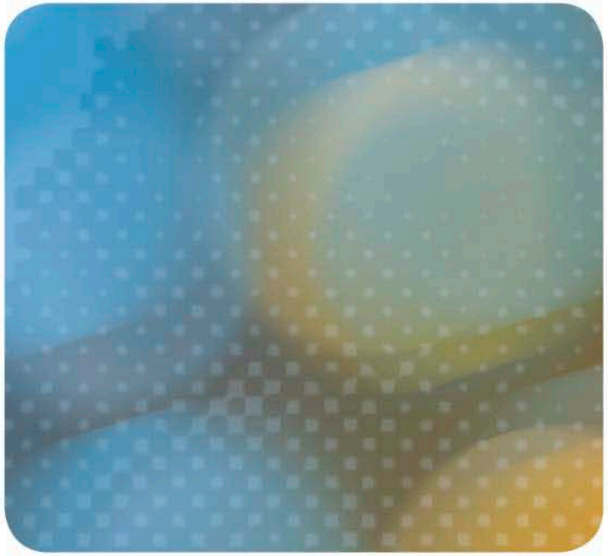
FFI Forsvarets forskningsinstitutt

Use of Conductive Adhesive in Fuze Applications



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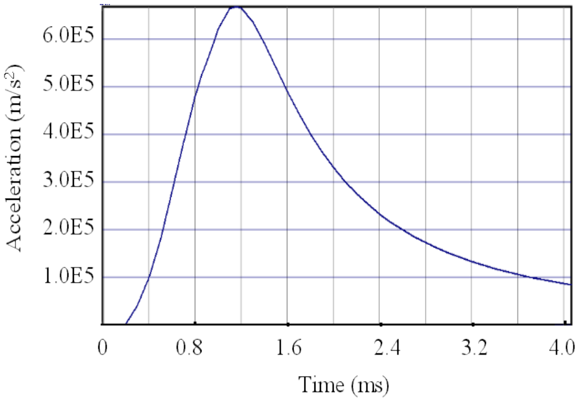
Outline

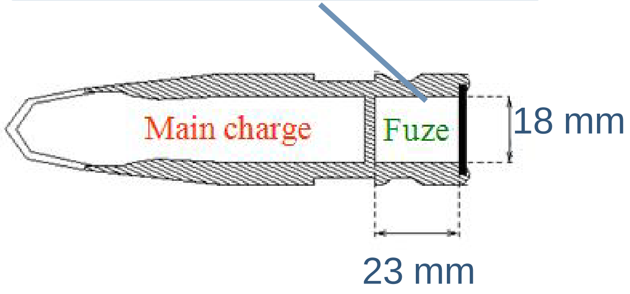
- Background and motivation.
- Conductive adhesive.
- Experiments.
- Characterization.
- Conclusion.

Background and motivation

- The electronic components in a fuze are exposed to severe mechanical forces during firing.
- For 30 mm ammunition, setback acceleration exceeds 60 000 g and the centripetal acceleration is 9000g/mm out of center.
- In 30 mm ammunition, the electronic components should not occupy more than 1-3 cm^3.

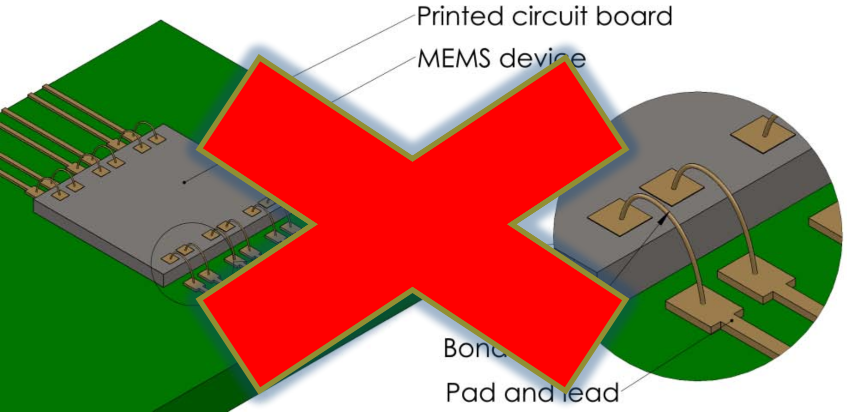


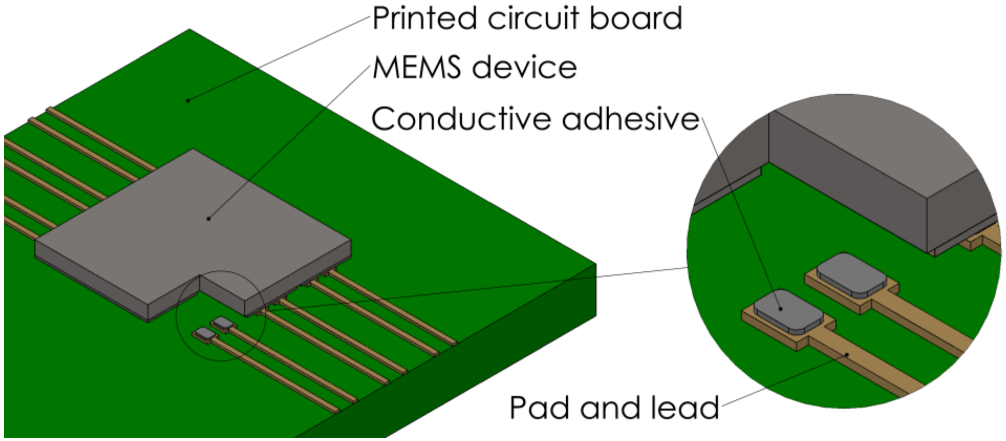
MEMS & electronic components e.g. programmable unit, power supply ++



Mounting of MEMS to PCB

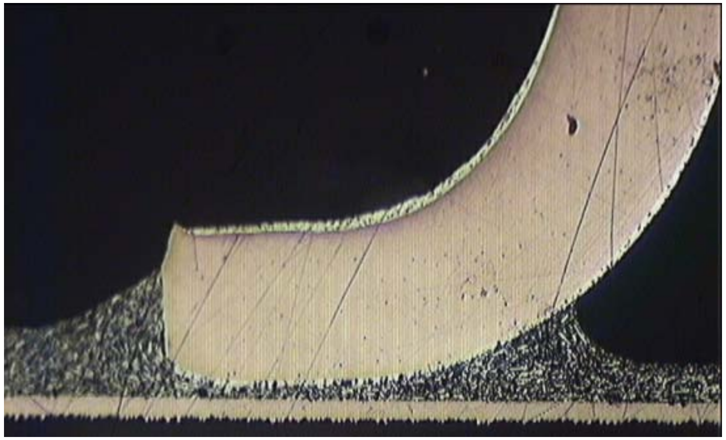
- It is advantageous to mount the MEMS chip directly to PCB omitting extra packaging level. This will require less space and cost saving is possible.
- Using wire bonding for direct contact between MEMS and PCB is not a favorable option.
- Using isotropic conductive adhesive (ICA) for interconnection between MEMS and PCB could be a possibility. However, performance of ICA in this demanding environment must be investigated.





Isotropic Conductive Adhesive

- ICA has been used for electronic packaging and interconnect for several decades.
- Composite material
  - Adhesive resin
  - Conductive material
- Silver particles are commonly used as conductive material.
- Common problem is brittleness due to CTE mismatch between filler and metal particles.



J.E. Morris, Portland State University

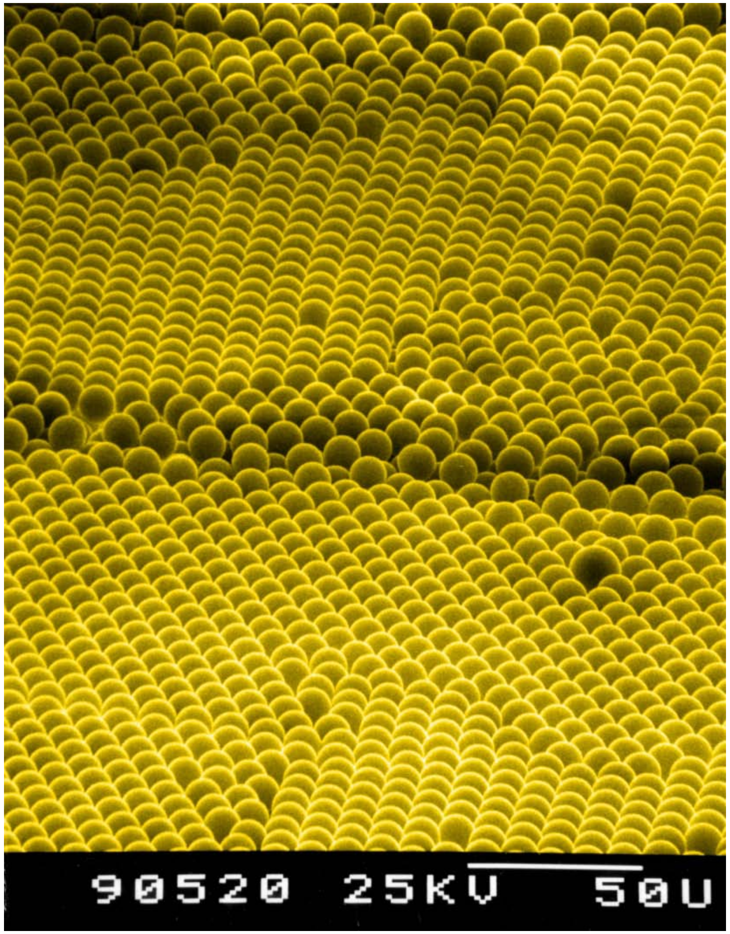
ICA based on metallized polymer spheres

- Replace e.g. silver flakes with highly uniform metallized polymer spheres.

- Size of the polymer spheres can be custom tailored.

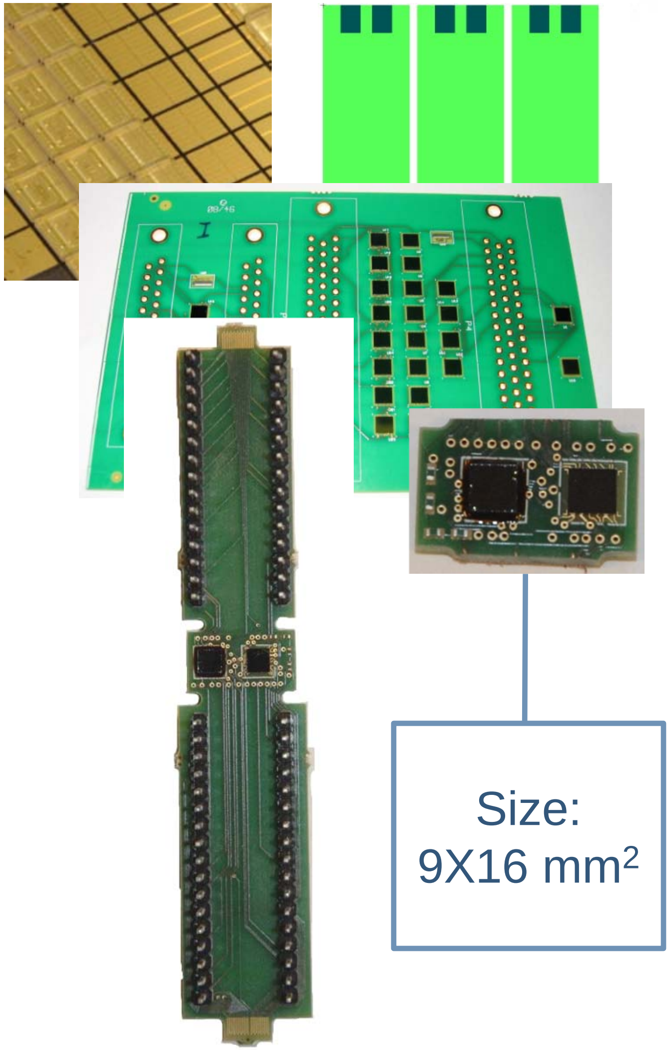
- Different core material can be used:
  - Optimization of Tg.
  - Match the CTE to the adhesive matrix.
  - Mechanical energy absorption.

- Noble metals may be used for metallization at relatively low cost.



Test structures and test boards

- MEMS test structures for interconnect testing were designed and fabricated on the same SOI wafers as the real MEMS devices.
- Board used for temperature cycling test. Contains daisy-chain structures and structures for Kelvin measurement of contact resistances.
- Board used for firing tests contains 2 test structures and 4 pcs of 0402 resistances on each side. Kelvin measurement of contact resistances before and after firing test.



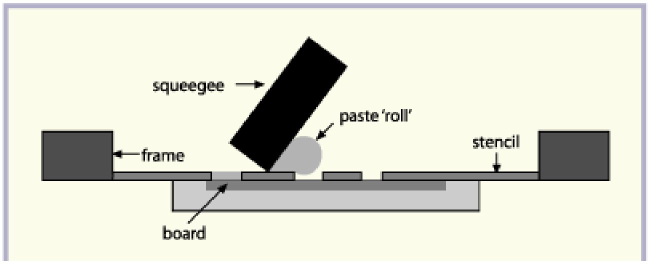
Size: 9X16 mm^2

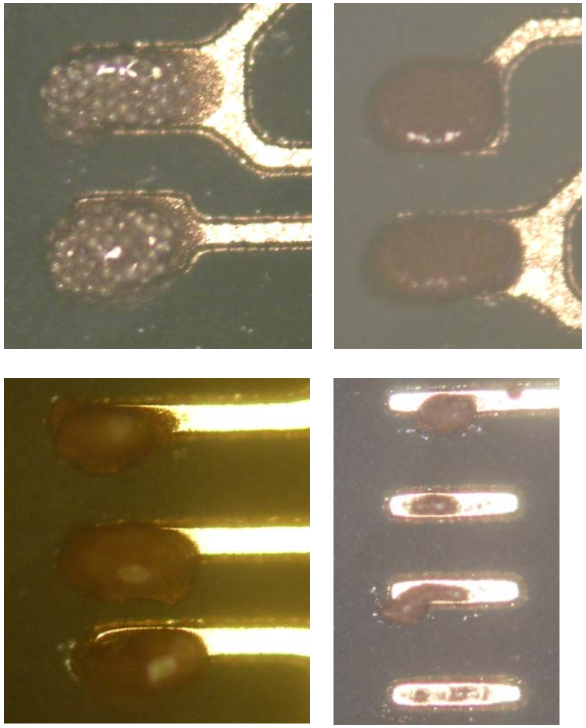
Stencile printing of ICA

- Used ICA with different sized polymer spheres.
  - 30 µm : silver coated (ICA-A).
  - 4µm : gold coated (ICA-B).

- ~50% volume fraction of spheres is used.

- Printing results dependent upon many factors such as:
  - Viscosity
  - Shear thinning
  - Stencil +++



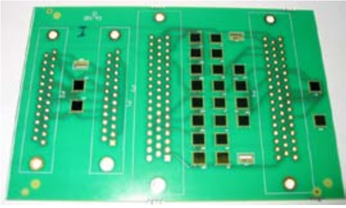


Experiments

- Temperature test between -46°C and +70°C. Compare performance of ICA-A adhesive vs. H20, a commercially available isotropic conductive adhesive.
- Temperature cycling test according to MIL-STD-883 G method 1010.8 test condition B (-55°C - 125°C).
  - 10 cycles
  - 100 cycles
- Vibration tests.
- Recovery firing tests. Temperature cycled samples were used in this experiment.

Comparison: ICA-A vs H20

- H20 is a silver epoxy based adhesive. The test structures were mounted by a commercial supplier.



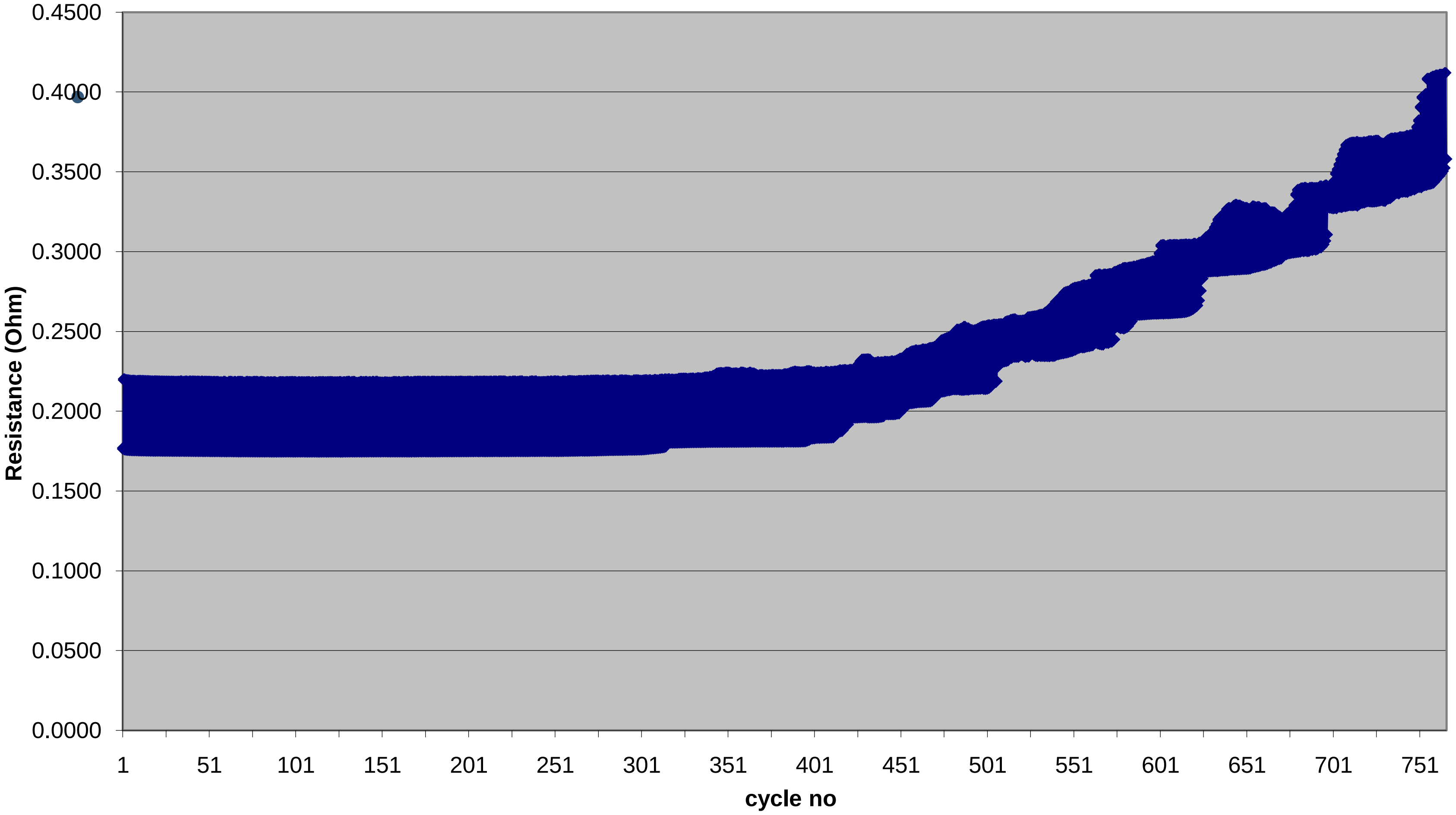
- ICA-A adhesive consists of 30 µm silver coated polymer spheres and EPO_TEK®353ND.

- Initial values for contact resistances:

Adhesive	R average (Ω)	Rmax (Ω)	Rmin (Ω)
H-20	0.061	0.098	0.048
ICA-A	0.549	1.394	0.182

Temperature performance: ICA-A vs H20

- H20: 14 of 23 CR passed 100 temperature cycles (60%).



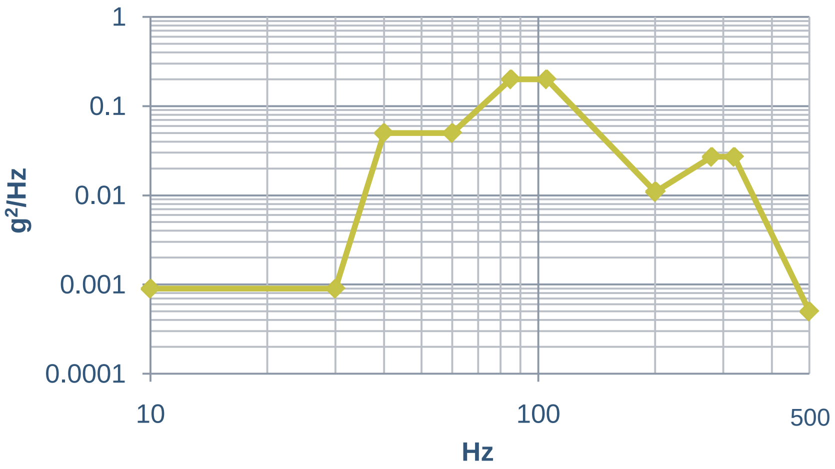
Temperature tests

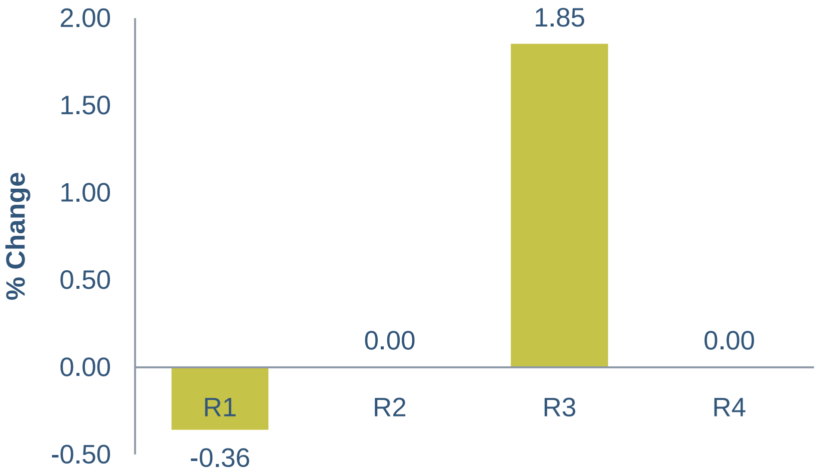
- Temperature cycling test according to MIL-STD-883 G method 1010.8 test condition B (-55°C - 125°C).
- No underfill on the test structures
- No resistances failed for the I-100 test structures.

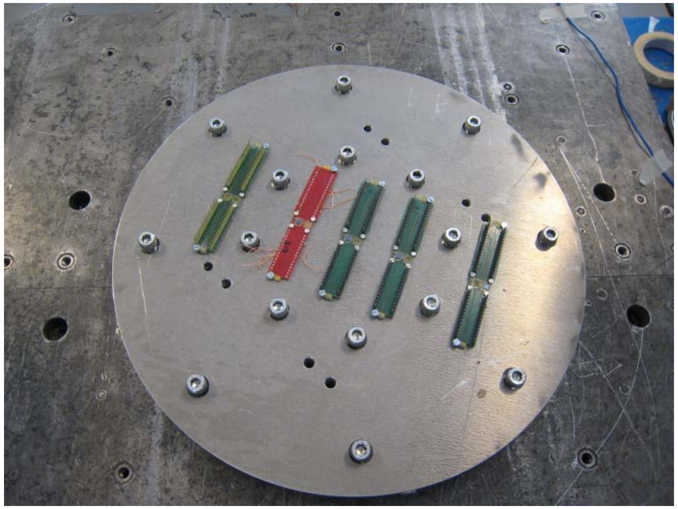
ICA with	No of cycles	Ω before	Ω after	% change
ICA-A (30µm silver spheres)	10	0.317	0.366	15.5
ICA-B (4 µm gold spheres)	10	0.091	0.079	-13.2
ICA-A	100	0.361	0.675	87
ICA-B	100	0.112	0.217	93.7

Vibration test

- Simulated transport vibration on tracked vehicle. Used acceleration spectral density from CV90 armoured combat vehicle.
- 1 hour test in each direction.
- Test structure mounted with ICA-A performed well.





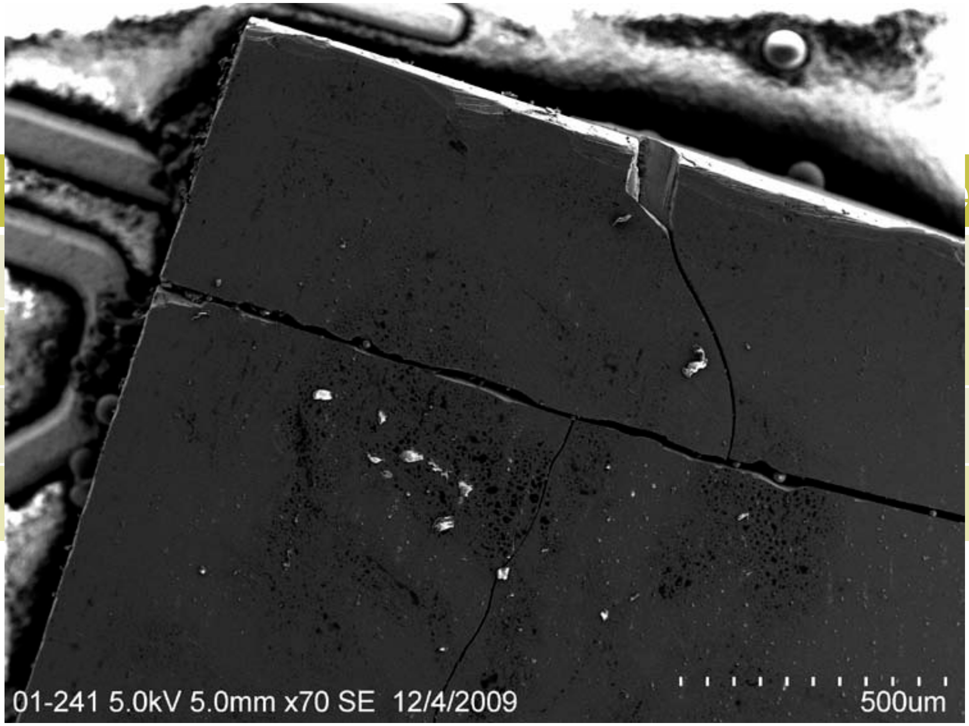


Firing test

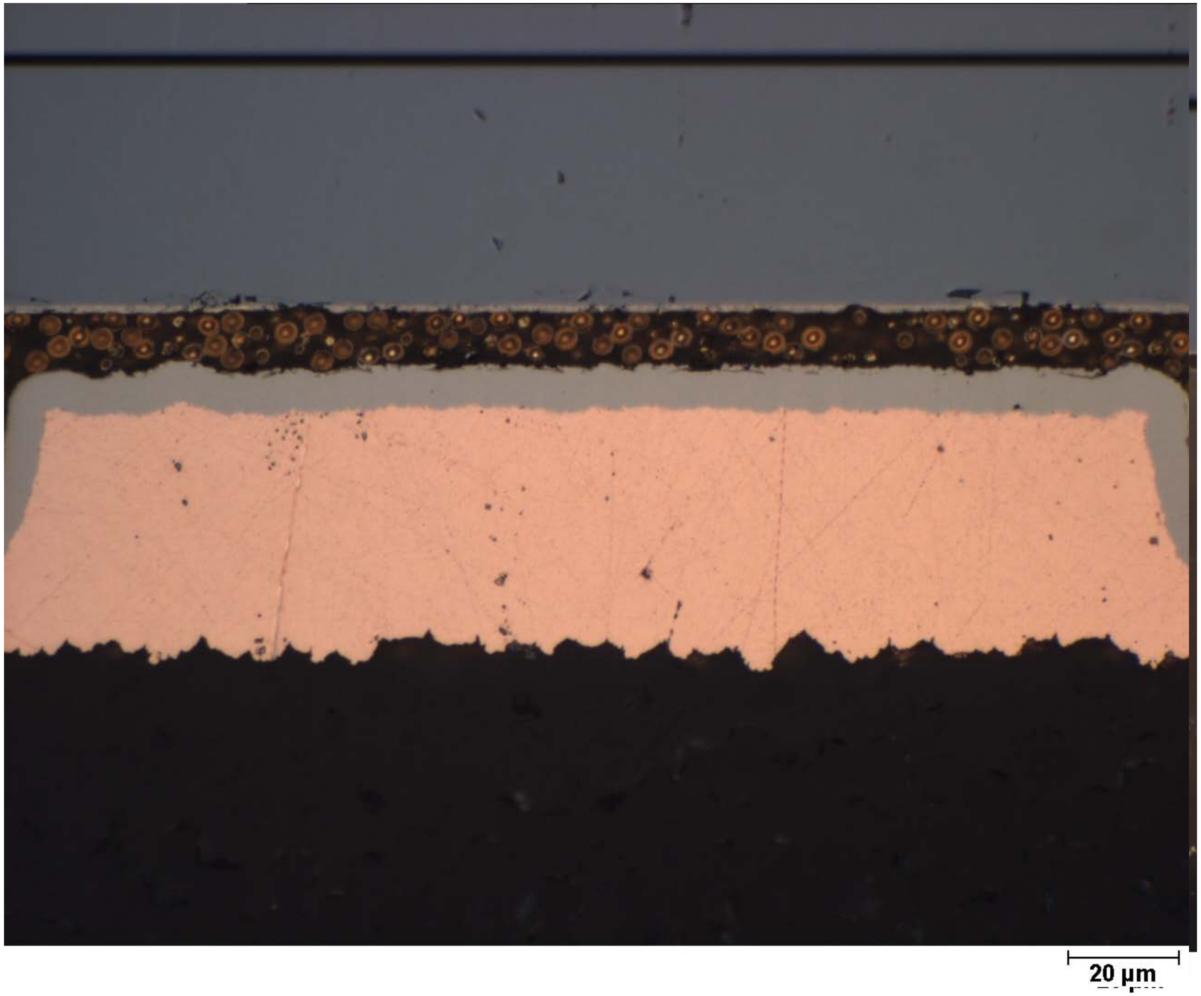
Firing test results

- All fired test structures have been exposed to temperature tests.
- 31 out of 36 contact resistances passed recovery firing test.
- Two test structures without underfill cracked.

ICA with	% change
ICA-A	-8.5
ICA-B	18.3
ICA-A	8.6
ICA-B	18.4



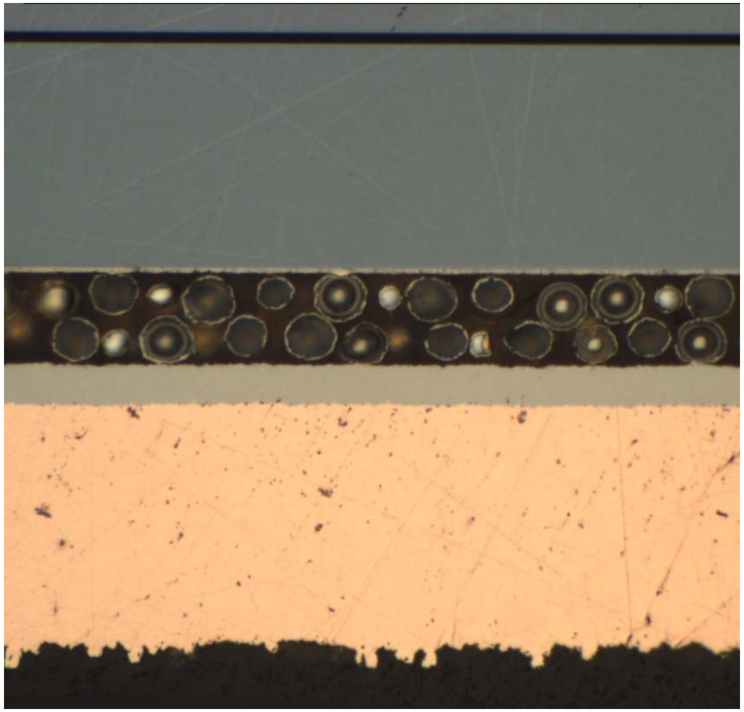
Cross sections



Conclusion

- ICA based on highly uniform metal coated polymer spheres seems to be a viable technology for mounting MEMS devices directly to PCB.

- Using this ICA technology may give higher packaging densities and reduced cost in future fuze applications. However, the stencil printing process must be improved.



Acknowledgement

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About the partners

- More information about the Norwegian Defence Research Establishment (FFI), Conpart and Sintef ICT can be found here:

- FFI: www.ffi.no

- Conpart: www.conpart.no

- Sintef ICT: www.sintef.no