic properties and extendibility, the level of discomfort can be reduced significantly as the SMA applies a continuous, gentle pressure over a longer period and hence, visits to the orthodontist are reduced to perhaps three or four per year (Fig. 4).

The exciting field of smart materials is expanding rapidly, with one of the most interesting areas being that of shape memory alloys. Surprisingly for materials with so many applications, shape memory alloys have not been around for a long time. Tremendous progress has been made in the science and technology of NiTi SMAs in recent years. The avenues for research and development in NiTi SMAs are seemingly endless and are increasing further with the advent of new applications in both engineering and biomedical fields.

Suggested Reading

1) K. Otsuka and C. M. Wayman, *Shape memory materials*, Cambridge University press, Cambridge, (1998).

2) T. W. Duerig, K.N. Melton, D. Stockel and C.M Wayman, *Engineering aspects of shape memory alloys*, Butterworth-Heinemann, New York, (1990).

3) J. Perkins, *Shape memory effect in alloys*, Plenum Press, New York, (1975).

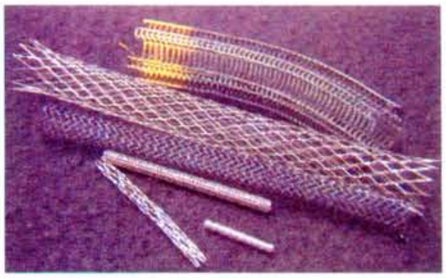

Fig. 3. Self-expanding NiTi stents

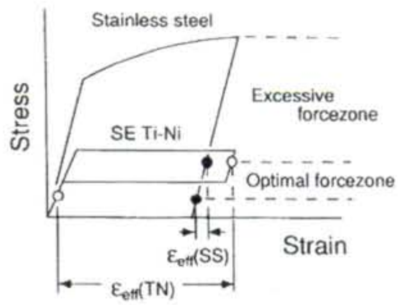

Fig. 4. Schematic illustration of the effectiveness of NiTi SMA in comparison with stainless steel for orthodontic applications

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University Buzz: Micro "juicc" flowing in Jadavpur H. Saha

The Jadavpur University IC Centre (juiccentre for short; see www.juiccentre.res.in) is a centre of excellence for Integrated Chip (IC) design and fabrication. It is located in Jadavpur, Kolkata. This centre was established in 1986 by the department of electronics and telecommunication at the Jadavpur University. Today, it is one of the nation's thriving academic research centres working in the area of electronics and microsystems devices. The centre has more than 10 faculty members who are working on a variety of topics. The centre is equipped with e-beam and thermal depositions units, an RF supttering system, oxidation/diffusion furnaces, liquid phase epitaxy (LPE) growth unit, a mask aligner and other lithography units, electrochemical etching unit, etc. It also has measurement setups for pressure and humidity sensors. It also has design and modeling software such as MEMSPro, ANSYS, etc.

Visit www.juiccentre.res.in for more information.

Current research activities of the Centre include: (i) MEMS-based microheater platform for gas sensors, (ii) nano-crystalline ZnO gas sensors, (iii) silicon nanowire-based pressure sensors, (iv) RF MEMS coplanar waveguide (CPW) switches, and (v) nanocrystalline silicon for solar cells applications, among others. The past achievements of this centre may be summarized as follows.

Gas and vapour sensor measurement setup at the Jadavpur University's IC design and Fabrication Centre.

1) MEMS microheater using nickel as heating layer has been successfully designed and fabricated for a power dissipation of a 150 mW with 5 V supply. The typical device dimensions are 4mm x 4mm with a 3mm x 3mm x 20m membrane and active area of 1.3 mm x 1.3 mm on a 100 micron silicon wafer.

2) Nanocrystalline ZnO (2 – 50 nm dia) has been successfully fabricated and tested to have a high sensitivity (200%) and operating temperature 100°C with pd contact. Both solgel and anodic oxidation techniques have been used in the preparation of ZnO.

3) Pressure sensors have been fabricated using nanostructured porous silicon and significantly high (50% max.) pressure sensitivity has been obtained experimentally which has also been explained theoretically.

4) RF MEMS shunt switch has been designed and simulated for switching RF signals in a CPW transmission line at Ku band having FOM in excess of 9000 GHz, RF isolation better than 50 dBs and insertion less that 0.25 dBs. Its use as 3-bit phase shifter is being investigated.

5) Thin silicon (5-10 micron) with nanovoids having enhanced optical absorption transport properties have been fabricated and tested for solar cell application.

To fulfill its mission of manpower training, the Centre offers an M.Tech. degree program in Microelectronics Technology and VLSI Design, and short-term courses in microelectronics, VLSI design, and photovoltaics in addition to running an undergratude IC lab.

Dr. H. Saha is a professor of electronics and telecommunications and is the coordinator of the Jadavpur University IC Design and Fabrication Centre. He can be reached at hsaha@juiccentre.res.in.

Conference Announcements

10th International Conference on Advanced Materials, Bangalore, 8-12 October, 2007. www.icam2007.com.

ICBN 2007: 3rd SPE International Conference on Bioengineering & Nanotechnology, Biopolis, Singapore, Aug. 12-15, 2007. www.icbn2007.com.

Watch for an announcement about the...

Second ISSS National Conference on Smart and Micro Systems Technologies that is to be held in CEERI-Pilani in November 2007.

Wireless LCD Message Display with USB Interface

Cranes Software International Limited (CSIL) is developing a wireless message display system for interfacing with microsensors. The figure on the right shows one of its prototypes towards the realization of a hardware board in the mixed-signal domain for a wireless communication with an LCD display system. The complete board-design integration for a transceiver with an in-built USB interface has been carried out in-house by CSIL. A signal communication system will be eventually integrated with MEMS.

India treading ahead in nano footsteps

Indian Nanoelectronic Users' Program (INUP) awareness workshop (see p. 1) held in IISc, Bangalore on 8-9 April, 2007 included presentations by researchers from LEOS (ISRO, Bangalore), SITAR (Bangalore), BEL (Bangalore), SCL (Chandigarh), and CEERI (Pilani). They described the work that is under way in the respective facilities, and their plans for upgradation/addition. Faculty from a few academic institutions also made short presentations about their activities in this area. It was an eye-opener to everyone present as they learnt about the impressive efforts made in various institutions. Professor Krishna Saraswat of Stanford University, who attended the workshop, said that "he was amazed at the progress being made in India". He also remarked that the efforts are going beyond nanoelectronics into other important and related areas of materials, medicine, and biology. He encouraged the INUP model by noting that a similar program, namely National Nanotechnology Infrastructure Network (NNIN: www.nnin.org), had remarkable success in USA. The final session of the Workshop featured a panel discussion, with Prof. Saraswat, Dr. Uttam (MCIT), Prof. V. Ramgopal Rao (IIT-B), and Prof. S.A. Shivashankar (IISc) moderating the discussion and making some opening remarks. Dr. Uttam described the vision in which there was no discrimination between "big" and "small" institutions, as they would all have access to the facilities being established. He emphasized that "more and more collaboration" was required in the endeavour, and urged the evolving of a number of collaborative R&D projects. Thus, one expects to see India surge ahead in the small technologies in the coming years. (Excerpted from Prof. Shivashankar's report on the INUP workshop.)

Accomplishments: Prof. J. Vasi

V. Ramgopal Rao

Juzer Vasi obtained his B.Tech. degree from the Indian Institute of Technology, Bombay, in 1969 and a Ph.D. from the Johns Hopkins University in 1973. He taught at the Johns Hopkins University and the Indian Institute of Technology, Delhi, before moving to the Indian Institute of Technology, Bombay, in 1981, where he is currently a Professor. He was the Head of the Department of Electrical Engineering during 1992-94, and is currently the Deputy Director of IIT-Bombay.

Dr. Vasi's research interests are in the area of Metal Oxide Semiconductor (MOS) devices and technology. He has worked on the growth and characterization of MOS insulators, radiation effects in MOS devices, degradation and reliability of MOS devices, and modeling and simulation of MOS devices. He has published and presented over 100 papers in these areas, and has acted as a referee for leading Indian and international journals.

Professor Vasi did pioneering work in

Microfabrication laboratory in IIT-Bombay, a result of the pioneering efforts of Prof. J. Vasi in 1980s.

characterizing the Si-SiO_2 interface and its role in the long-term reliability of MOS gate dielectric under high electrical fields and radiation environment. This work has resulted in new characterization techniques for quantifying the generation of oxide traps using C-V, I-V, and charge pumping measurements.

Dr. Vasi has interacted widely with industries in India and abroad, and has been involved with many sponsored projects from government agencies and industries. His work on developing the radiation-hard CMOS technology using re-oxidized nitrided oxide (RNO) gate dielectric has found use in the semiconductor fab facilities in the country.

Dr. Vasi initiated indineous development o process and device simulation tools, which were used as part of post-graduate teaching curriculum in 1980s when it was difficult to procure commercial Technology CAD software. His group also developed models for the simulation of radiation induced reliability effects in MOS devices.

Prof. Vasi's pioneering efforts in 1980s lead to the establishment of successful microelectronics teaching and research programmes at both IIT-Delhi and IIT-Bombay. For example, the group that he formed at IIT Bombay in 1983 now has 14 faculty members working in the broad areas of Microelectronics & VLSI, and has over 150 post-graduate students, including over 25 Ph.D. students on rolls. The microelectronics group at IIT-Bombay collaborates with most of the leading semiconductor industries, and received a funding of over Rs. 100 crores in 2006 from the government and industries for its research and teaching programmes.

Prof. Vasi has received many honors for his contributions to the electron devices area and for the growth of microelectronics in India.

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