

Position Paper: MEMS Fabrication

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My research interests:

- (1) Application of light pressure as an actuation mechanism for bi-stable MEMS switches. Such MEMS can be used for optomechanical computing as well as sensing in harsh environments.
- (2) Materials behavior at submicron scale for MEMS reliability
- (3) Cell adhesion and mechanotransduction of single cells using MEMS sensors with pn-nn force resolution and large displacements (μms)
- (4) Solid-liquid interaction phenomena at small scale relevant to bio-MEMS application

The above involves design, analysis, fabrication and testing of MEMS sensors and actuators. I have been in the field of MEMS for the last seven years. Based on my experience in the field, I have the following comments regarding MEMS fabrication:

Fabrication is still a bottleneck: the major challenge that we face in conducting MEMS research is the fabrication. Even if the fabrication process is well established, which are very few in number, one may spend a considerable amount of time in fabricating a new device using the old process. The process needs tuning to suit the new design. One thus has to carry out trial and error.

Developing a new process with new materials, which in many cases is very relevant to MEMS, usually takes substantially more time. Once the process works in one laboratory, it is not guaranteed to work in another. It needs calibration to suit the new set of machines, for example the RIE chambers of the new lab.

Development of a process that works to fabricate a simple cantilever is one thing, using the process for a more complex device is another. The process needs to be investigated to explore its limitations. How the process works (the recipe) is the first step that needs to be complemented by looking into the question as to why does it work. The latter allows to develop variations of the process as well as new processes.

Sharing the knowledge base on fabrication: it is understandable that many fabrication processes are proprietary and hence cannot be shared until proper paperwork is completed. However, within such constraints, we need to share as much as possible the knowledge on a process among the community to prevent the reinvention of the wheel.

Fabrication is expensive: developing a MEMS fabrication facility for research purpose requires several million dollars, even if there is an available microelectronics cleanroom. Such fab needs to be maintained by trained staff, not just by graduate students. Furthermore, many machines, such as an ICP, a stepper, a PG, need service contracts to minimize their downtime. Such costs need to be recovered from user fees from a broad class of users and/or heavy institutional

commitments. The users may be from within the institution or from nearby regions. This implies that a partial MEMS lab is extremely difficult to sustain.

A Few Recommendations: NSF, darpa and other government sponsors may jointly assist in developing or upgrading existing fabs in different parts of the country to fully equipped MEMS labs where users can use the machines themselves with a user fee. Such labs can be viewed as national centers (such as cornell nanofabrication facility) where researchers from different institutions can meet. This approach will considerably save federal support that are being used to develop small MEMS infrastructures in different institutions, many of which offer limited and duplicate capabilities.

NSF and other agencies can also help by supporting more research that investigates the fundamentals of MEMS processes, their limitations, integrability with microelectronics, and why do they work. The results of such research will be more accessible to a broader audience since they will be less likely to have proprietary constraints.

Finally, NSF and other agencies can help by supporting more research on microscale phenomena and MEMS device physics both of which are intimately related to MEMS fabrication, process limitations, and operational reliability.