Tuesday Afternoon, November 5, 2002

Manufacturing Science and Technology
Room: C-109 - Session MS+MM-TuA

Manufacturing Issues in MEMS and Related Microsystems
Moderator: E.G. Seebauer, University of Illinois

2:00pm **MS+MM-TuA1 Silicon Micromachines for Science and Technology**, ***D. Bishop***, Bell Laboratories, Lucent Technologies **INVITED**

The era of silicon micromechanics is upon us. In areas as diverse as telecommunications, automotive, aerospace, chemistry, entertainment and basic science the ability to build microscopic machines from silicon is having a revolutionary impact. In my talk I will discuss what micromachines are, how they are built and show examples of how they will have a revolutionary impact in many areas of science as well as technology.

2:40pm **MS+MM-TuA3 Silicon Nano-biotechnology**, ***G. Timp***, University of Illinois, Urbana **INVITED**

Silicon nanotechnology can now manufacture logic that incorporates more than 43 million Metal-Oxide-Semiconductor Field Effect Transistors (MOSFETs) into a monolithic integrated circuit (IC). Some of these MOSFETs have a gate or control electrode that is only 130nm long with a gate oxide that insulates the control electrode from the current-carrying channel that is as thin as 1.7nm. Moreover, we have recently shown that further miniaturization is practical. We have produced nanometer-scale MOSFETs or nano-transistors with a gate electrode as shorter than 40nm and a gate oxide thinner 1nm. Inexorably, within the next ten years (according to the ITRS roadmap) the electronics industry is expected to integrate over a billion nanotransistors into a ~3-10cm2 area chip, packing about 5-10 nano-transistors/mm2. Integration on this scale, along with the facility for nanofabrication, will enabled new types of ICs. For example, we will show that it is now possible to fabricate ICs so small that they could inserted inside a living cell. Since the cell is the key to biology, such a chip combined with sensors could provide unprecedented access to it. We will also show how silicon nanofabrication technology can be used to produce sensors out of nanometer-scale pores (~2nm in diameter) in an ultra-thin glass membrane (~2nm thick), which function like ion channels in the membrane of a living cell. Such devices may ultimately be used in proteomics or for rapid sequencing of minute amounts of DNA to discover the genetic origin of a disease.

3:20pm **MS+MM-TuA5 Manufacturing Issues in MEMS and Related Microsystems**, ***B.P. Gogoi***, Motorola **INVITED**

MEMS(MicroElectroMechanical Systems) use IC(Integrated Circuit) manufacturing technology for the fabrication of sensors and actuators that utilize a wide variety of transduction principles to interact with the physical world. The three dimensional aspects of the sensor require some additional process technology that is not available in conventional IC technology. Also, since many of these sensors and actuators require the presence of intentional gaps in which mechanical motion is initiated, MEMS technology also require methods to form these intentional gaps. Using this enabling technology, a number of high volume sensors have been developed for the mainstream market in the automotive, consumer, industrial and medical segments. However, as the trend in IC manufacturing has progressed towards more shallower and planar technology, the trend in MEMS technology has moved towards high aspect ratio structures. The issues related to manufacturing of sensors and actuators using MEMS technology will be discussed. Some of the specific requirements of the process technology to enable well-controlled high volume manufacturing of sensors will be presented. In addition, examples of failure mechanisms that result from the interaction of design and the fabrication process will be discussed. The choices in the integration of these sensors and actuators with the system circuitry will also be presented.

4:00pm **MS+MM-TuA7 MEMS Technology Challenges for Volume Manufacturing**, ***V. Rao***, Intel Corporation **INVITED**

MEMS(Micro Electro Mechanical Systems) is a silicon technology for fabricating miniature mechanical devices made mostly of beams, membranes and channels. These mechanical devices are integrated with electronics to form Microsystems which find use in Communications and computing, Inertial sensing, environmental sensing and Biomedicine. MEMS devices are particularly attractive in the personal communications space because they can provide significant benefits such as energy efficiency and small footprint. However as these are high volume markets the technology must provide the required reliability and cost characteristics for these applications. In RF systems today many passive devices are discrete and off chip. MEMS technology provides a way to integrate the high value passive elements (such as switches, filters and high Q inductors) thereby reducing footprint and enhancing performance. Another example in the communication space is in the use of micromirrors for all optical switching. This is very compelling as light signals can be switched directly in the optical domain by moving mirrors avoiding the expensive Optical to Electrical to Optical conversion as is currently done. This paper will discuss some of the key manufacturing hurdles that must be overcome to realize the reliability and cost benefits that MEMS technology must meet. We will start by discussing key process modules that differentiate MEMS technology from traditional CMOS. We will then describe the stare of the art for these modules today and discuss the technological hurdles that must be addressed for future volume manufacturing.

4:40pm **MS+MM-TuA9 Manufacturing Issues of Automotive Sensors produced at Bosch**, ***M. Offenberg***, Robert Bosch GmbH, Germany **INVITED**

An ever increasing number of electronic systems in vehicles helps to increase the safety and comfort of the driver as well as to increase fuel efficiency and to reduce toxic emissions. Sensors are enabling components for the functionality of these electronic systems. Over the last decade microfabrication technologies have contributed to reduce the cost of these sensors - and thus overall system cost - while at the same time increasing their functionality and reliability. This paper describes selected micro sensors that have been successfully introduced to the market such as pressure sensors, mass flow sensors, acceleration and angular rate sensors. Manufacturing aspects and processes with and without monolithic integration are illustrated for a surface micro-machining process. The embedding of MEMS manufacturing in an existing 6-inch ASIC production environment to achieve an optimized low-cost process is described. Key process steps such as deposition of mechanical-grade thick poly-silicon layers, trench etching, sacrificial oxide etch and hermetic sealing are illustrated. Some of the key processes require dedicated equipment that was developed in collaboration with equipment manufacturer. High rate silicon deep silicon etcher in cluster tools ensure low cost of ownership. Process monitors for mechanical stress and stress gradient will be presented and manufacturing issues such as cross contamination and particle protections are discussed using inertial sensors as an example.

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