Packaging technologies for high temperature control electronics

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Outline

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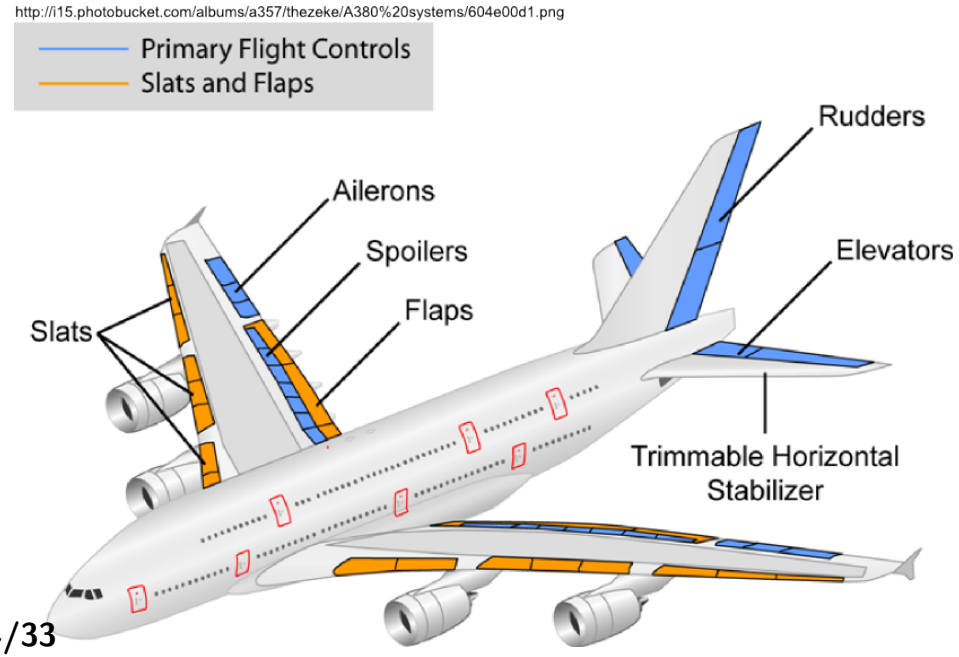
CREAM

Compact and **R**eliable **E**lectronic
integrated in **A**ctuators and **M**otors

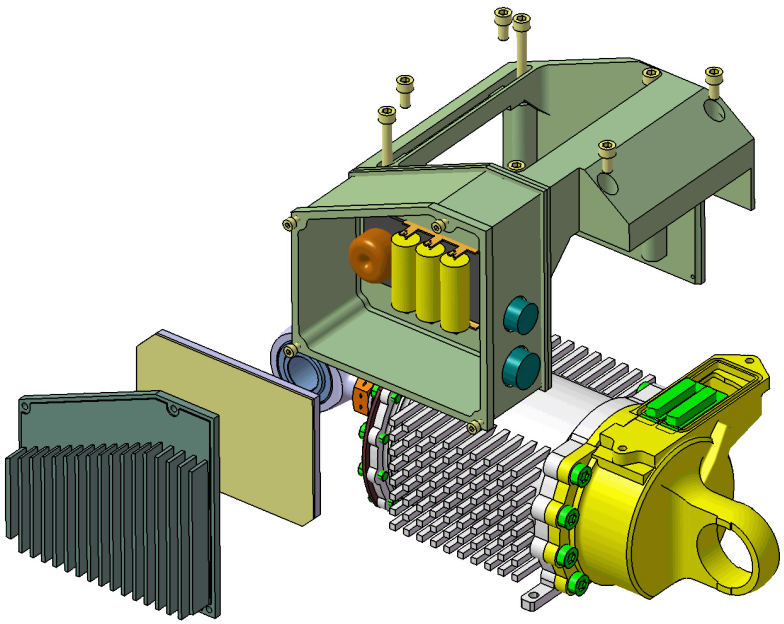
- Future Aircraft will have to meet environmental goals while still remaining competitive—requiring a reduction in size, weight and complexity

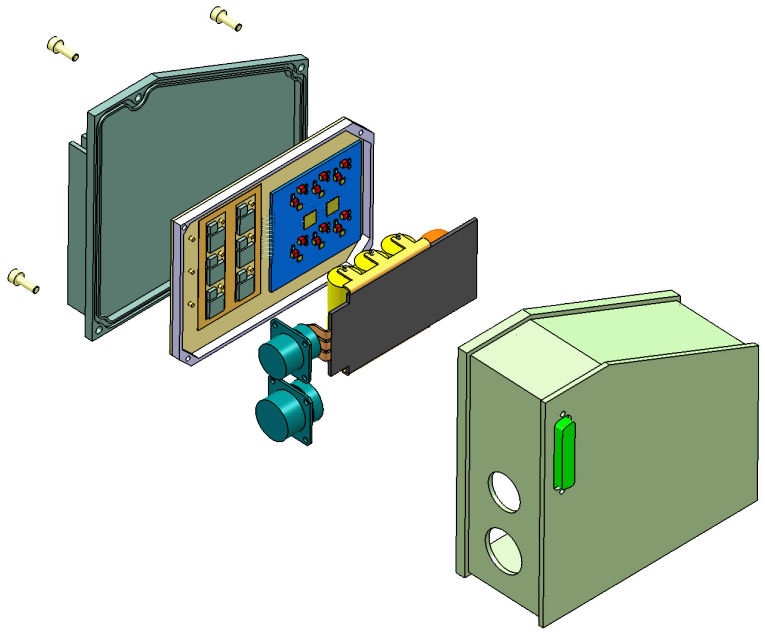


- Removal of all Aircraft hydraulic and Pneumatic systems
- All are replaced with Electro-Mechanical Actuators (EMAs)
- Engines to supply **Propulsion** and **Electricity** only

High Temperature Electronics

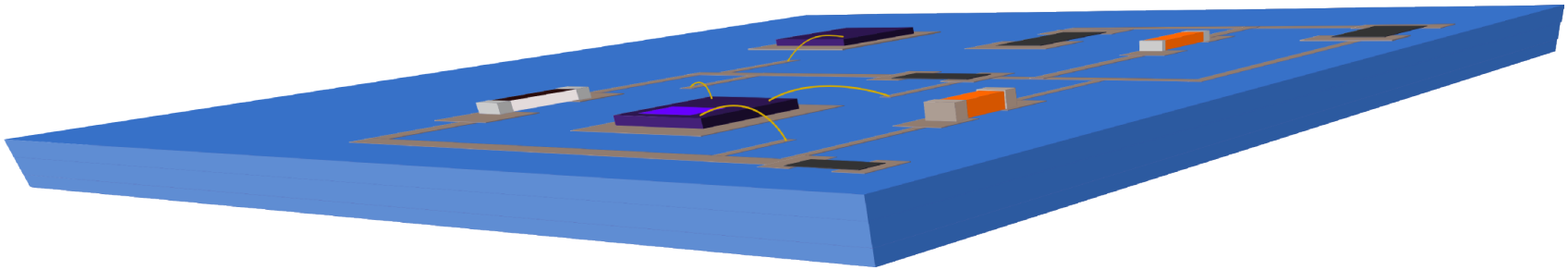
- Reduce size — Increase power density
- Reduce complexity — Remove cooling from system
- Necessitates high temperature (200°C) electronics





High Temperature Packaging

- Chemical reactions, diffusion of particles increase exponentially with temperature
- Larger change in temperature applys more stress on materials



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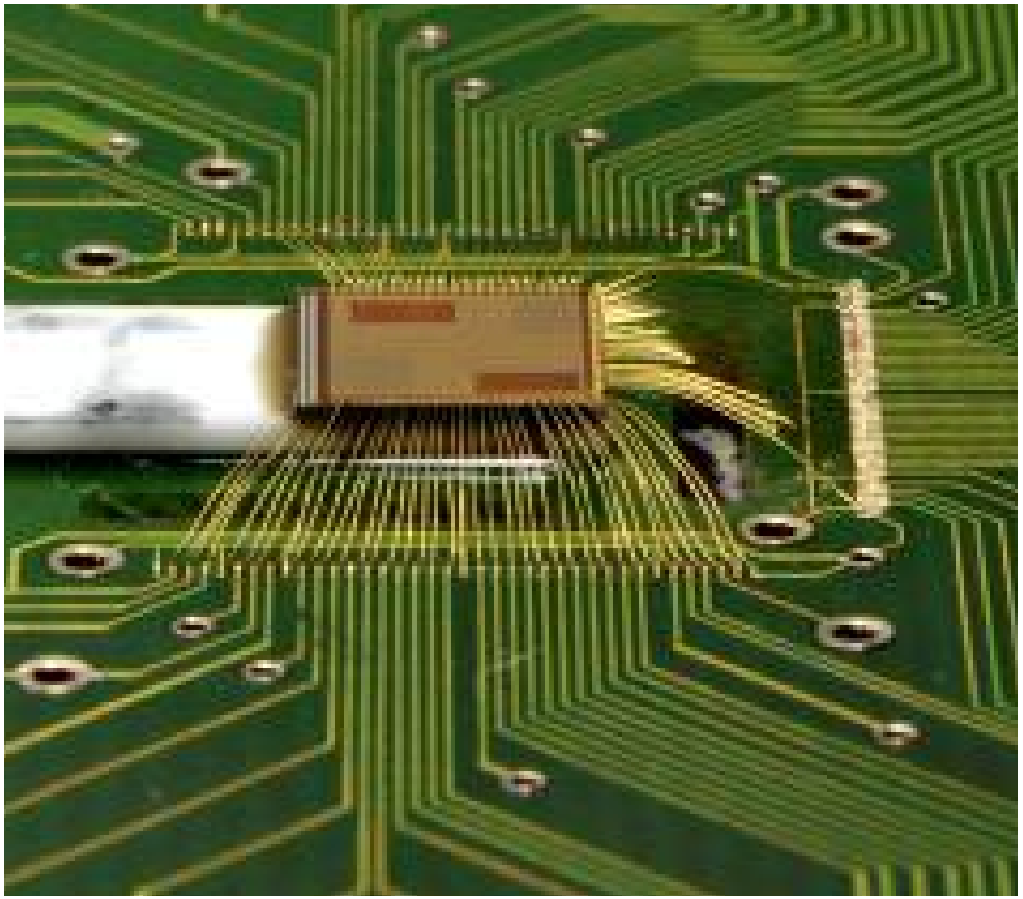
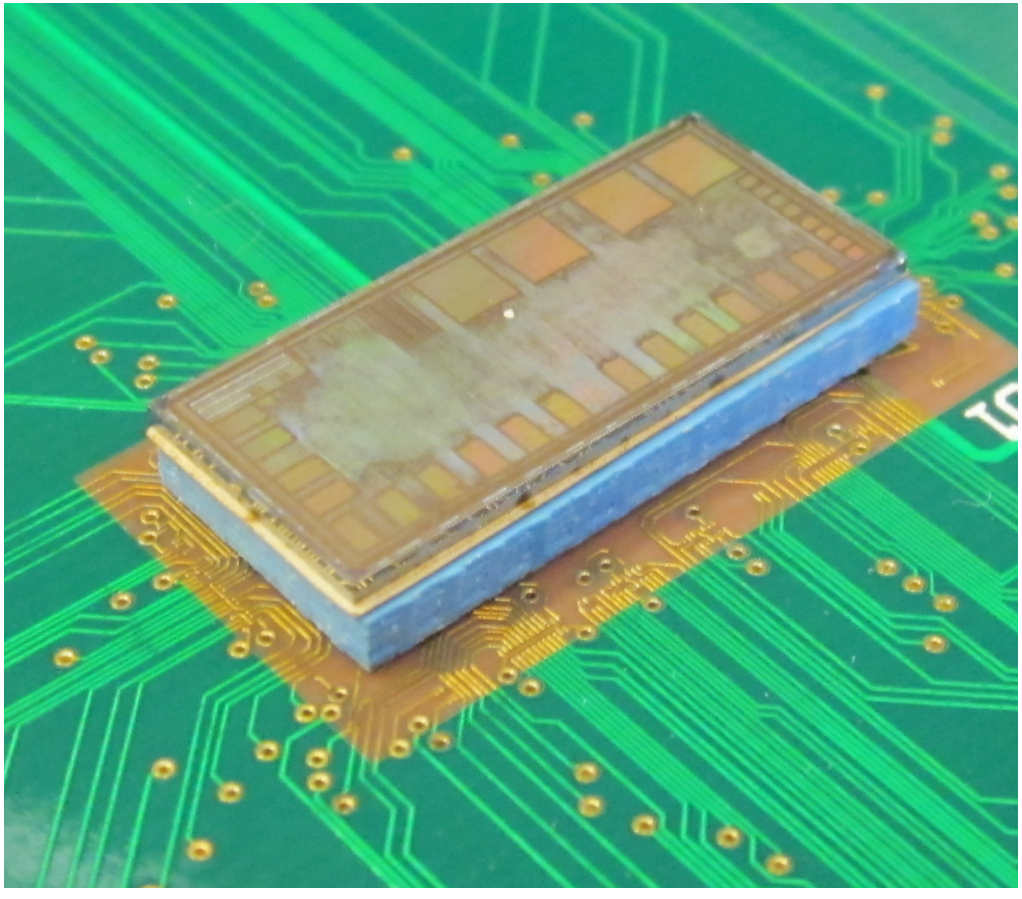
"Prometheus"



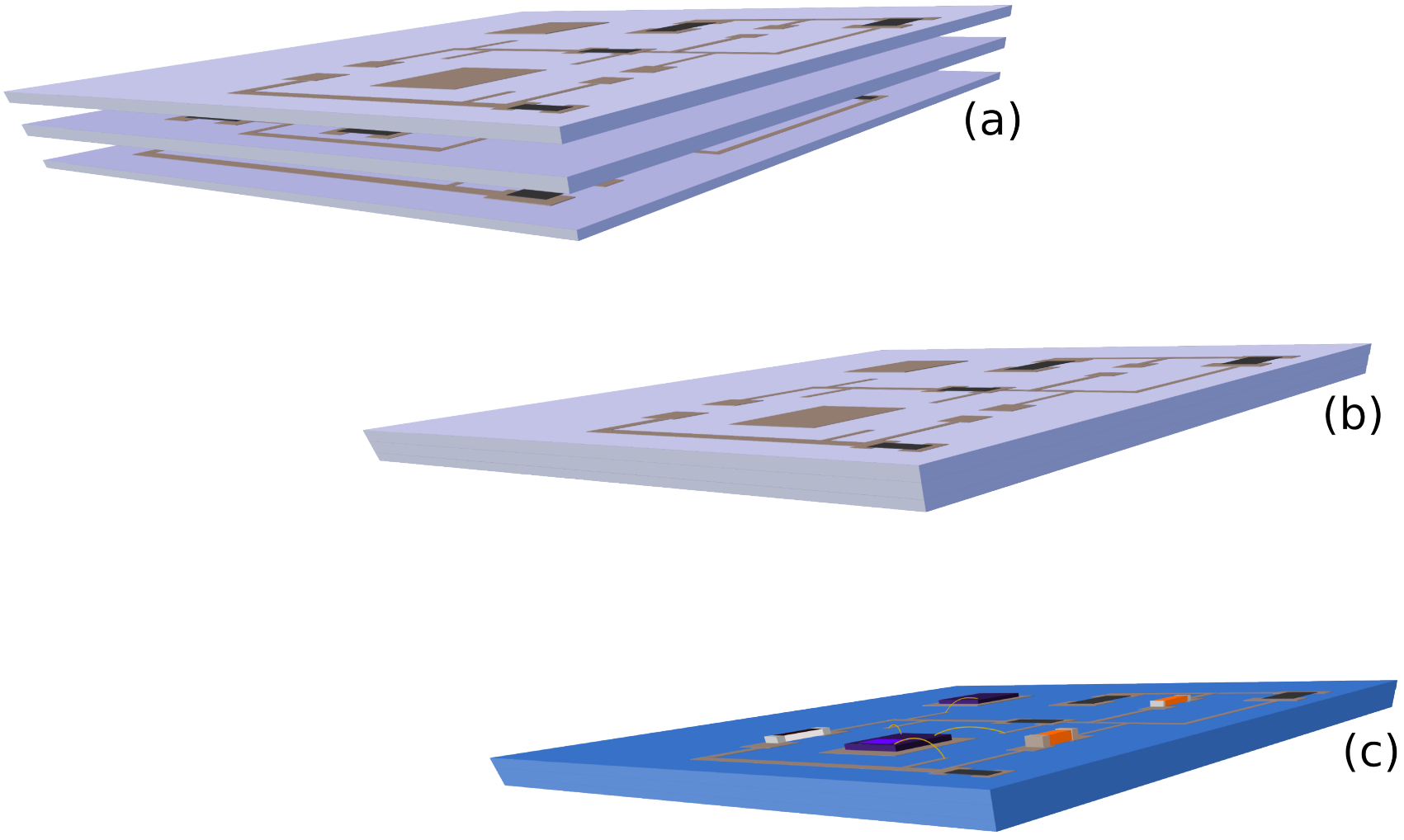
- Silicon on Insulator
- 160 interconnects
- 5×5 mm area
- 725 μm thick
- Aluminium top metal
- Bare silicon base

"Firebird"



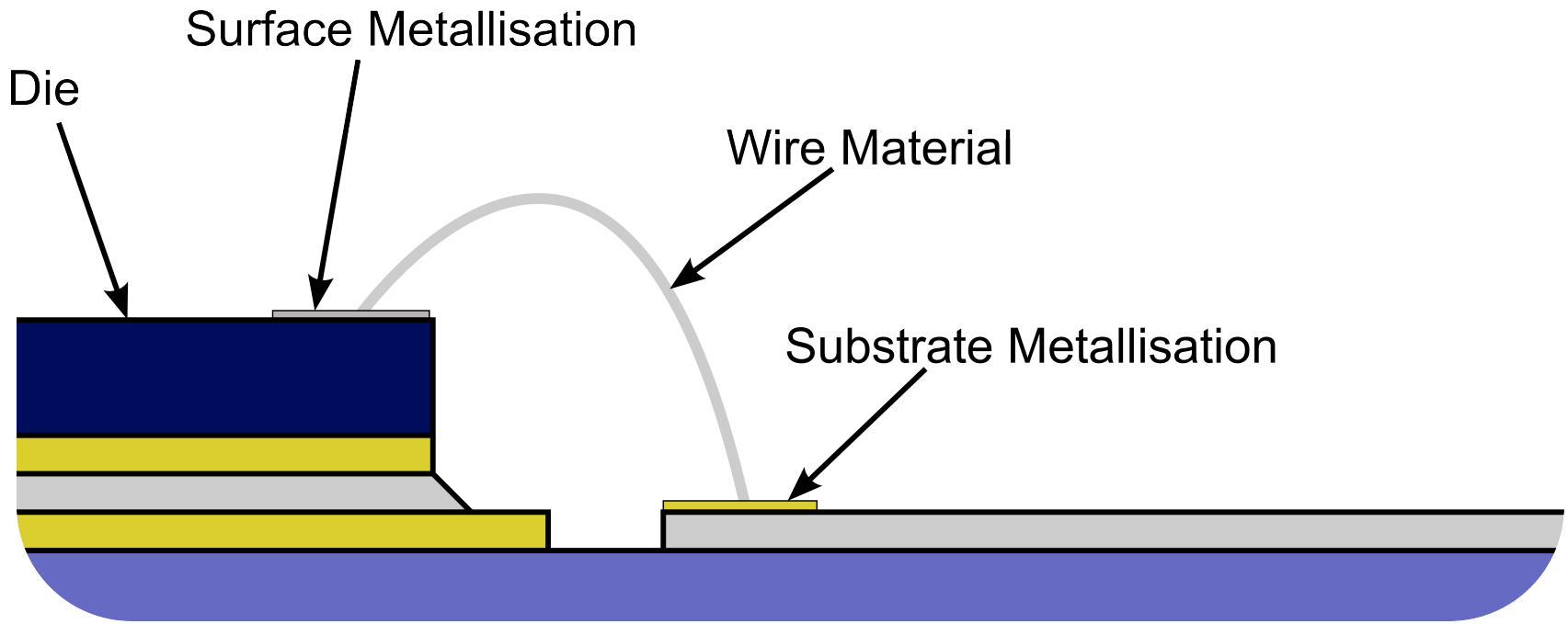
- CMOS Bulk
- 256 interconnects
- 20 $\times$ 9 mm area
- 725 μm thick
- Aluminium top metal
- Bare silicon base

LTCC



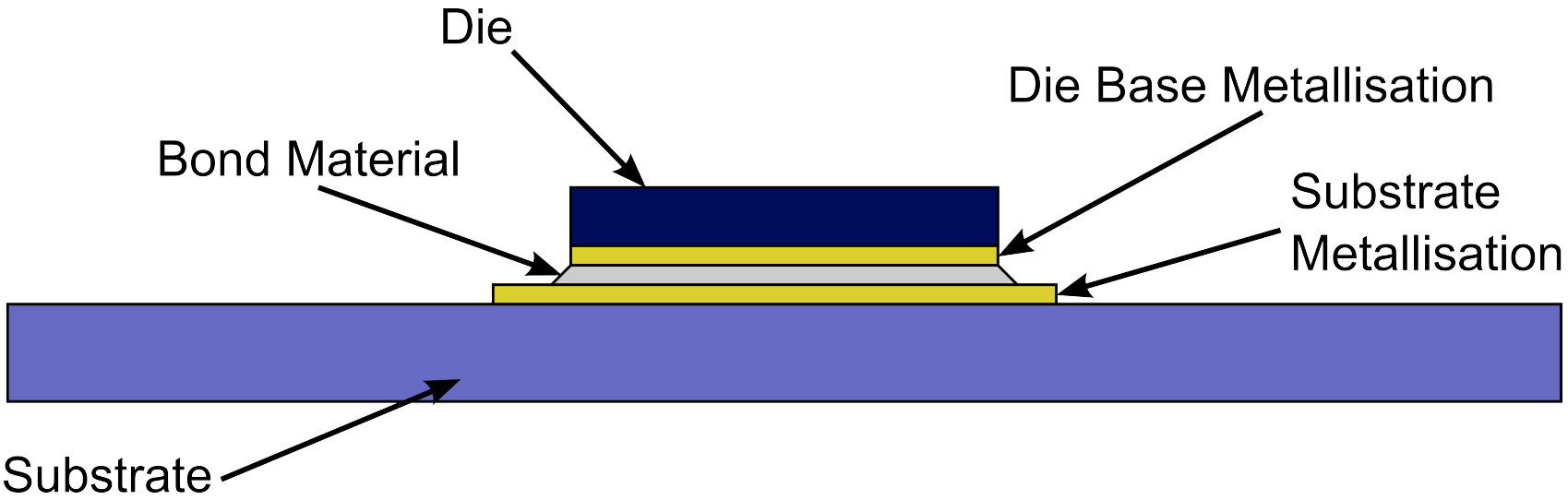
- Multilayer technology
- Stable at high temperatures

Wire bonds



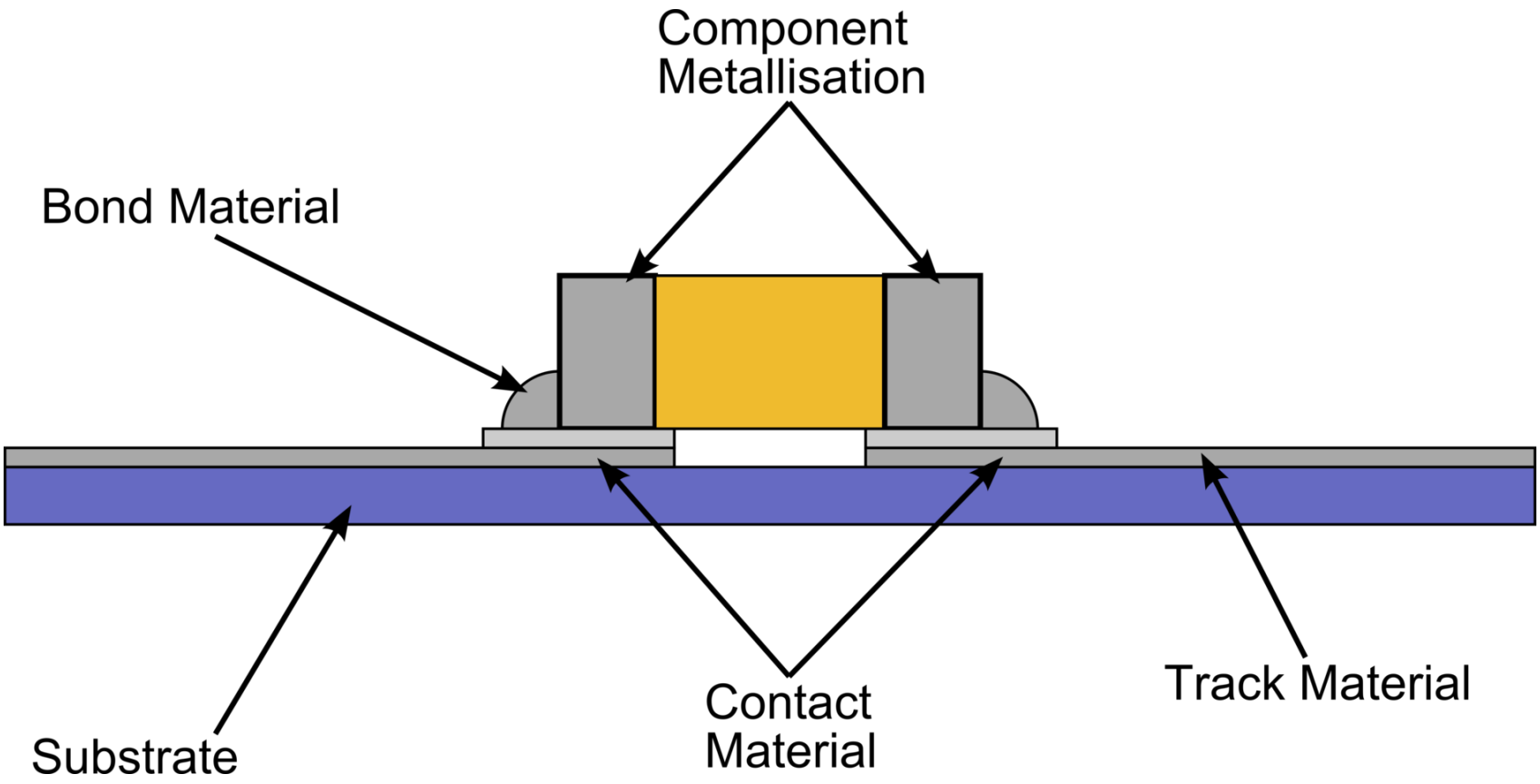
- High density of interconnects
- Aluminium wire bonds

Die Attach



- No back-side metallisation
- Epoxy adhesive suitable

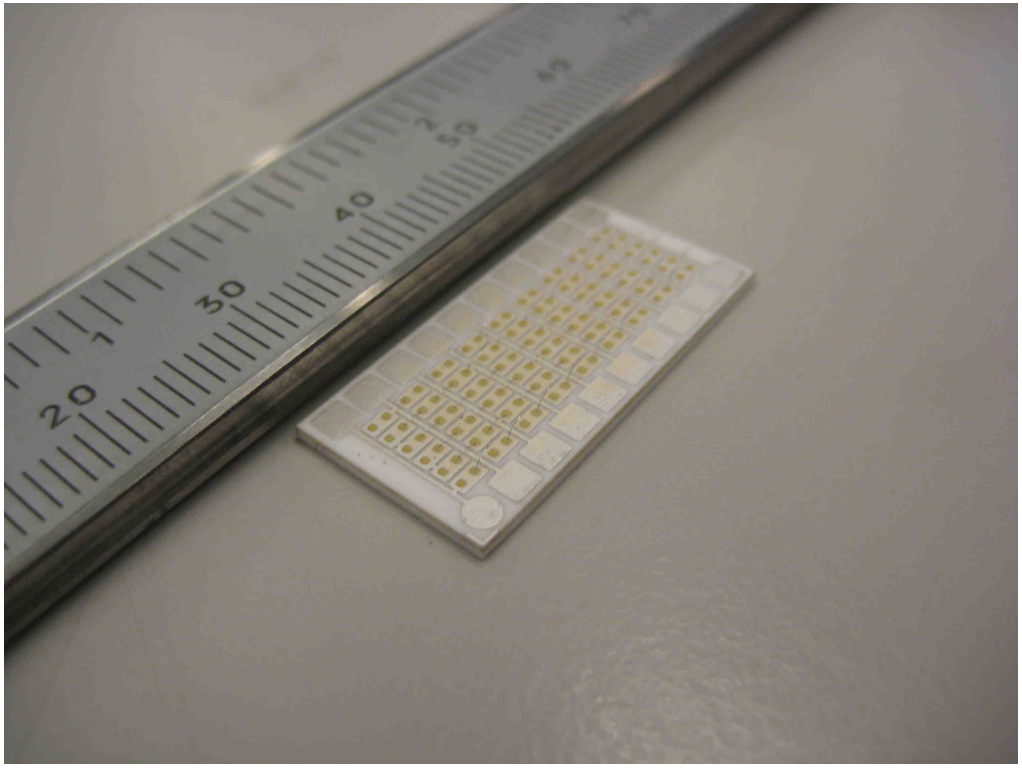
Discrete Components



- Conductive adhesive — low conductivity
- High lead or lead free solder

Outline

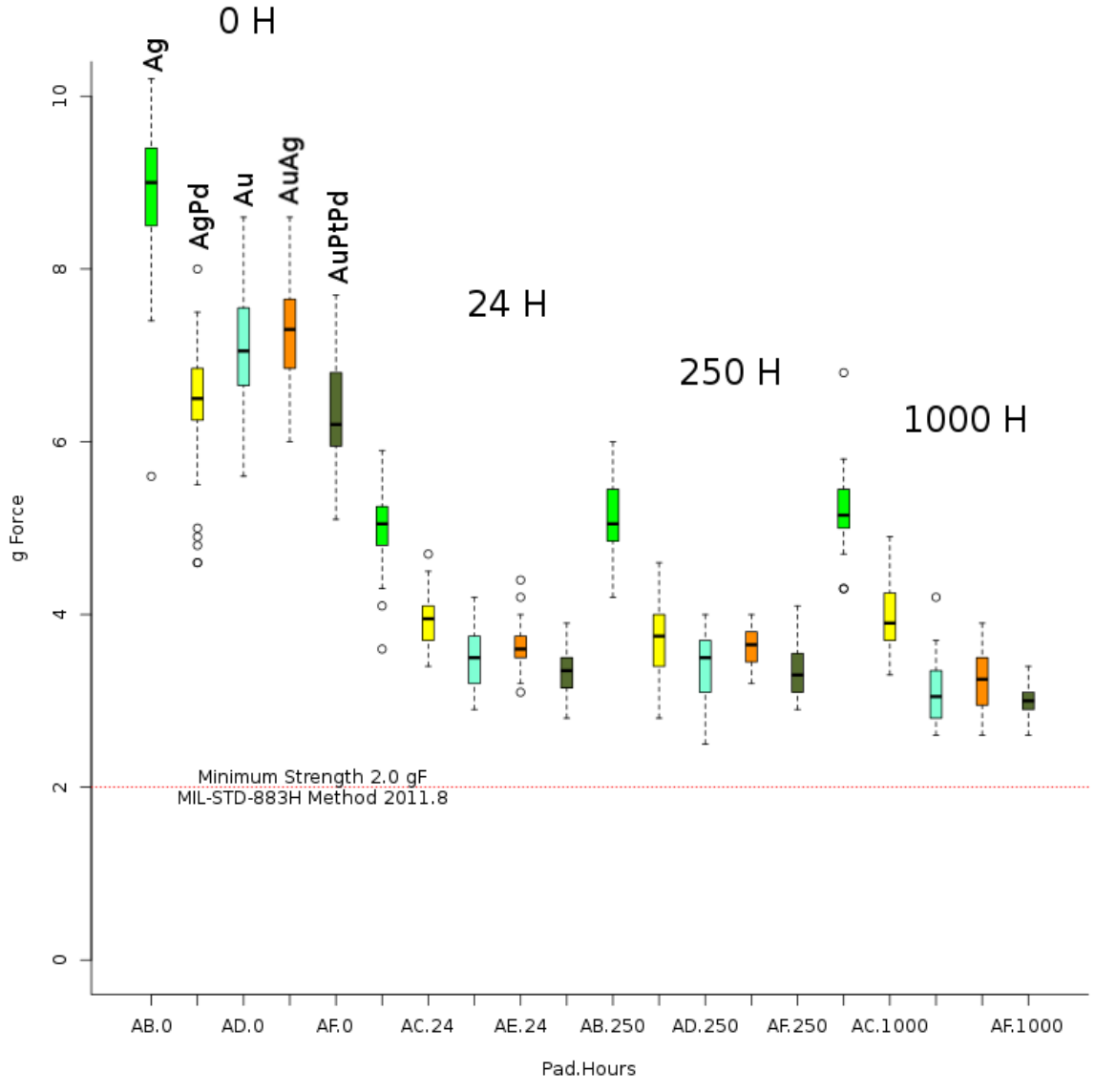
Wire bond test vehicle



48 25μm 99%Al 1%Si wirebonds in daisychain

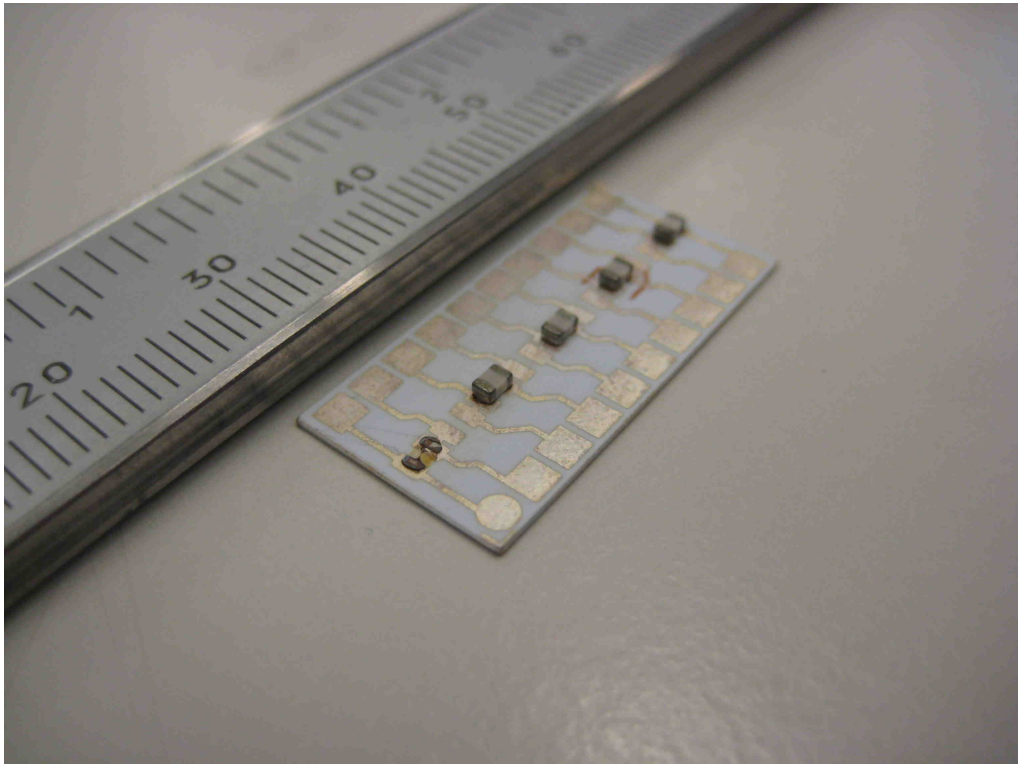
Type
Silver
Silver Palladium
Gold
Gold-Silver
Gold-Platinum-Palladium

High temperature storage and pull tests



- 210°C storage
- Pull tests at 0, 24, 250, 1000 hours
- Silver strong but oxidizes
- All gold containing pads show similar performance

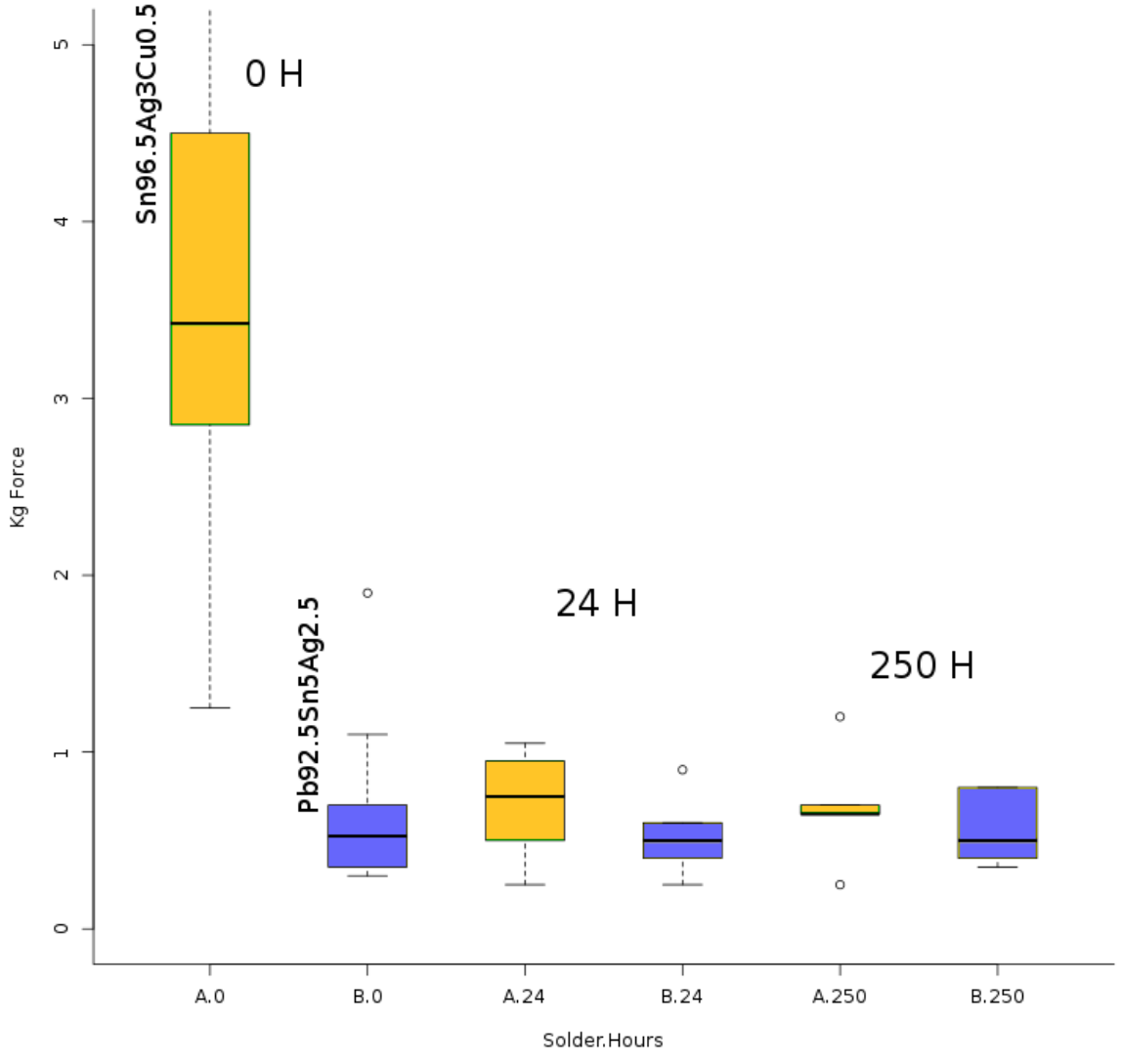
Discrete component test vehicle



5 high temperature capacitors

Type	Liquidus/ Solidus
Sn96.5Ag3Cu0.5	220/217
Pb92.5Sn5Ag2.5	310/300

High temperature storage and shear tests



- 210°C storage
- Shear tests at 0, 24, 250 hours
- Fracture through solder for higher shear strengths
- Lower strenth from pad dissolved by solder

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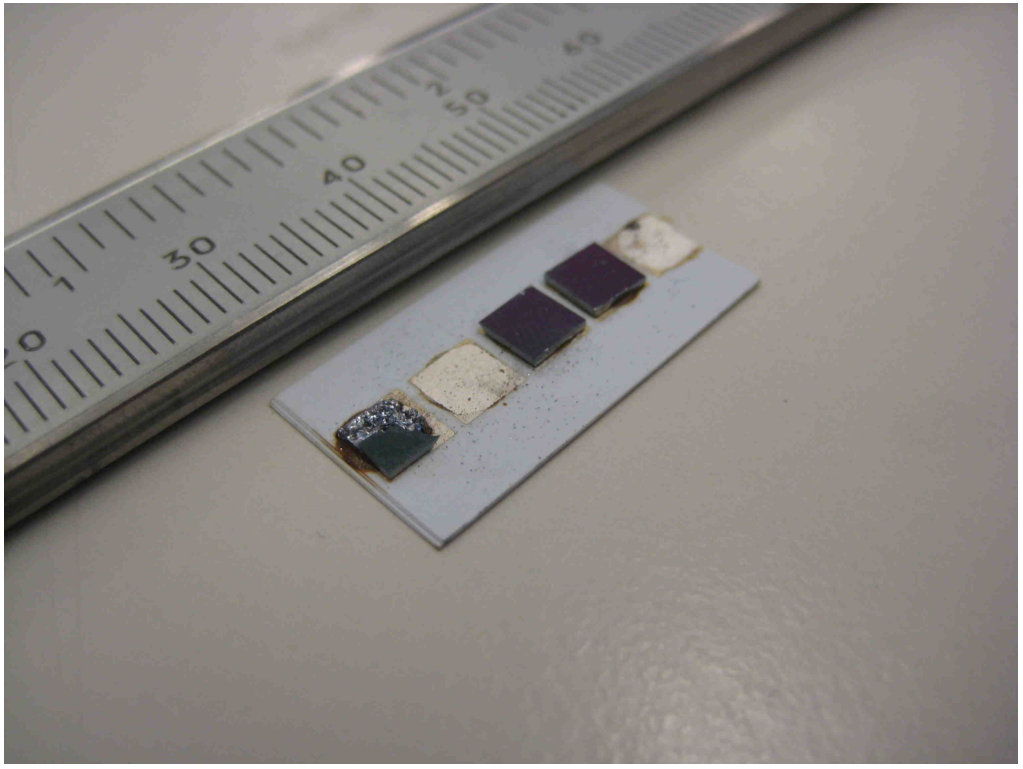
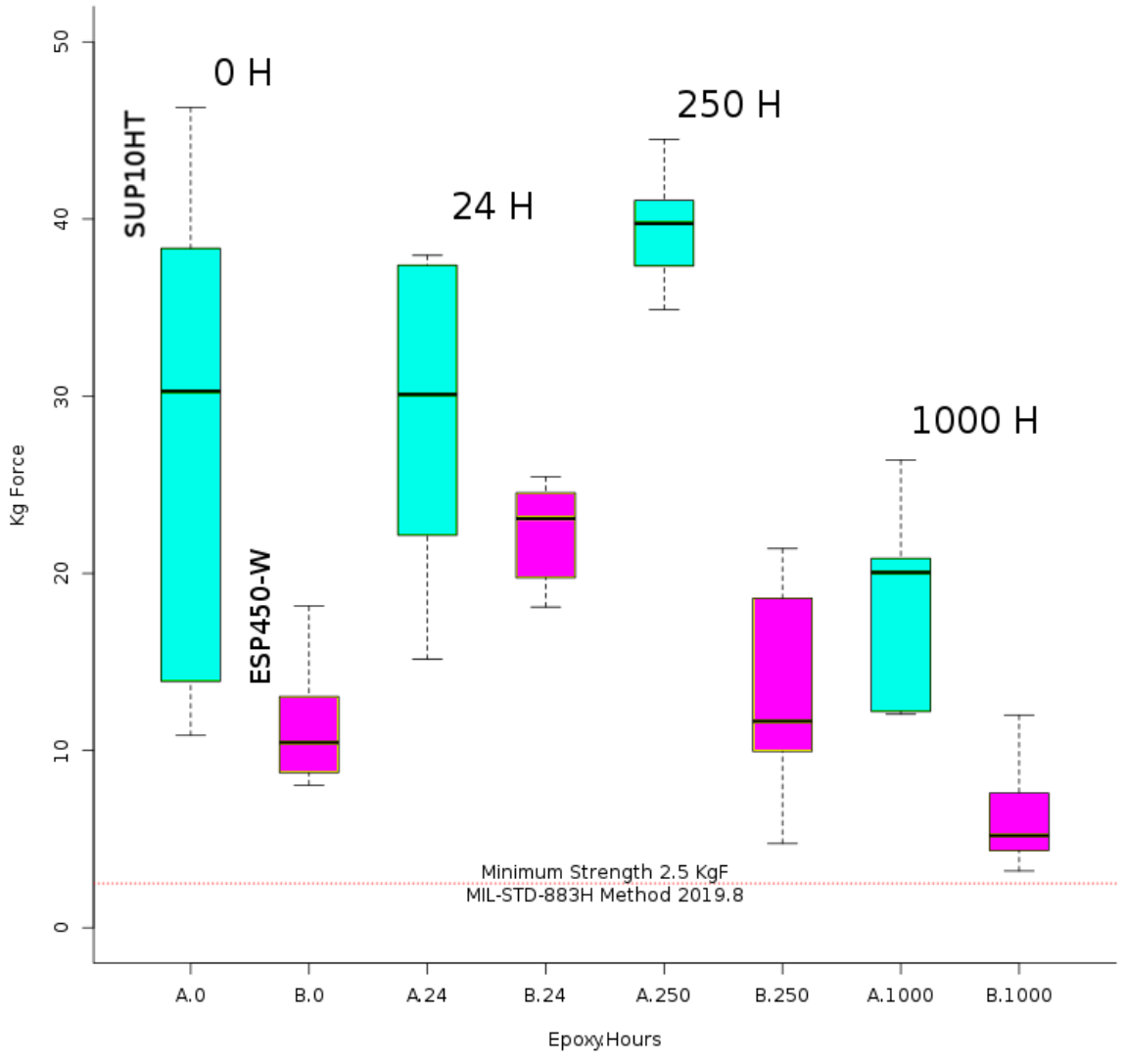
Die attach test vehicle



5 silicon dummy dies bonded to substrate

Type	
SUP10HT	
ESP450-W	Ag filled

High temperature storage and shear tests

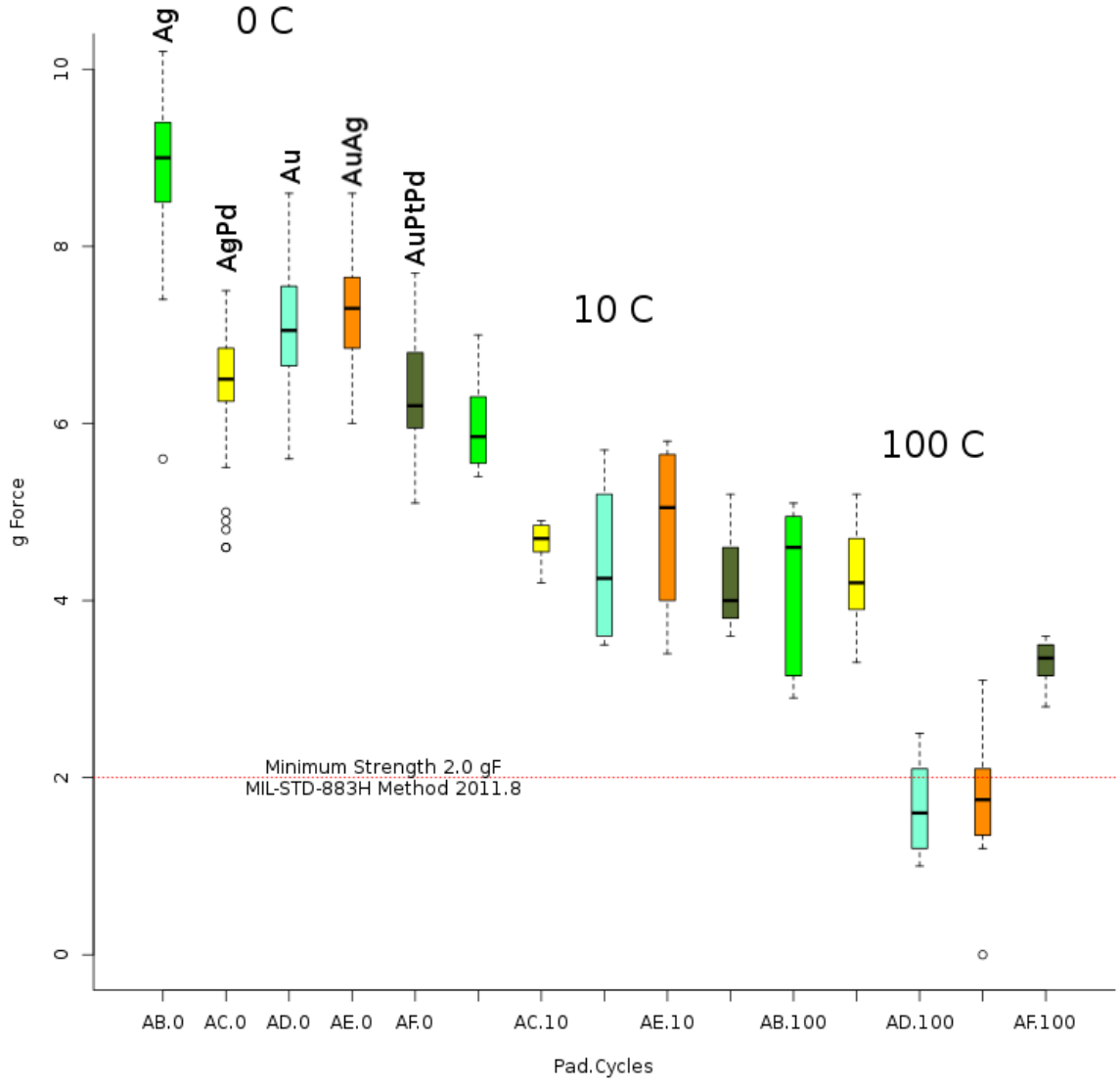


- 210°C storage
- Shear tests at 0, 24, 250, 1000 hours
- Initial increase in strength — continued curing
- Later decrease in bond strength — breakdown of bonds

Outline

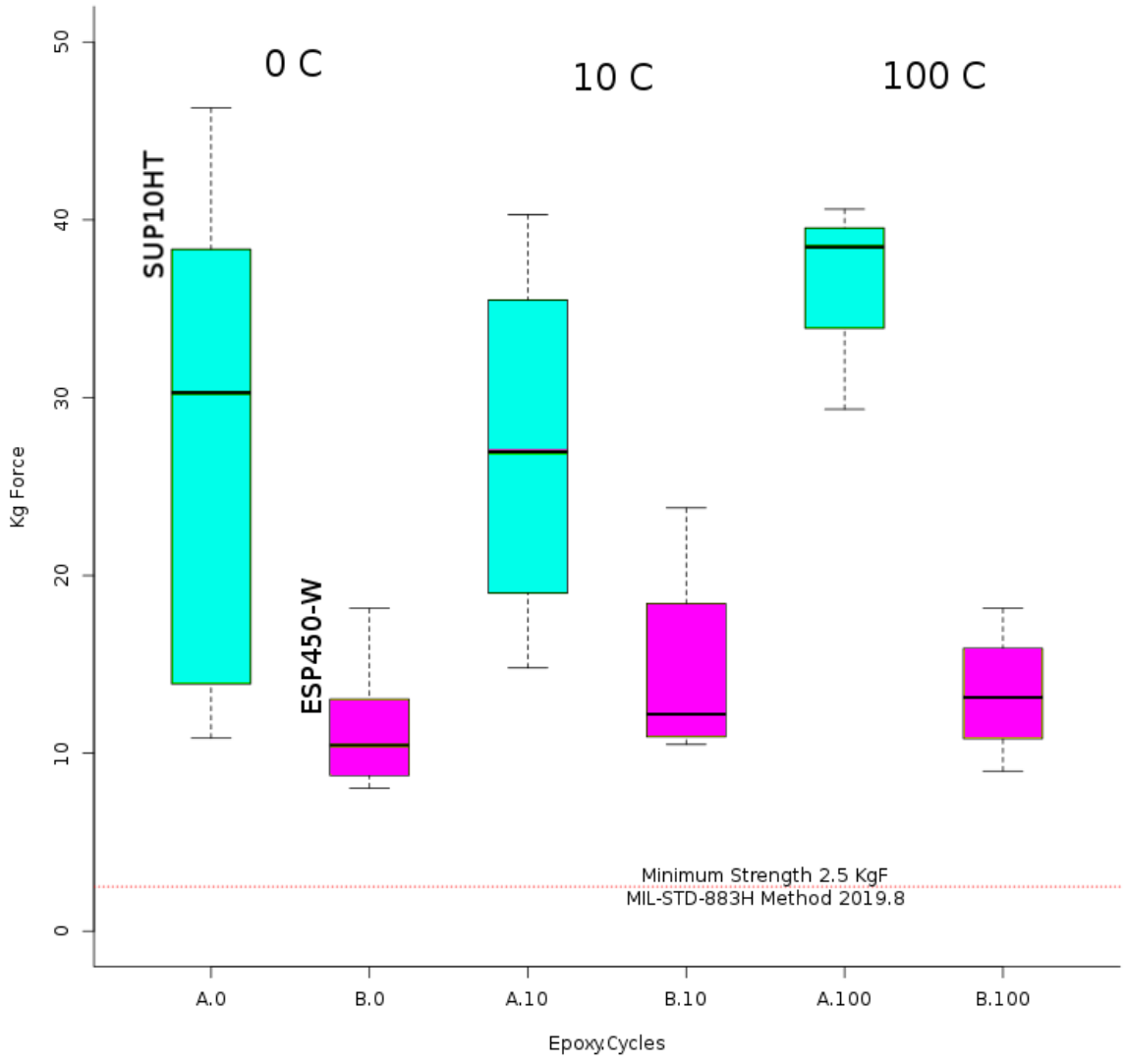
Wire bond temperature cycling and pull tests

- Cycles from -20°C to 180°C
- Pull tests at 0, 10, 100 cycles
- Drop in pull strength for all types
- High gold containing pads worst



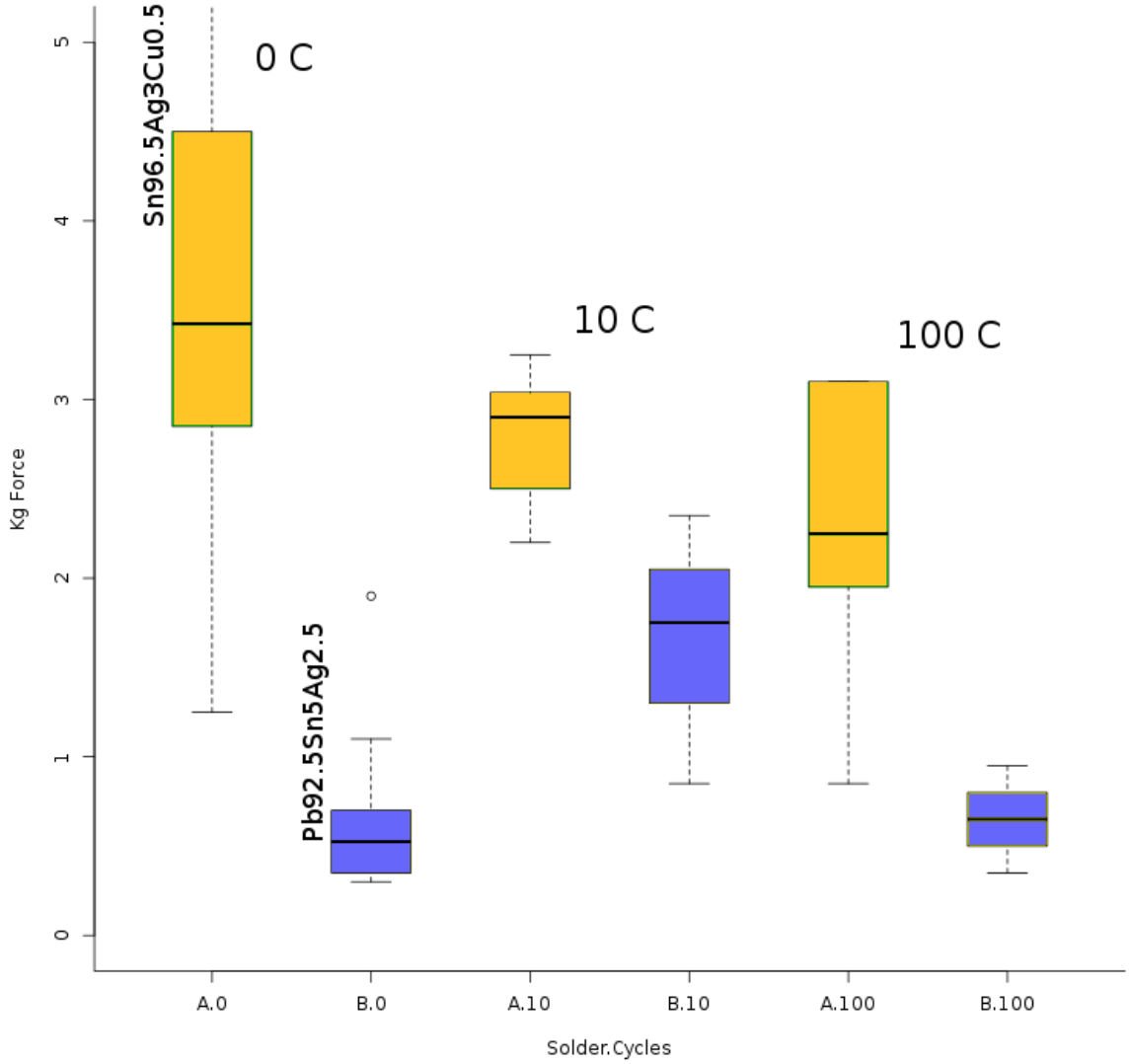
Die attach temperature cycling and shear tests

- Cycles from -20°C to 180°C
- Shear tests at 0, 10, 100 cycles
- No decernable change
- High flexibility



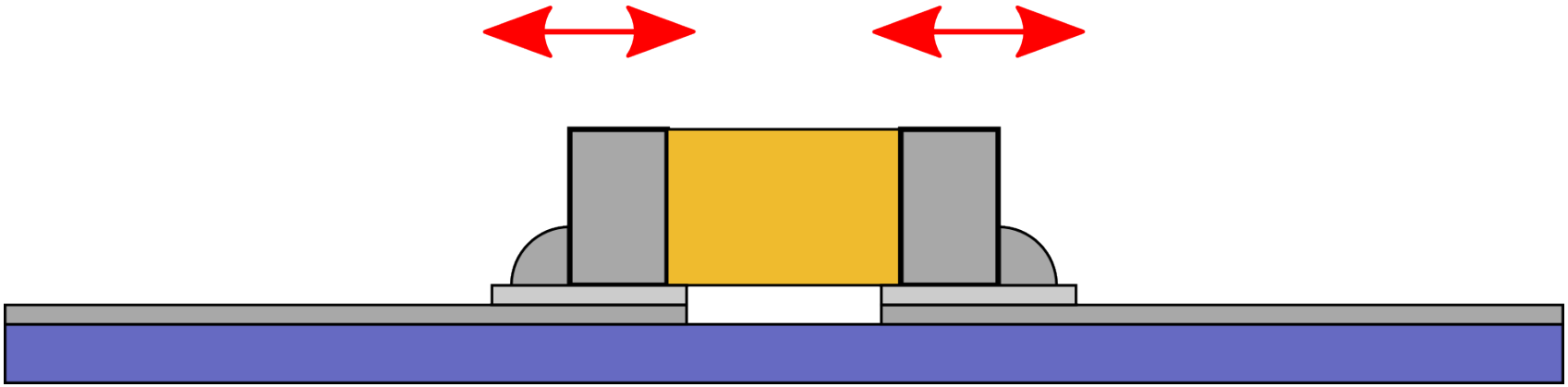
Discrete components temperature cycling and shear tests

- Cycles from -20°C to 180°C
- Shear tests at 0, 10, 100 cycles
- No change for high lead solder
- Slow decrease in strength for lead free



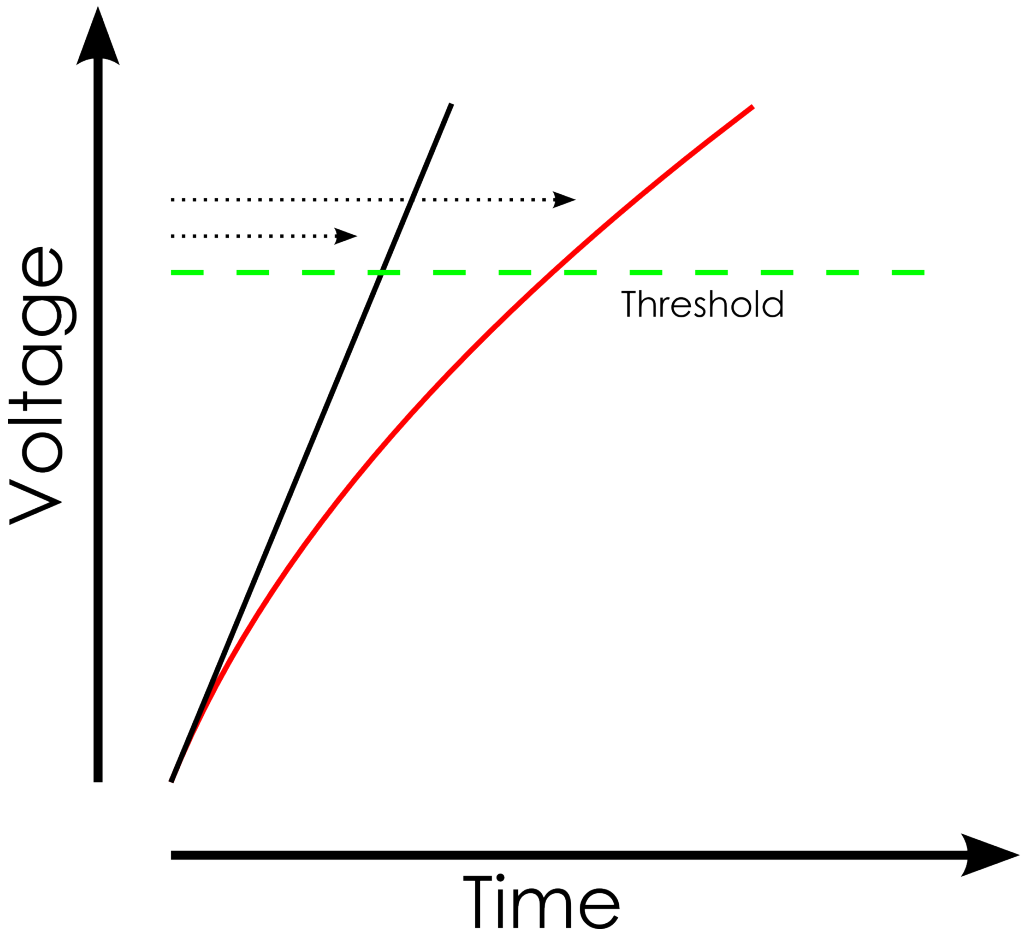
Outline

Effect of packaging on component



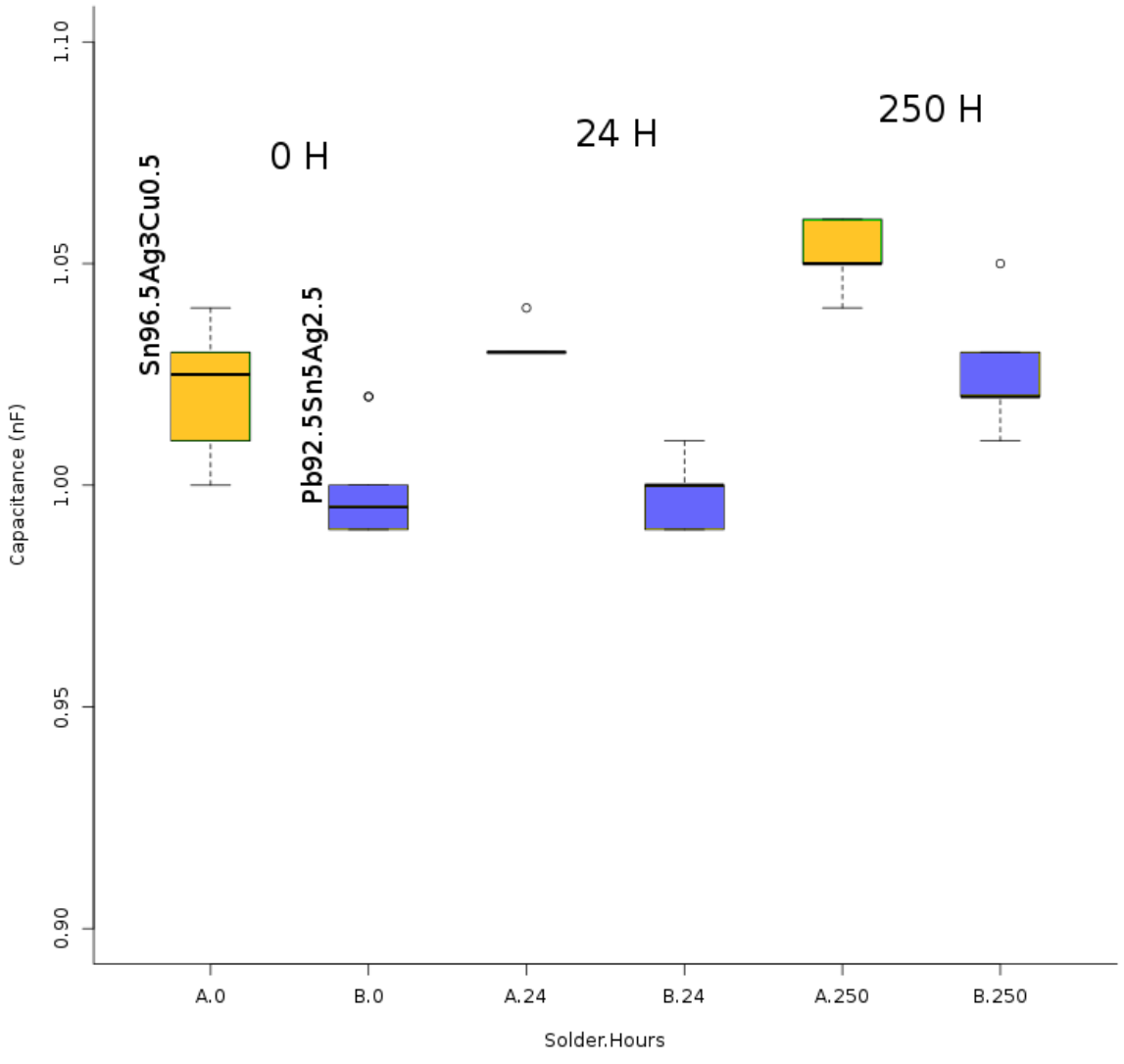
- Package to protect component
- Capacitors sensitive to packaging type

Capacitance Measurement



- Leakage current affects measurement
- Increase in capacitance an indication of leakage
- Simple method for determining damage

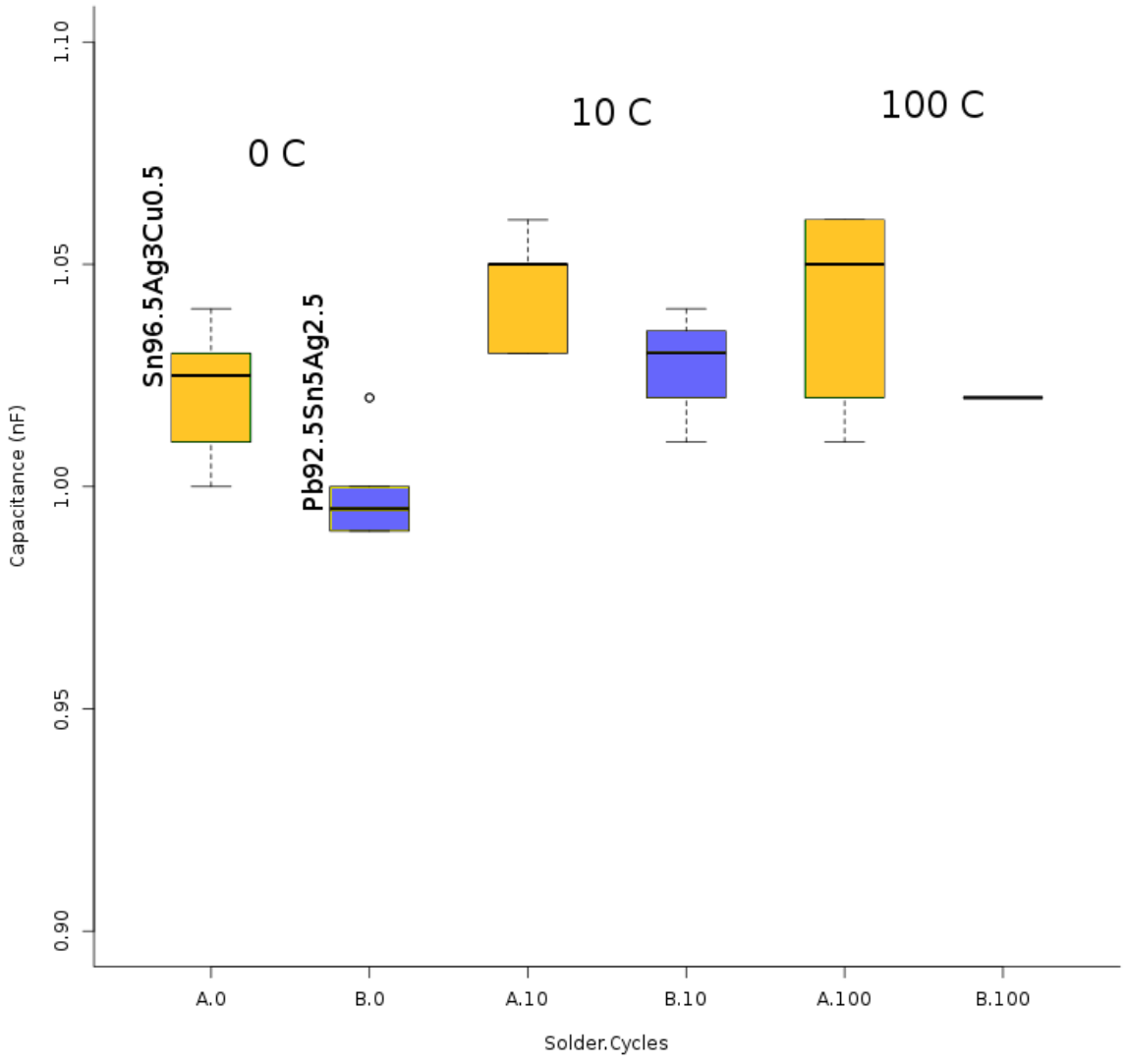
Change in capacitance after temperature storage



- 210°C storage
- Capacitance measurment at 0, 24, 250 hours
- Increase in capacitance after 250 hours
- High lead less effect than lead free

Change in capacitance after cycling

- Cycles from -20°C to 180°C
- Cppacitance mesurements at 0, 10, 100 cycles
- Increase after 10 cycles
- Lead containing less effect



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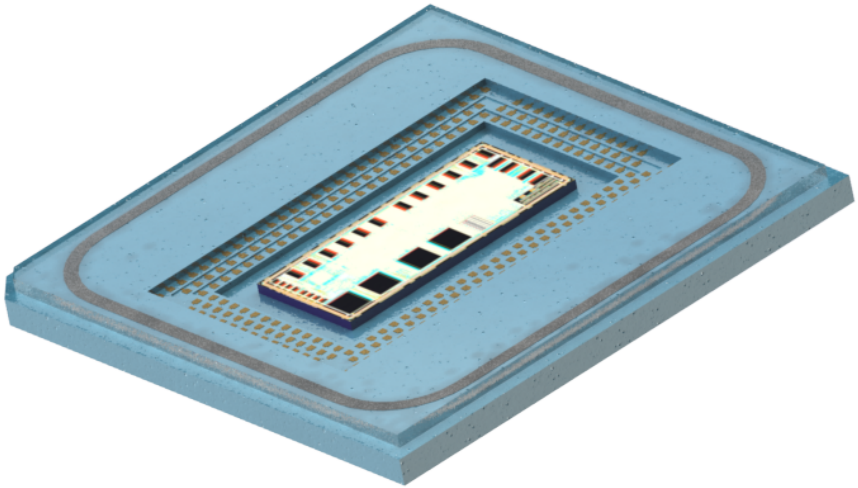
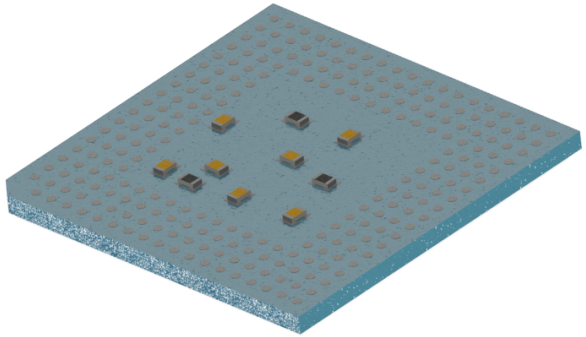
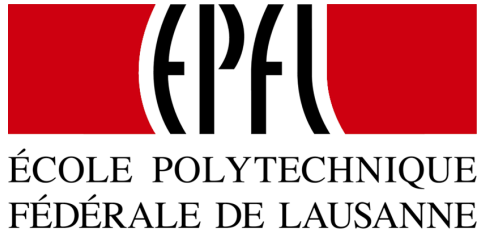
Conclusions

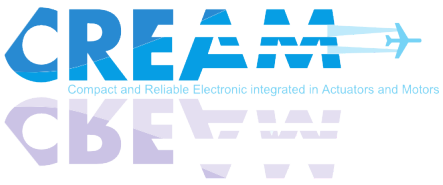


- Epoxy Die Attach
- Aluminium Wire Bonds — Au-Pt-Pd Pads
- High Pb Solder



Thank you for your attention





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