**Position Paper: NSF Workshop on Manufacturing of Micro-Electro-Mechanical Systems**

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**Overview:** Micro-Electro-Mechanical Systems (MEMS) packaging encompasses the design, fabrication, assembly, and test of a reliable and functional "home" for a MEMS device. Our specific application applies to the Digital Micro-mirror Device (DMD™); an optical MEMS currently used for projection display applications. The DMD™ is a reflective light modulator that requires the package to provide an optical interface with the external environment. The micro-mirror array can contain upwards of two million digitally controlled (on-off) microstructures (mirrors). Over the expected life of the DMD™ these mirrors are required to move freely millions and millions of cycles. This free movement is sensitive to many parameters that include contamination, moisture, and forces at the molecular level. In addition, the optical requirements imposed on the device/package add a vast array of concerns regarding contamination control and optical focus/alignment. These concerns place strict requirements on package piece part fabrication and assembly. These requirements make it evident that the package itself is an integral part of the DMD™ device.

Our experience has shown that the reliable packaging of the DMD™ is a formidable task. Conventional packaging technology is not applicable in many areas concerning the DMD™. Like other MEMS devices, the application specific nature concerning the packaging requirements limit the development of packaging standards. There are however, areas of technology that could be developed which would aid in the packaging of the DMD™, and MEMS devices in general. To date, industry wide there is little MEMS packaging infrastructure and very few partnerships between industry and academia. TI supports the idea and purpose of this workshop in an effort to advance MEMS technology through collaborative efforts.

**Research Priorities:** The following list identifies some areas we have identified where collaborative efforts could be developed. With regards to each, low cost and automated assembly must be considered a high priority.

- hermetic packaging techniques (weld, o-rings, Teflon gaskets, etc.)
- "quasi-hermetic" packaging solutions (adhesives, gaskets, combinations, etc.)
- wafer level packaging of optical MEMS
- die singulation and separation techniques (fast anisotropic particle free etching)
- silicon through vias, wafer bonding to glass (anodic bonding, etc.)
- MEMS reliability models
- stiction and lubrication strategies for micro-structures
- low surface energy thin films
- mechanical wear and creep of micro-structures
- die attach optical alignment capability (x, y, and z control – parallelism)
- high quality optical interface (windows – particle, defect, blemish free)
- particle control within MEMS packages (particle getters ("storage")
- packaging mini-environments (mini-clean areas)

- many others can be identified as relationships evolve

**Role of NSF:** I see NSF facilitating and promoting cooperative partnerships throughout government facilities, industry, and academia. They can monitor key technologies being worked throughout the MEMS packaging community and communicate where mutual interests exist and identify where possible relationships might be developed. Technologies being worked for a given application may be suited for other applications, and communication of such information is important.

**Recommendations:** I feel it would be helpful to understand what NSF sees as its role and how these efforts would be implemented in practice. After inspection of the workshop participants inputs, a discussion of not only what the top priority topics to be addressed are, but how the relationships are to be coordinated and developed is necessary. How will the logistics be handled, will there be quarterly meetings, web site interactions, e-mail? What is the NSF plan to develop and promote collaborative efforts?