CECD
CENTER FOR ENERGETIC CONCEPTS DEVELOPMENT

MEMS PACKAGING AND RELIABILITY

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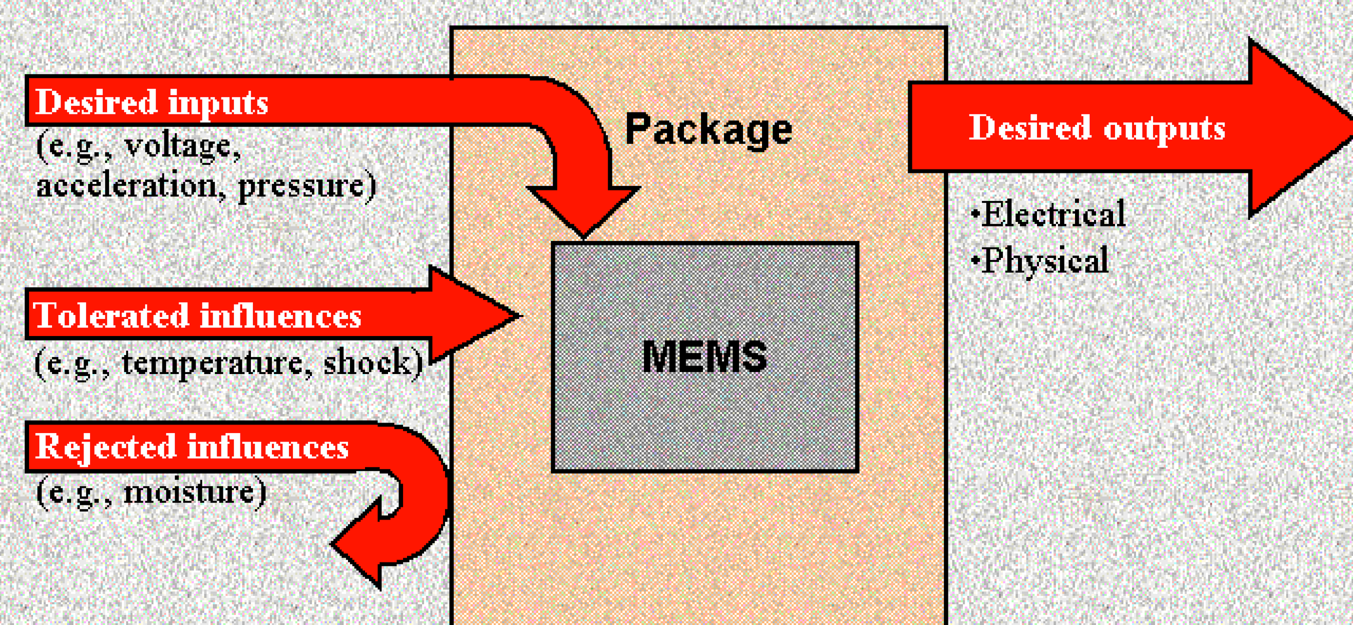
Microelectromechanical Systems (MEMS) embody the technology and practice of making three-dimensional structures and devices with dimensions on the order of micrometers.

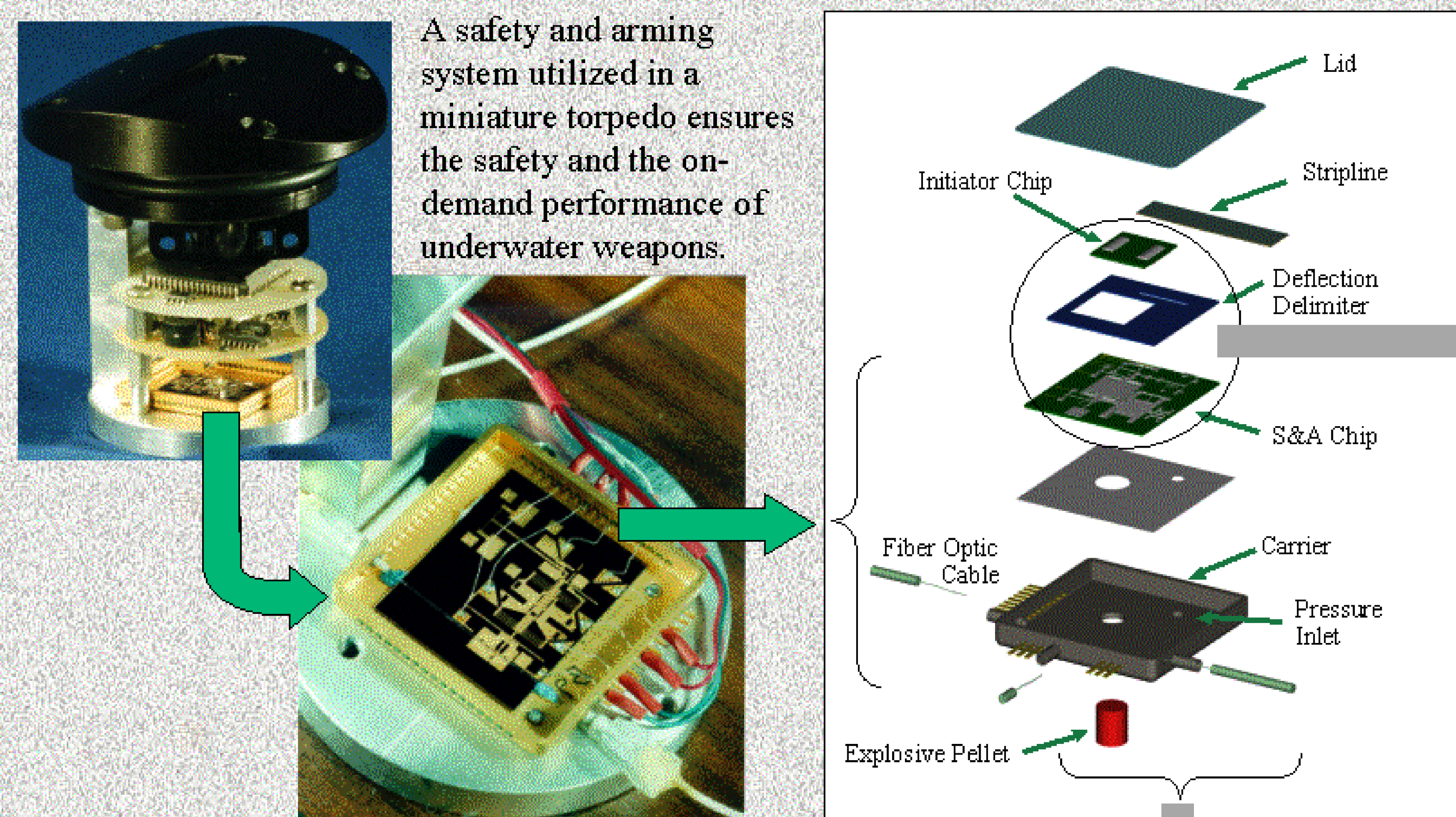
While the basic principles of silicon micromachining are well understood, significant advancements in the packaging of MEMS and the assessment of the long-term reliability of MEMS are now necessary to support their transition into real systems.

Packaging MEMS Applications



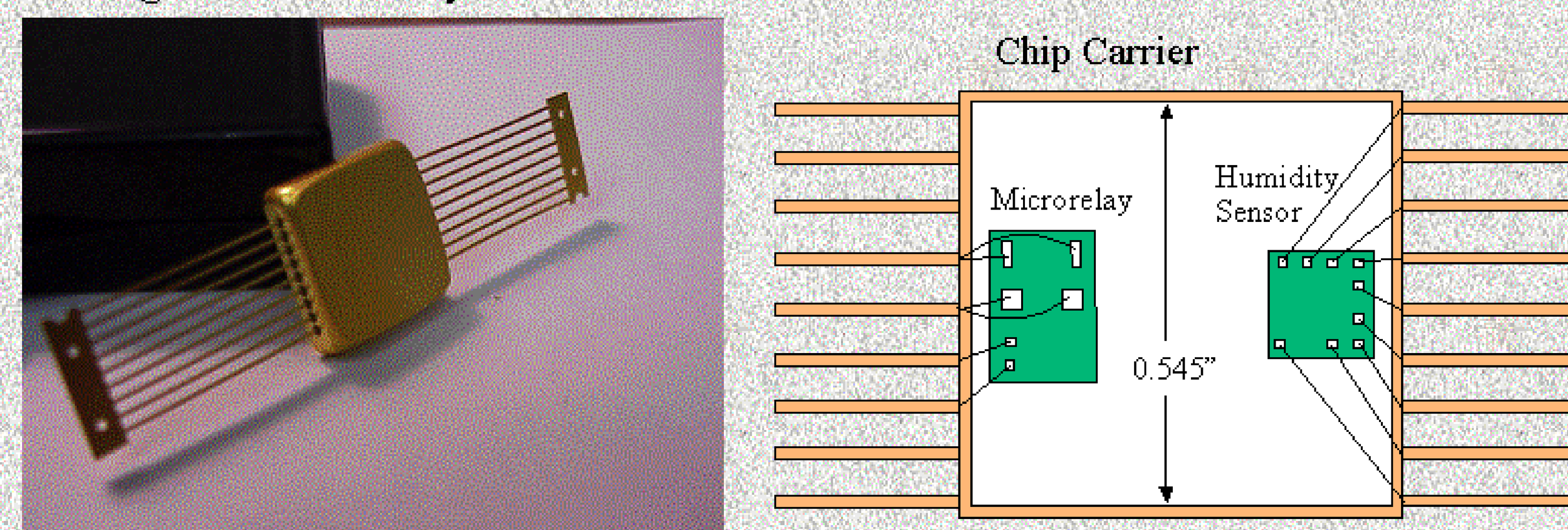
Safety and Arming System

A safety and arming system utilized in a miniature torpedo ensures the safety and the on-demand performance of underwater weapons.

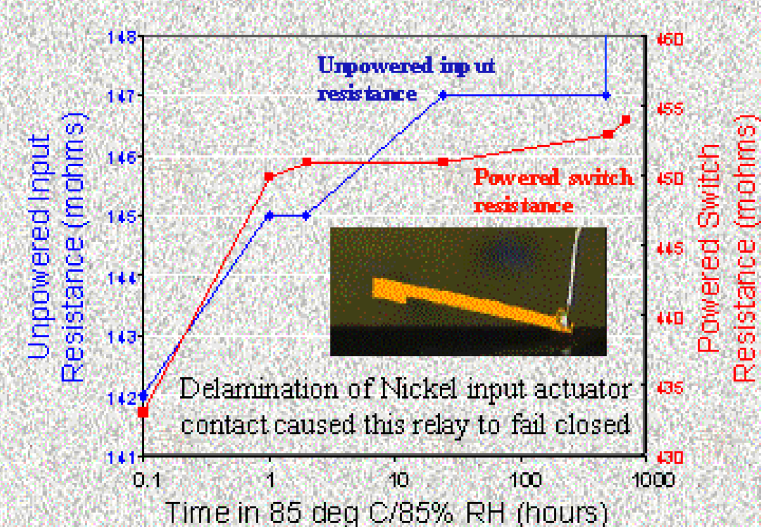


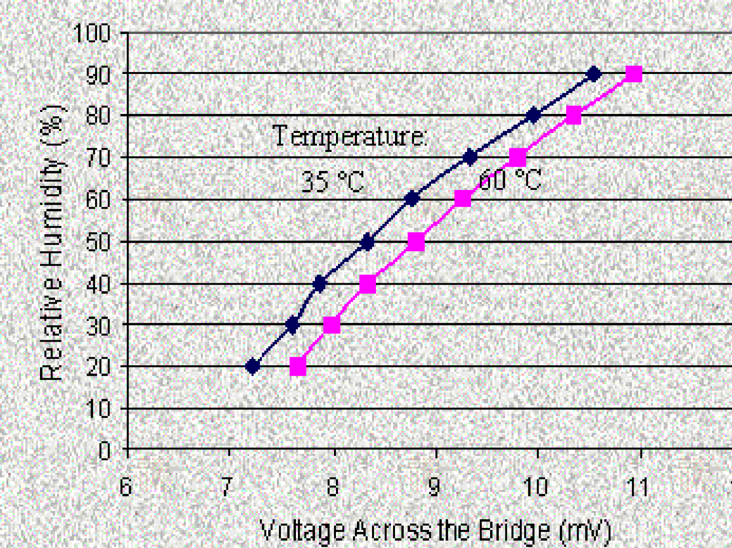
Carrier-Level Packaging

Simulation of the Safety and Arming system, a microrelay (fabricated using similar technology and materials) is used in a chip carrier that is the same size as the Safety and Arming carrier assembly.



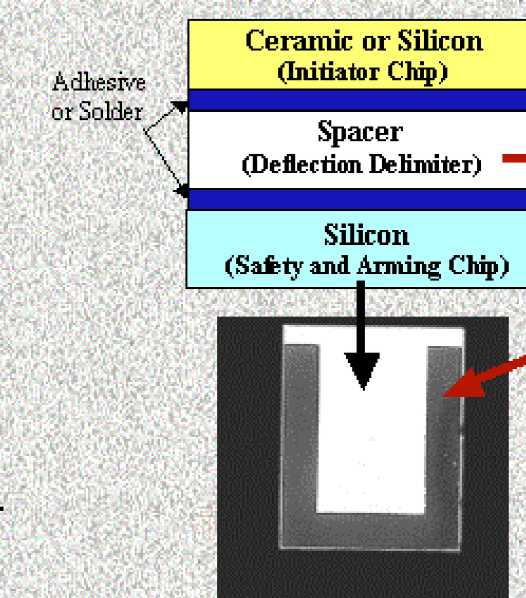
This carrier, has been used to study the long-term effects of moisture on the operation of a MEMS device.



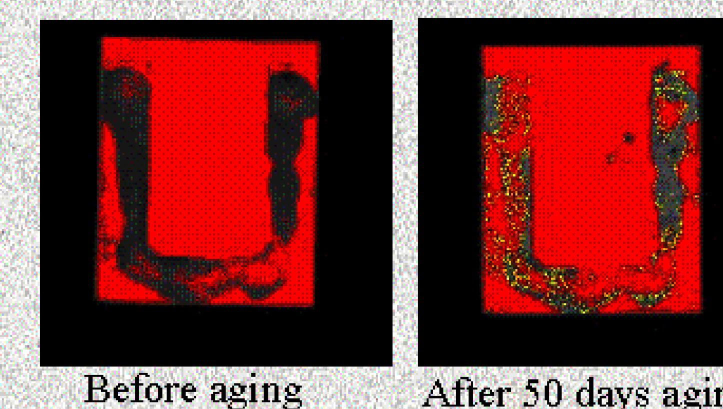


Chip-to-Chip Bonding

- The Safety and Arming system requires precise alignment between a micromachined silicon chip, a patterned Alumina ceramic chip, and a deflection delimiter.
- Several candidate designs were subjected to a series of environmental tests including thermal cycling, accelerated stress tests, mechanical shock, and combinations of the above conditions.
- A Scanning Acoustic Microscope (SAM) was used to measure initial delamination and to identify incremental damage due to environmental exposure. The tests were used to rank the suitability of the bond layer material for chip-to-chip attachment.



Accelerated Aging



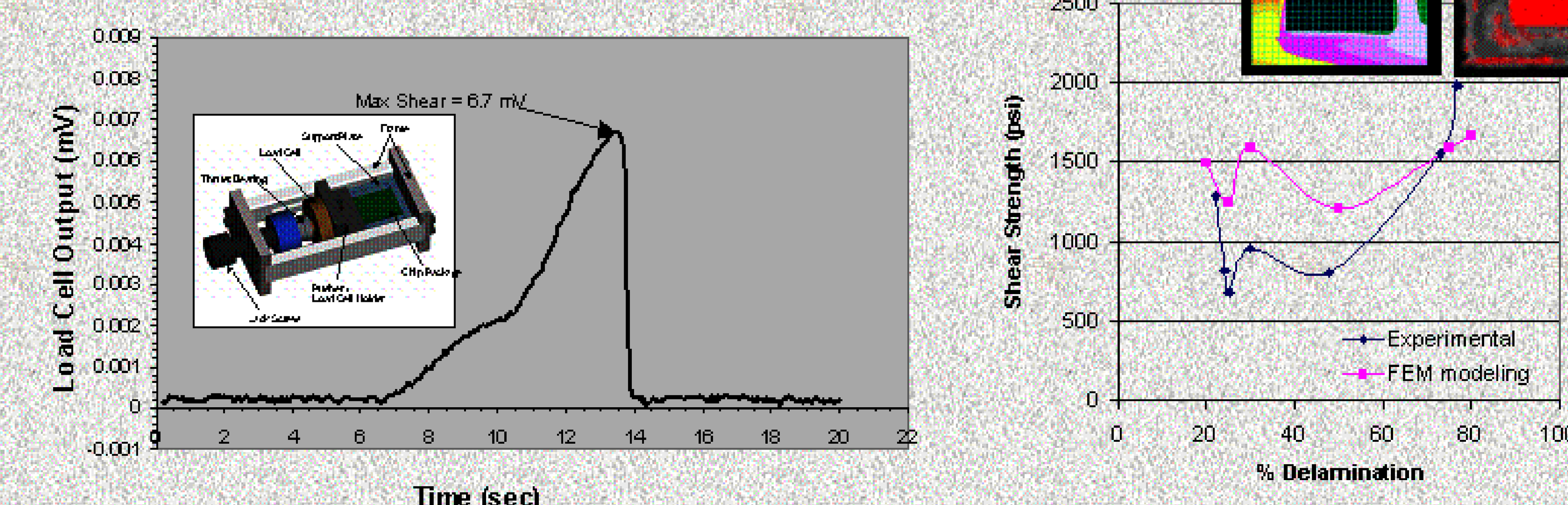
Before aging After 50 days aging

Samples were subjected to accelerated aging at 85 °C/85% relative humidity for 100 days with periodic removal for delamination measurement.

Scanning Acoustic Microscope images of sample constructed using Thermoplastic film with deflection delimeter.

Die Shear

Determine the strength of the bonds for varying degrees of delamination by assessing the effect of the delamination on bond strength through die-shear testing. Verifies delamination measurement methodology.



Summary of design variations and environmental testing results:

Design No.	Bond Material	Bottom Substrate	Top Substrate	Spacer (Deflection Delimeter)	Bond Thickness (mm)	Aging Delamination Growth*	Thermal Cycling Delamination Growth**	Die Shear Stress (lbs/sq inch)***
1	Thermoplastic Paste	Silicon	Ceramic	Alloy 42	0.051	Catastrophic	Insignificant	780 (σ=657)
2	Thermoplastic Film	Silicon	Ceramic	-	0.178	Insignificant	Insignificant	1374 (σ=440)
3	Epoxy Film	Silicon	Ceramic	-	0.178	Insignificant/ moderate	Insignificant/ moderate	1109 (σ=326)
4	Thermoplastic Film	Silicon	Silicon	-	0.178	Insignificant	Insignificant/ moderate	1246 (σ=341)
5	Epoxy Film	Silicon	Ceramic	Alloy 42	0.051	Insignificant/ moderate	Insignificant/ moderate	507 (σ=332)
6	Thermoplastic Film	Silicon	Ceramic	Alloy 42	0.051	Insignificant	Insignificant	908 (σ=440)
7	Indium Solder	Silicon	Ceramic	Alloy 42	0.005	Insignificant	Insignificant	1177 (σ=465)

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