Tutorial Seven

MEMS: Technology, Design, CAD and Applications

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Abstract

Micromachined Electro-Mechanical Systems(MEMS), also called Microfabricated Systems (MS), have evoked great interest in the scientific and engineering communities. This is primarily due to several substantive advantages that MEMS offer: orders of magnitude smaller size, better performance than other solutions, possibilities for batch fabrication and cost-effective integration with electronics, virtually zero dc power consumption and potentially large reduction in power consumption, etc. The application domains cover microsensors and actuators for physical quantities (MEMS), of which MEMS for automobile & consumer electronics forms a large segment; microfabricated subsystems for communications and computer systems (RF-MEMS & MOMS); and microfabricated systems for chemical assay (microTAS) and for biochemical and biomedical assay (bioMEMS and DNA chips). This tutorial would give an introduction to these exciting developments and the technology and design approaches for the realization of these integrated systems.

The full day tutorial would begin with a synoptic overview of the area, highlight some of the challenges and outline the scope of the tutorial. It would be followed with an introduction to the design of microsensors, such as the pressure sensor and the accelerometer, that began the MEMS revolution. We begin with a quick introduction to material properties at the micron scale and show that silicon is eminently suited for micromechanical devices and therefore the possibility of integrating MEMS with

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VLSI electronics. Unit processes for bulk and surface micromachining of silicon and integration of processes for fabricating silicon microsensors will be presented.

Smart cell phones and wireless enabled devices are poised to become commercial engines for the next generation of MEMS, since MEMS provide not only better functionality with smaller chip area, but also alternative transceiver architectures for improved functionality, performance and reliability. We, therefore, have two lectures on the structure and design of RF-MEMS covering passive & resonant elements, switches and transmission lines. Some applications of MOMS in communication systems will also be discussed.

We shall have a lecture on bioMEMS to highlight the immense possibilities that exist for MEMS in the life sciences & medicine. The idea of integrating microfluidics and biological or biomimetic material with electronic systems is alien to electronic systems designers and there are problems with integrating wet systems with electronics. We give a synopsis of the types of structures required and approaches for the design and test of such systems.

Finally, we shall discuss the issues involved with embedding MEMS in complete systems, including issues related to design tools, simulation, test and parameter extraction & de-embedding.

The faculty for the tutorial have been in the forefront of integrated circuit technology development in the country and are currently involved with various facets of research with MEMS.

Dr. Lal *is a Professor of Electrical Engineering at IIT Bombay. His research interests include the physics and modelling of semiconductor devices, radiation and high-field effects in devices and circuits, and device characterization. He has also been working on radiation sensors, biosensors and biosensing systems, much of the latter work as part of an interdepartmental effort involving Chemistry, Materials Science and Biomedical Engineering.*

Dr. Apte *is at TIFR and would be a visiting professor at IIT Bombay, slated late autumn 2001. He had been instrumental in developing India's first TTL technology. Current, research interests are micromachining, high temperature superconductor devices and quality improvement using innovative problem solving tools.*

Dr. Bhat *is a Professor of Electrical Engineering at IIT Madras and has coordinated the microelectronics activity of the department. His research interests include SOI MOSFET modeling and technology, GaAs and InP surface passivation, GaAs MISFET technology and modeling, polysilicon thin film transistors and grain-boundary passivation, and silicon icromachining and micromachined sensors.*

Dr. Bose *and* ***Dr. Chandra*** *are faculty members at CARE, IIT Delhi and have both contributed substantially to CARE's microelectronics development. Dr. Bose has worked extensively with lithography & CMOS process integration and is currently interested in micromachined sensors for temperature, pressure and sound. Dr. Chandra has worked in the areas of plasma CVD and RTP processes, laser recrystallization, direct wafer bonding, and SIMOX based SOI technologies. Current interests are micromachined sensors and actuators with focus on switches and millimeter wave devices using MEMS.*

Dr. Sharma *is a Professor of Electrical Engineering at IIT Bombay. His interests are broadly in the areas of MOS device modeling, simulation & characterization, and VLSI design & technology. His current interests include mixed signal and digital signal processing VLSIs, asynchronous design, embedded system design, radiation hard technology and the effect of technology and device scaling on design architectures and tools.*