MEMS PACKAGING ISSUES

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The Packaging Dilemma?

We probable all agree that packaging MEMS and especially the optical kin, MOEMS, is a major challenge. But older solutions are being deployed. The *de fault* approach is the hermetic package, especially for optical systems. The time-tested metal or ceramic hermetic packages work, so what's the problem? Most, but not all-hermetic packages have these limitations:

1) Much higher cost than mass-produced commercial packages
2) Poor fit with the commercial packaging infrastructure
3) Poor fit with high-volume automated SMT component assembly.

But does this matter? No, if new MEMS is to remain a low volume, niche product. Is this really acceptable? We need to pause a moment and recognized that MEMS can be grouped into two broad categories even though most lists, especially those based on "type of motion", are quite extensive. For convenience, lets classify the simple products that have been around for a long time as traditional MEMS. Traditional MEMS is exemplified by vehicle accelerometers, ink-jetting chips and pressure-sensing devices. These rather simple products have evolved into mass-produced lower cost, but still specialized packages. These packages are not a generic solution for MEMS and may not be applicable to MOEMS.

Let's call the 2nd device category "Advanced" or "Complex" MEMS. This is where the challenge of the future lies that must be met to enable sophisticated MEMS products. Cost per device drops as we move along the learning curve and MEMS, based solidly on semiconductor process, will not be an exception. Unless we devise cost-effective MEMS packaging, a time will come when the package will cost many orders of magnitude more that the contents. The package will then be the bottleneck and the technology will be held back as has happen many times before until packaging break-thoughs came to the rescue. The last two important "packaging revolutions" were surface mount technology (SMT) and area array (BGAs, Flip Chip and Chip Scale Packaging)

A fundamental package question is, "**Can the MEMS package be non-hermetic**?" Common wisdom says that most MEMS devices, especially optical, must be encased in a hermetic package. Could atmosphere control agents such as getters (molecule-specific scavengers) allow near-hermetic packaging? Recently, Texas Instruments indicated that testing of near-hermetic packages for their complex micro-mirror arrays (DLP™) was positive. Sealing of the glass lid using plastic adhesive gave reasonably good lifetimes provided that moisture getters were used.

Do we need novel packages for MEMS? Since we are still in the midst of the 1990's Packaging Revolution, this is the right time to explore new concepts and seek better solutions for MEMS. A recent trend in micro packaging is wafer-level (W-L) processing. Several Chip Scale Packages have followed this trend and are in production. Some new, still emerging W-L packages could possible fit MEMS. One concept is called "0-Level" hermetic packaging where a cap of silicon (cap-on-chip), glass or metal is fused to the base silicon over the active areas of the chips in wafer form in a vacuum environment. The singulated chip may then be classified as full- or near-hermetic even before packaging. The chips could then be run through commercial packaging processes such as overmolding. Optical MEMS devices would be sealed with a transparent cap and any encapsulation would need to accommodate a light path. One company, ShellCase, has already produced CSPs with windows (*Shell*MEMS) but only limited reliability data has been generated to date. A German company, iC-Haus GmbH, has announced the OptoBGA^{TM}, which appears to use clear plastic encapsulants. Figure 1 shows the 0-Level Cap-on-Chip concept. This chip, or micro-module, could then be packaged in a conventional fashion perhaps building a Plastic BGA.

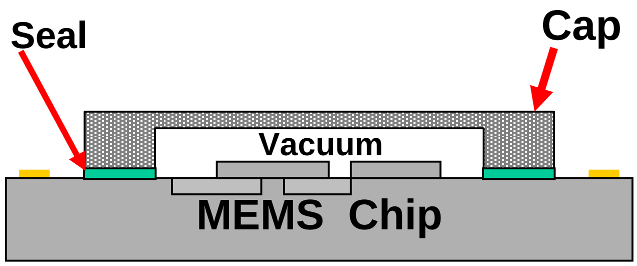

Figure 1 – Zero-Level Hermetic Package

Surface Control - Friction, and Stiction

Stiction is strong and undesirable attraction between parts in contact that are design for motion relative to one another. It is a natural consequence of a very high surface area/mass ratio. While many commercial MEMS designers recommend avoiding designs with contact, this is not feasible in most cases. Even micro-mirrors using flexing beam elements for the moving axis have stiction problems. Position stops are reported to experience random stiction problems during extended use.

Anti-Stiction Coatings?

While the patent literature indicates that liquids, especially silanes, are effective, are vapor-deposited polymers a better choice? The parylenes are noted for high chemical inertness, strong barrier properties and high conformity. A fluorinated, teflon-like version called Nova HT, was developed as a low k dielectric for semiconductors, but was not selected as a leading candidate. Nova HT seems to have much better properties than the conventional hydrocarbon and chlorinated materials. It could possibly work for anti-stiction as it can handle over 500^{o}C and is optically clear. The surface tension approaches that of Teflon. The supplier is offering material for research or will vacuum coat devices.