Managing MOEMS

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Micro-Opto-Electro-Mechanical System (MOEMS) packs a lot of technologies into one small piece of real estate. Electronics, physics, chemistry, optics, mechanics and biotechnology all converge in this nanoworld to delivery unimagined new features. But is this really so that remarkable since all of these technical domains are combined at the macro level? Yes! There are two exceptional features that make optical MEMS, or MOEMS, a nearly magical arena. First, there is the infinitesimal size. At least 250,000 moving mirrors have been crafted on a slice of material that is only about 12 mm (0.5") on a side. The total parts count is much higher, so high, in fact, that the Digital Micro-Mirror Device (DMD™) from Texas Instruments, is now the most complex machine in the world with more parts than the Space Shuttle or a new Boeing 777. The second feature is the manufacturing wizardry. All of the million-plus parts are crafted in s sequence of mass processes producing hundreds of modules on a single wafer with a total count of trillions of movable parts. In the macroworld, a MEMS equivalent product would consist of countless sub-units made in many countries, by dozens of companies, by tens of thousands of workers. Figure 1 shows a close up of just one MOEMS micro-mirror made by Texas Instruments (TI) and used in very compact, but high out put digital projectors.

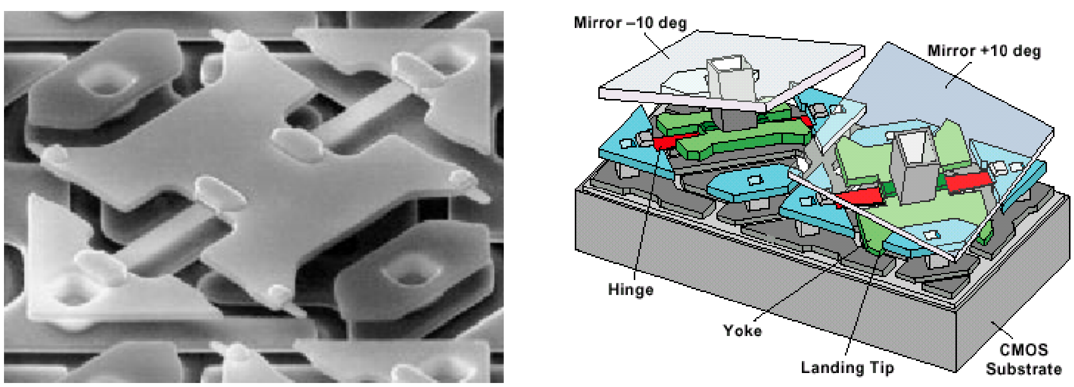


Figure 1 – DMD™ from Texas Instruments

While significant fabrication issues remain, products, like TI's DMD, have successfully entered the market place with others products from dozens of companies also moving quickly to commercialization. The MOEMS products will control light, not just in projectors and displays, but also along the Internet Highway as photonics becomes the fundamental transmission technology. Modulated beams of laser light traverse the globe so quickly, that a message could circle the planet 7 times in just one heartbeat. But these broadband Internet data streams are optimally switched and routed directly as photons, not with electronic conversion impose "speed bumps" on the Information Highway. MOEMS is the answer! Full photonics Internet switches are already in beta testing and begin limited service during 2001. The micro-mirrors and other opto control devices will catch multi-colored lamda waves and beam them to the desired fiber channels and out into cyberspace. Exceptional bandwidth has been gained by using a rainbow of colors sent along the same fibers and made possible by Wave Division Multiplexing (WDM). The more wavelengths, the greater the payoff in moving to MOEMS. Figure 2 shows a new MOEMS switch used in Lucent's Lamda Router^{TM}. But there are some shadows - problems seeking better solutions.

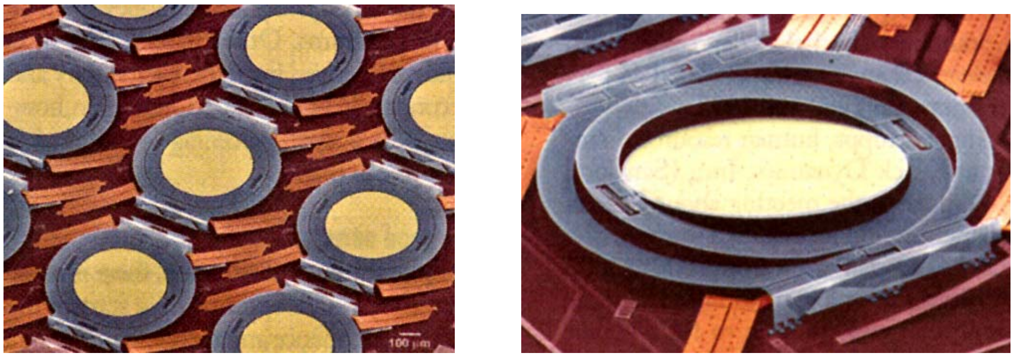


Figure 2 – Lamda Router Mirror Switch – Lucent

Perhaps the principal concern beyond fabrication is packaging. Nanoscale MEMS devices can be easily impaired or damaged by atmospheric contaminants such as submicroscopic particles and moisture. Particles will jam up the mechanical mechanism and immobilize components. Worse yet, particles can be produced inside the package as a by-product of wear. *But moisture is the real MOEMS killer*.

Water vapor can fog and corrode delicate optics but it plays a more insidious role. Water increases the phenomenon called "stiction". Stiction is a friction-like affect that "locks" surfaces together as if they were instantly glued. Stiction goes unnoticed in our macro-world because it is miniscule. But as parts get smaller, the surface area-to-mass ratio becomes excessive and this in turn multiplies surface affects like stiction. Stiction can be a "show stopper" for MEMS when moving parts get permanently stuck. The "breaking force" can be up to a million times higher than the force that MEMS "engines" can generate.

Stiction is being attacked from at least three directions. Water vapor is kept at a minimum with moisture getters, powerful desiccants, placed inside the package. Many of the moisture getters are also designed with a sticky surface that traps microscopic particles (particle getter). MEMS designers also try to minimize surface contact area. One more approach is to coat surfaces with low-energy, Teflon-like molecules. A new fluorinated parylene, Nova HT, is in testing as an ultra-thin, vapor-applied coating. Now lets look into the MOEMS "window".

MOEMS deals with electrons and photons. The photons must be move in and out of the package to interact with the device. The common approach is to add a “glass” window, but light ports and optical fibers can also be used. TI uses a bonded glass lid for their DMD mirror array package shown in Figure 3.

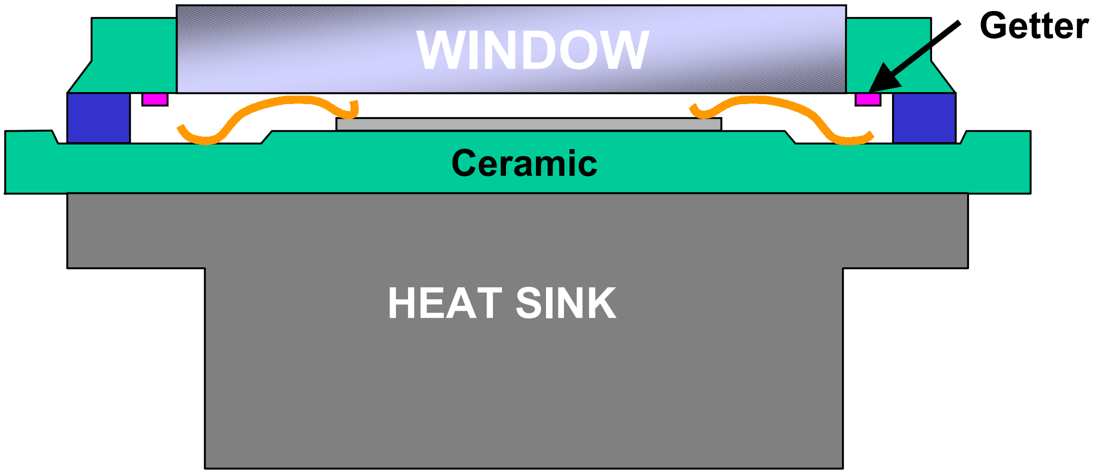
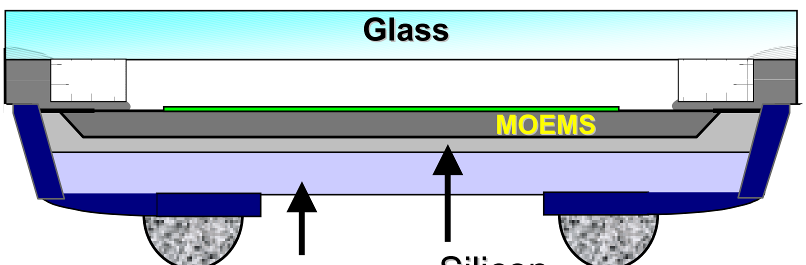


Figure 3 – DMD Package Diagram

The micropackaging industry is also offering novel packaging solutions for MOEMS. One new package from Chip Scale Package (CSP) maker ShellCase, is the ShellMEMS shown in figure 4. A glass cap is used in this wafer-level CSP.



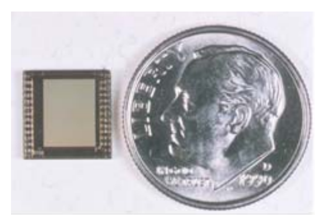


Figure 4 – Optical CSP - ShellCase

There are other photon-enabling solutions like glass substrate modules offered by Intarsia shown in Figure 5. While not designed specifically for MOEMS, the glass could let light pass in and out. A flip chip MOEMS device could be used to point the light through the glass substrate. Other flip chip constructions could possibly be used by with more conventional opaque substrate by using light ports or optical fiber. Figures 6, 7, and 8 show some ideas.

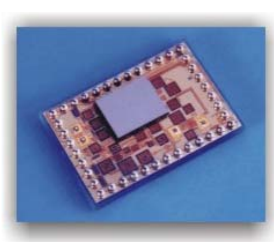


Figure 5 – Glass Substrate - Intarsia

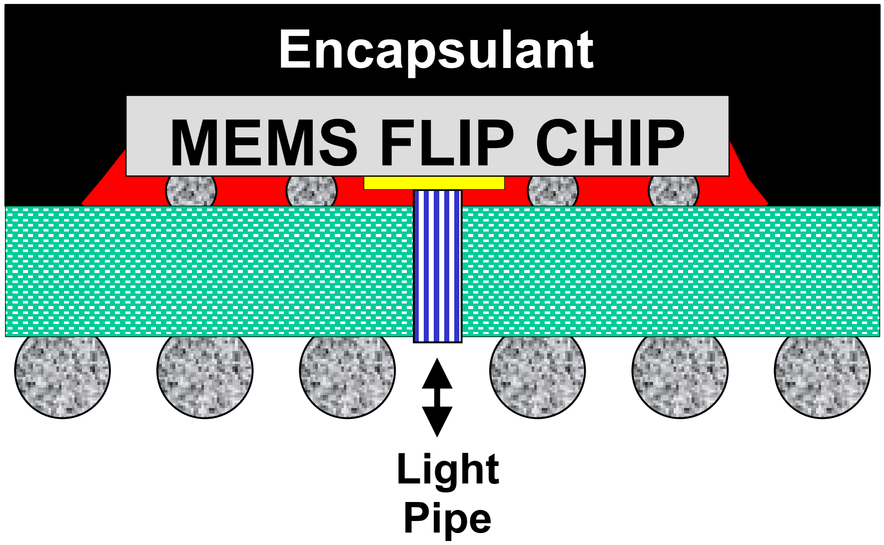


Figure 6 – Flip Chip In Package MOEMS

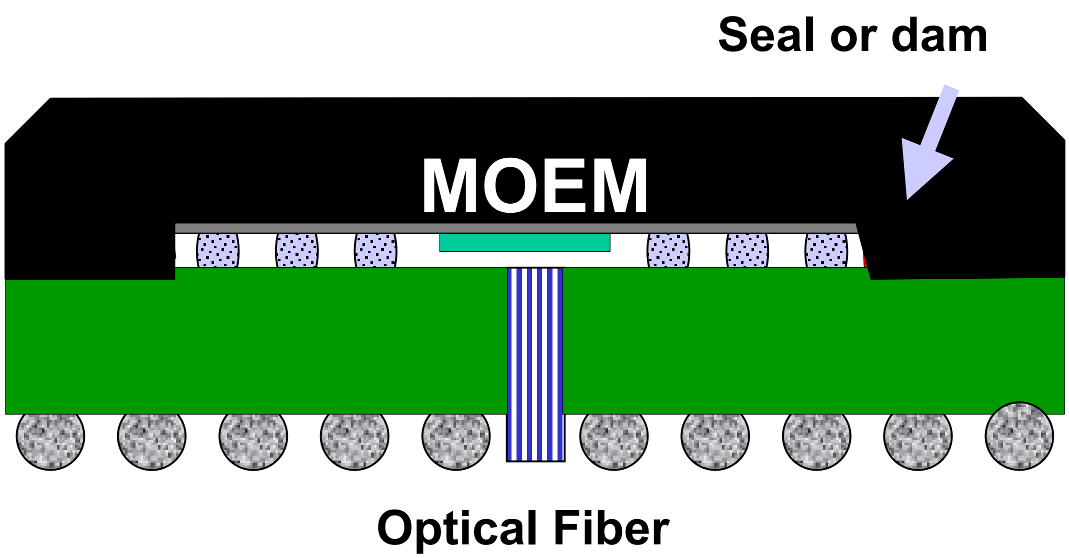


Figure 7 – Flip Chip with Fiber

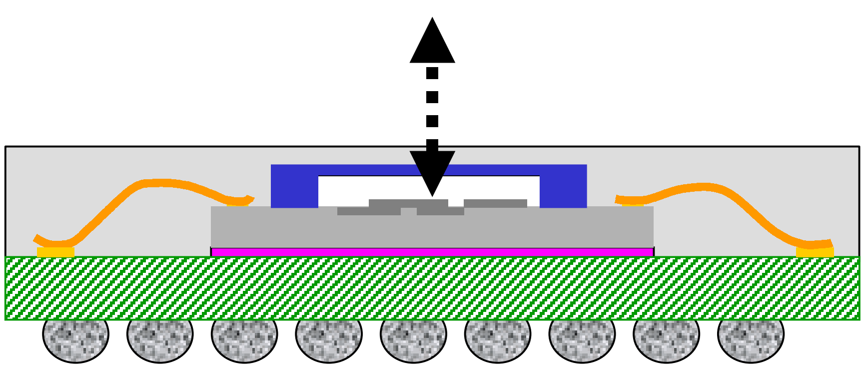


Figure 8 – Transparent Cap & Encapsulant

Conclusion

We are certainly in an exciting phase of technology as telecommunications moves to the forefront. The Internet has become the *worldwide hub* that connects the entire world. Photonics has become the primary backbone technology as more and more optical fiber is deployed on land and under the sea. Nearly all major landmasses are now “wired” for light. The vast glass highway made of hair-thin gossamer filaments will use MOEMS as the speed-of-light traffic control system as the industry provides the solutions for this enabling but disruptive technology. Photonics, however, will not displace electronics. Photons and electrons will coexist in the MOEMS environment with a high level of synergy. So let’s catch the multi-colored wave – the telecom rainbow. And yes, it points to the pot of gold!