

Position Paper: Manufacturing of MEMS

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Micro-Electromechanical Systems (MEMS) is the integration of mechanical elements, sensors, actuators, and electronics on a common silicon substrate through the utilization of microfabrication technology. MEMS is a relatively new technology which exploits the existing microelectronics infrastructure, as suggested by the definition given above, to create complex machines with micron feature sizes. Extensive applications for these devices exist in both commercial and defense systems.

Manufacturing of MEMS has its origins in Integrated Circuit (IC) processing. It has progressed from that to more sophisticated processes driven by the need to create 3-D features. Typically oxidation, diffusion, LPCVD, photolithography, epitaxy, sputtering etc. are IC processes. In addition to these processes, MEMS manufacturing utilizes bulk micromachining, wafer bonding, deep silicon RIE, LIGA, micromolding etc.

All these processes are based on the notion that mechanical and electronic subsystems in MEMS should be manufactured by compatible processes in a single fabrication sequence. Theoretically, the cost of the overall component should be lower than two separate ones because the sensor and circuitry are manufactured in a single processing sequence. The most successful applications created on this basis are sensors. Even in these applications, it has been realized that the integration drastically increases the number of steps in the fabrication process.

MEMS that have moving and rotating parts are not as reliable as sensors with non rotating parts, as evident from no successful commercial devices available in this category. Friction between rotating and non rotating parts has proven to be more of an impediment than initially viewed. Friction creates heat that does not dissipate easily from microscopic region and exponentially accelerates wear and tear of parts. For example, this has been the problem with creating MEMS hard drives for data storage.

Currently, 75 percent of the cost of developing a MEMS device goes into packaging and testing. MEMS packaging presents unique challenges compared to IC packaging due to diversity of MEMS devices and corresponding requirements. Dr. Agonafer recently left IBM and formed "Electronic, MEMS & Telecommunications Systems Packaging Center (EMTSPC)" at UTA. EMTSPC will target the needs of the computer industry and the telecommunications industry as a fundamental research area as these technologies have and will continue to overlap. The center will be unique in that it will be coupled to the "NanoFAB-Microelectronics Center (NMC)." The research at NMC enables extremely compact, lightweight, low-power, electronic systems for surveillance, communications, planetary exploration, medical, intelligence, and defense applications. The proximity to the DFW industrial sector will enable design, testing and characterization capabilities not only at UTA but also at industrial facilities. The above capabilities will put UTA in a strong position related to MEMS activities. The center also has expertise in the estimation of thermo-physical properties in quasi-continuum media.

As mentioned earlier, MEMS design is heavily dependent on processing, and therefore mechanical functionality is sacrificed over complexities of fabrication processes. The mechanical components are more often viewed as 3-d geometries that should fit the processing requirements. This view to some extent is due to the belief that any abnormal mechanical behavior can be compensated by sophisticated electronic circuit design. We could say that at present MEMS design is driven by fabrication processes. We believe that in future this trend will reverse and system needs will define the subsystem technologies.

Research Priorities: The following research priorities are evident from the current state of the MEMS technology. We will separate them into fundamental and technological research.

Fundamental research:

1. Heat generation and transport in microscopic mechanical systems.
2. Nanoscopic origins of friction
3. New, not necessarily compatible with IC fabrication processes, fabrication processes that eventually make complex system-on-a-chip, such as lab or material processing-on-a-chip possible
4. Understanding of failure mechanisms and processes for life time prediction
5. Microfluidics

Applied technological research

1. Innovations in MEMS packaging
2. Analysis and design software development
3. Microrobotics
4. Microscopic power generation systems
5. Miniaturization of conventional, metal, plastic and composite manufacturing techniques

The Role of NSF: NSF initiated MEMS research in eighties. It has funded close to three hundred proposals related to MEMS. These grants include research centers, user facilities, individual investigators and educational proposals. We believe that NSF should continue to play this role by expanding centers of excellence in education and research. It should also continue to fund fundamental research identified as crucial to further development of MEMS technologies. NSF can also help create system driven fabrication and packaging technologies for MEMS. MEMS research is a multidisciplinary in nature and therefore reviewing processes should be continuously refined to favor multidisciplinary programs.

Last but not least is the elimination of cost sharing requirements because they inadvertently favors established research institutes over intrinsic value of the proposed research. One way of making an equitable adjustment is to base cost sharing as percentage of total federal grants obtained by institute in previous years rather than a percentage of the budget for the specific proposal. In this scheme the absolute cost sharing burden on disadvantaged institutes reduces.