Preface

Advancements in Microsystem Technology (MST) have led to the development of a large variety of sensors and actuators. Microsystems or MEMS (Microelectromechanical systems) are designed and fabricated by integrating different microcomponents into one functional unit comprising sensors, actuators and integrated circuits for data processing. In this development, a variety of micromachining technologies, ranging from conventional silicon bulk and surface micromachining to LIGA and LASER techniques are employed, each one having specific advantage or merit for a specific product.

Many types of sensors and actuators have been developed using smart microsystems. Typical sensors consist of strain gauges, silicon diaphragms and cantilevers, optical fibers, piezoelectric films and piezoceramics. Typical actuators consist of piezoceramics, magnetostrictives, electrostrictives and shape memory alloys. Piezoelectric materials have proved to be very useful for fabricating sensors and actuators in smart structures.

Microsensors and microsystems find countless applications in process control, aerospace, automobiles and healthcare. The challenges here are inherently multidisciplinary providing subjects for research within the disciplines of engineering, materials science, electronics and chemistry. Many of the microfabrication techniques and materials used to produce MEMS have been borrowed from the IC Industry. The field of MEMS has also driven the development and refinement of other microfabrication processes and materials not traditionally used by the IC industry. Deep-reactive ion etching (DRIE), a dry etch process, patented by the Robert Bosch Corporation, can be used to etch deeply into a silicon wafer while leaving vertical sidewalls and is independent of the crystallographic orientation. This unique capability has greatly expanded the flexibility and usefulness of bulk micromachining. The combination of DRIE and conformal deposition processes, such as LPCVD polysilicon and silicon dioxide, can be used to create micromolded structures. Another process useful for MEMS application is substrate bonding. Silicon, glass, metal and polymeric substrate can be bonded together through several processes, i.e. fusion bonding, anodic bonding, eutectic bonding and adhesive bonding. Substrate bonding helps in achieving a structure that is difficult to form otherwise, e.g. hermetically sealed large cavities, a complex system of enclosed channels for adding mechanical support and protection.

The miniaturization of a complete microsystem represents one of the greatest challenges to the field of MEMS. One well-known example of a chip-scale microsystem is the ADXL 50 accelerometer by Analog Devices Inc. This is a closed loop microsystem where capacitive displacement detection is used to measure the motion of the proof mass, integrated circuit to determine the voltage necessary to balance initial motion and electrostatic actuators to control the position of the proof mass. Microfluidic systems constitute the majority of the present microsystem development efforts due to their broad applicability, particularly as biochemical analysis systems. Market outlook for MEMS is quite strong. Accelerometers for automobile industry are being mass-produced for use in air bags during a crash and for active suspension control. Another important use is in vibration monitoring of rotating machinery. Microscopic pressure sensors embedded in automobile tyres have led to huge savings in oil. Tiny blood pressure 5 IISc THESES ABSTRACTS sensors are popularly used in many medical applications. Piezoelectric acoustic sensors are designed for both audible and high-frequency sensing and find use in hearing aids too. An infrared focal plane array (FPA) of microbolometers with read-out electronics on monolithic silicon chip is an important application in night vision devices. MEMS technology is able to provide probe tips close to atomic dimensions integrated with sense and drive electronics for the probe of an atomic force microscope.

What makes the future possibilities exciting is not only the decreasing size of the sensors which is directly proportional to the cost of the sensor but developement of stand-alone systems with high sensing capabilities and on-chip calibration. Futuristic applications include: nose on a chip, camera on a chip, monolithic hearing aid, vehicle dynamic sensor, lab on a chip, embedded sensors in aircraft skins, jet engines and onboard systems for continuous monitoring of stresses, temperature histories, pressure and other parameters resulting in on condition maintenance practice. A large number of applications have been forecast for defence, space and medical fields. Therefore, potential exists in MST to establish a second technological revolution with an impact on society that exceeds that of IC industry.

The special issues of the Journal of the Indian Institute of Science focus on various materials, design, technology development and characterization of devices in microsystems. There are 16 papers covering these topics written by experts in their respective fields. The aim is to give readers an overview of this upcoming technology.

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