Fabrication and test of high-temperature ceramic transformer

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Outline

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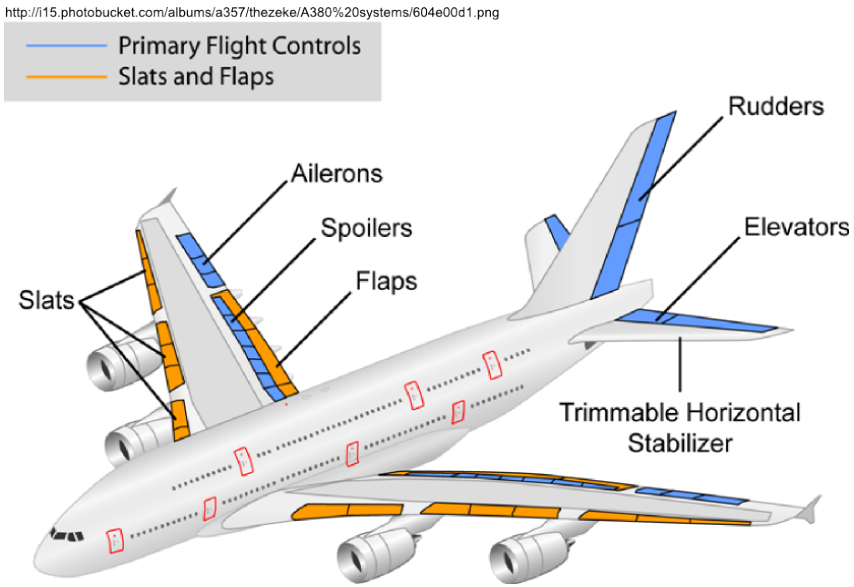
CREAM — FP7 Project

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

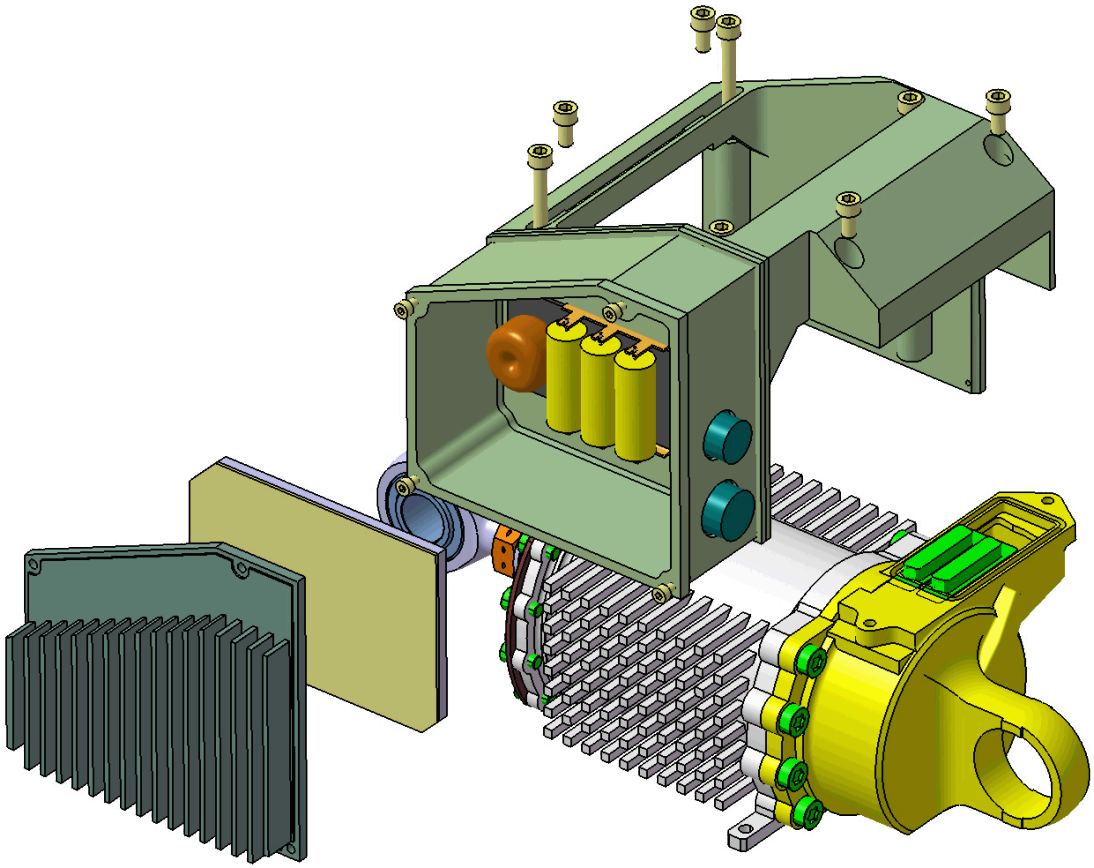


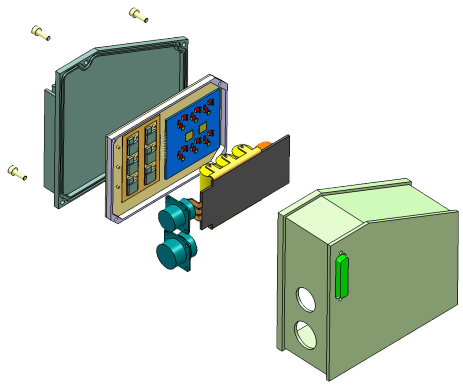
- Removal of all Aircraft hydraulic and Pneumatic systems
- All are replaced with Electro-Mechanical Actuators (EMAs)
- Engines to supply **Propulsion** and **Electricity** only

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

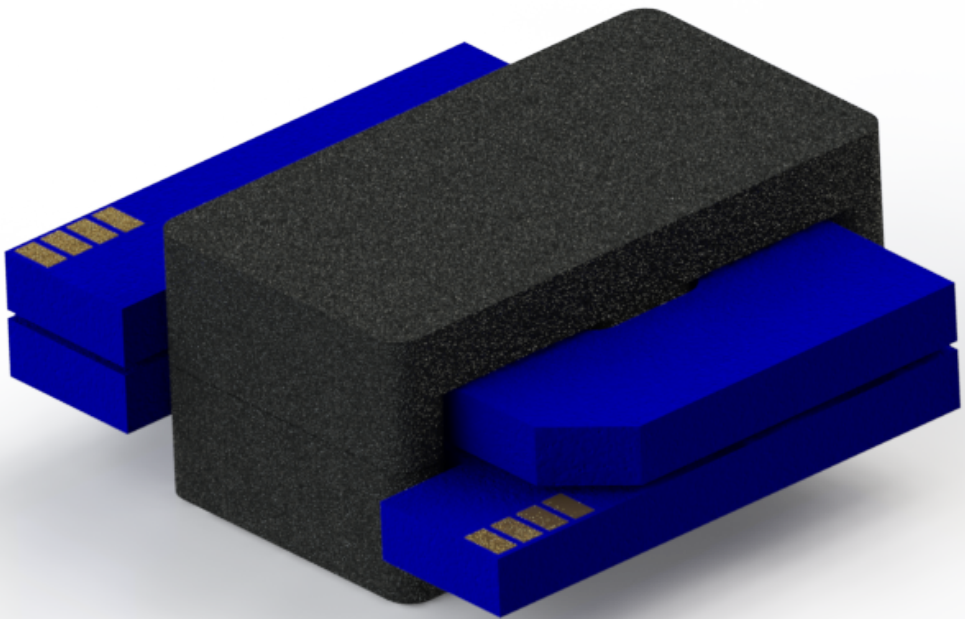
High Temperature Electronics

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





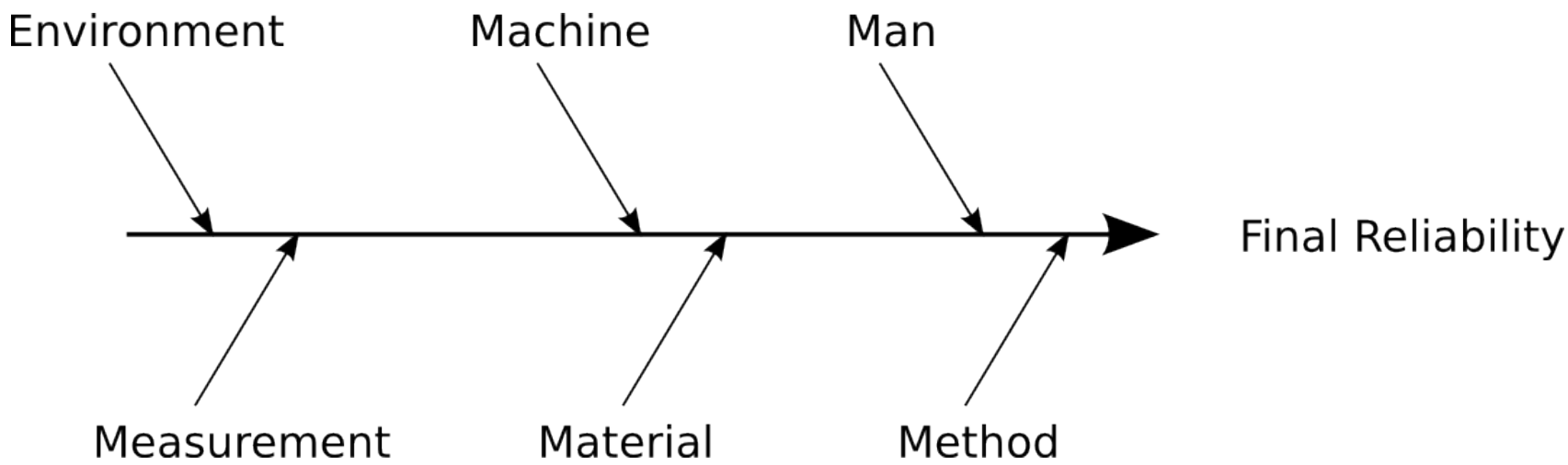
High Temperature 200°C Transformer



- 5 windings
- 2 Sections of LTCC
- 2 E-cores
- 250 μm gap for LTCC
- 40 μm gap between cores

Reliability

"...in the future there will be less focus on developing precise measurements of failure rate by sampling the output of a manufacturing line, and more focus on understanding and controlling the many input variables of a manufacturing line which ultimately affects the product reliability" — Crook, 1990



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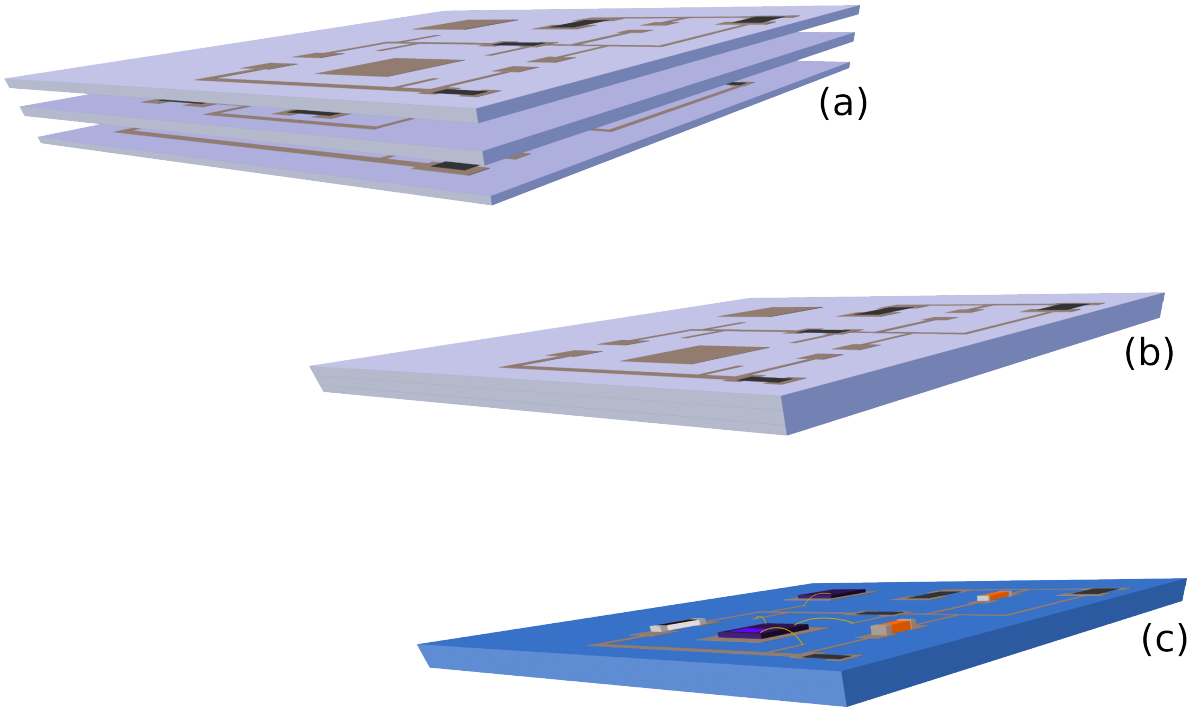
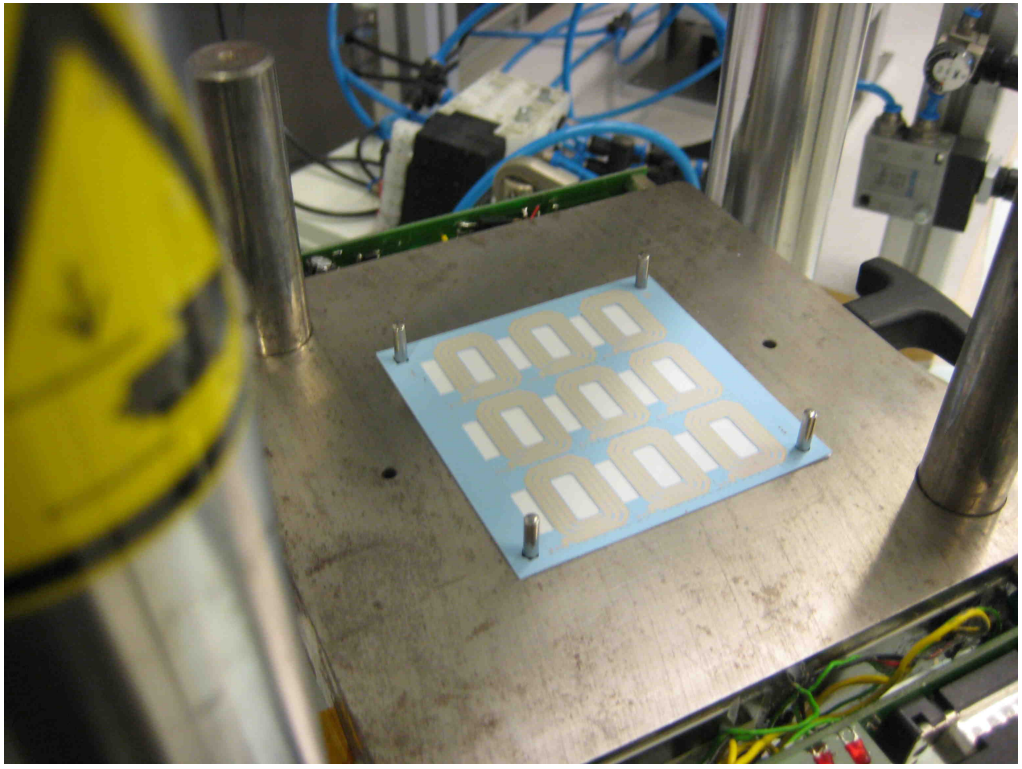
LTCC Process



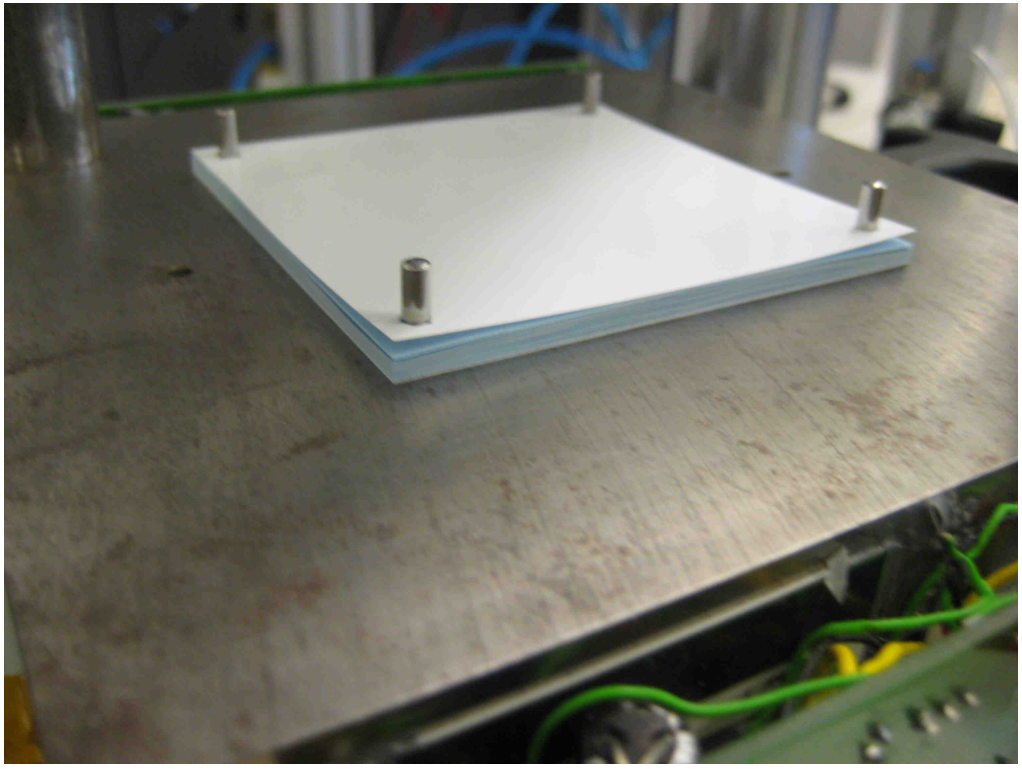
- (a) Collation
- (b) Lamination
- (c) Firing and Post-process

Screen Printing



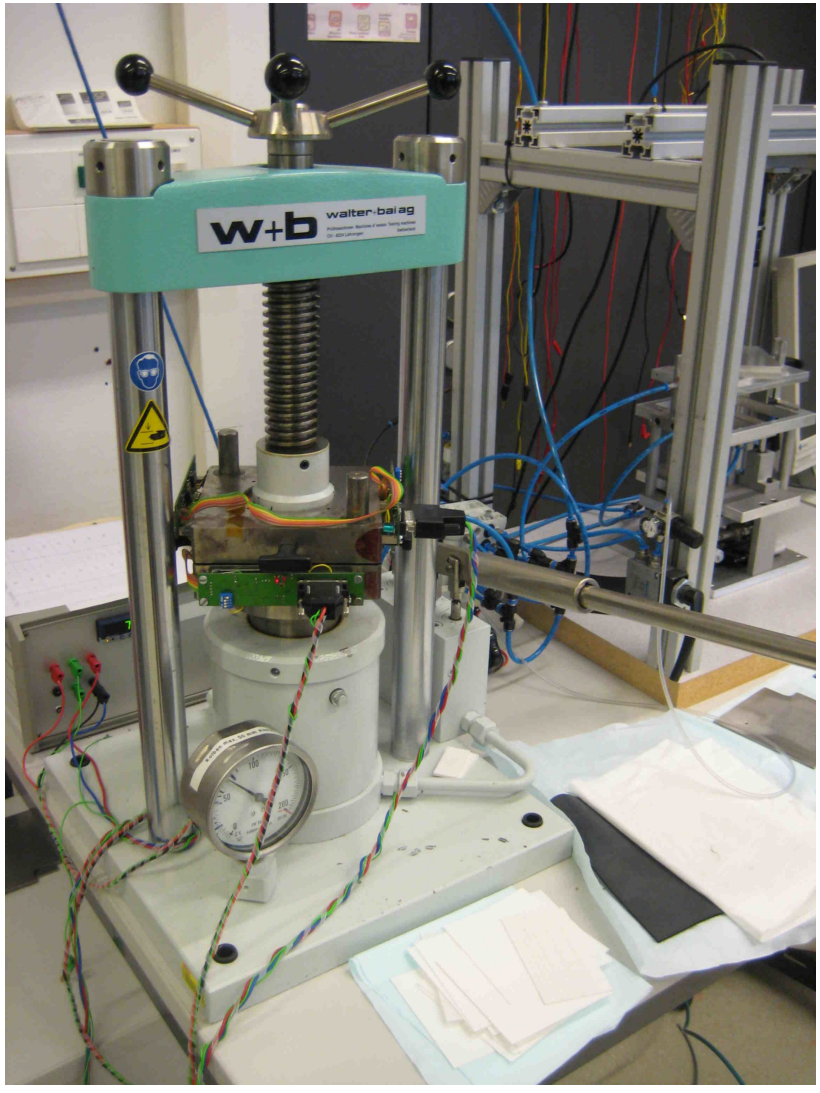
- Windings printed on green tape
- Laser cutting for vias
- Via fill with screen printer

Stacking



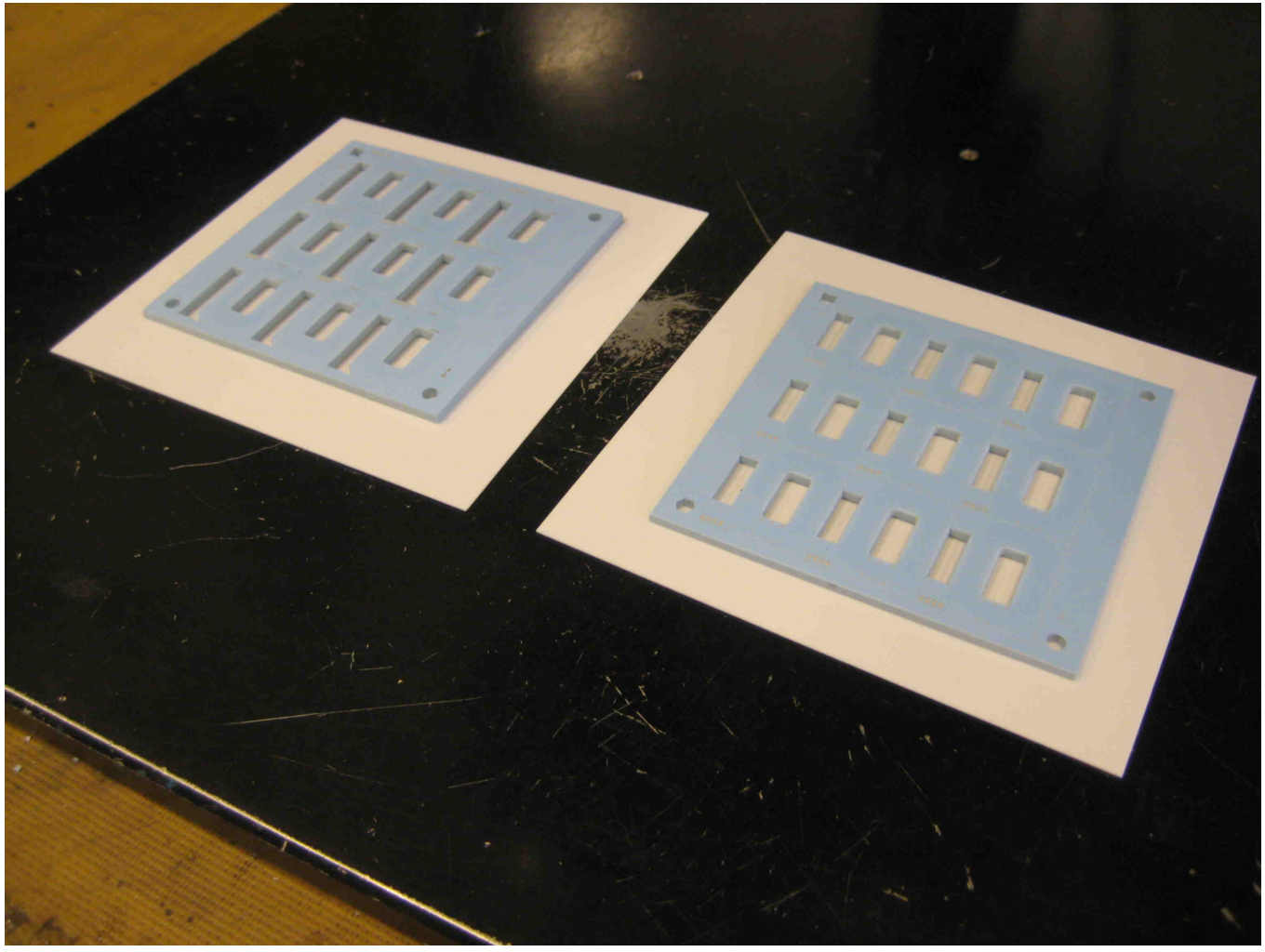
- Layers aligned with pins
- 15 layers bottom section, 17 top
- Tedlar sheets top/bottom

Lamination



- Uniaxial Lamination at 70°C
- Pressure 14 — 18 MPa
- 10 minutes

Lamination



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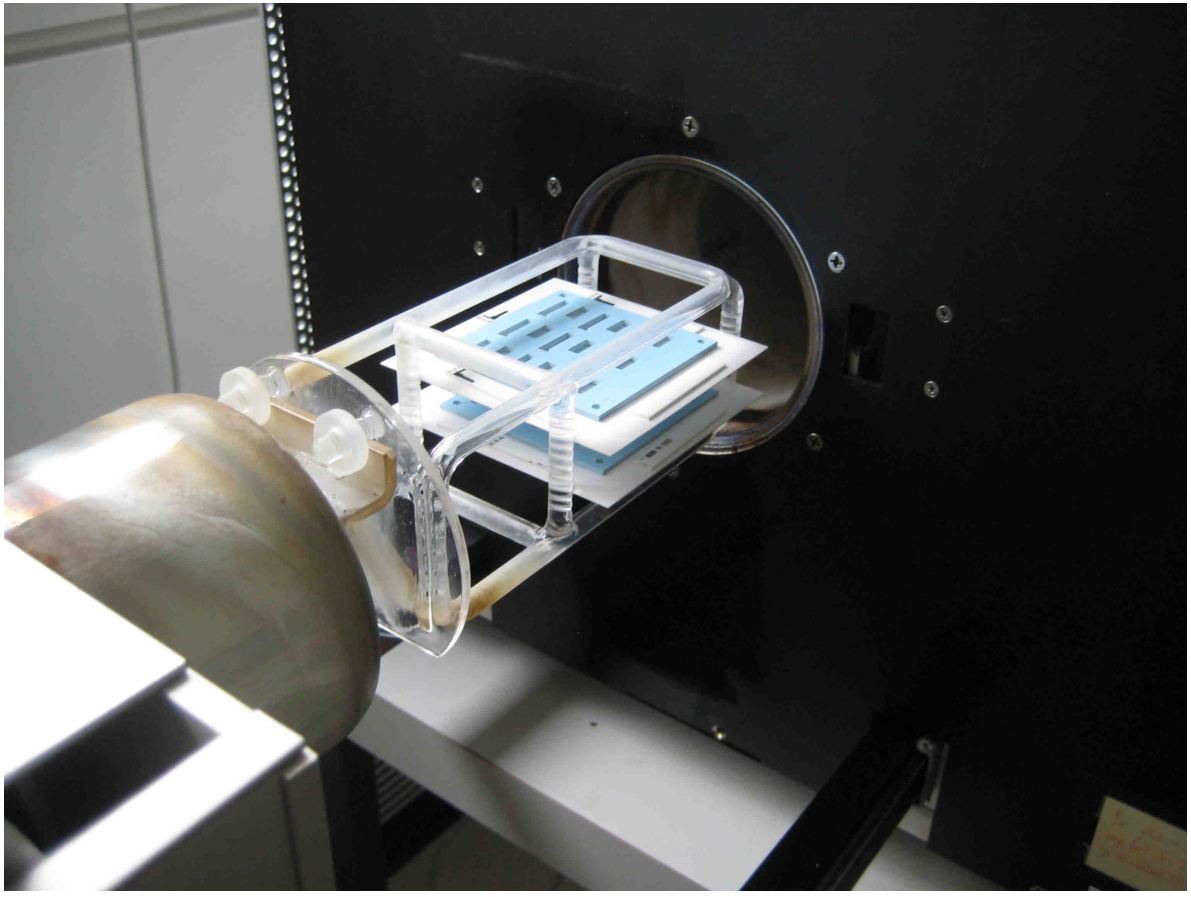
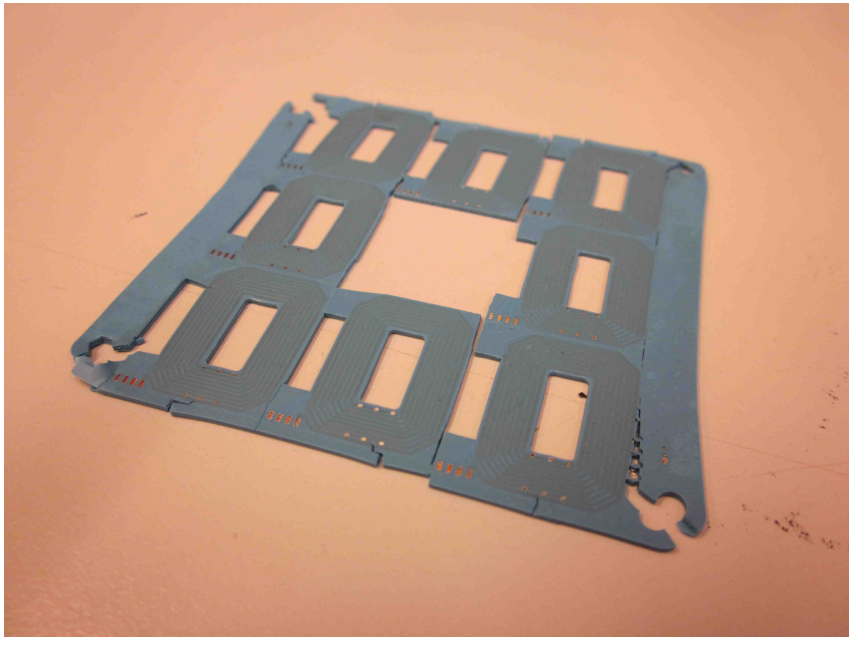
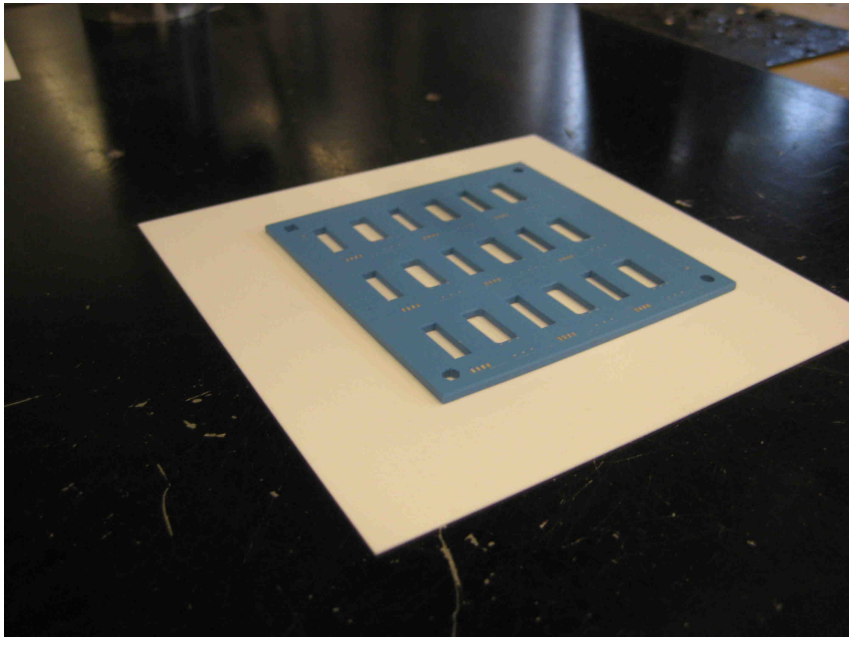
LTCC Furnace



- Co-Fired in Box Furnace
- 90 minutes at 400°C
- 30 minutes at 896°C

Fired substrates

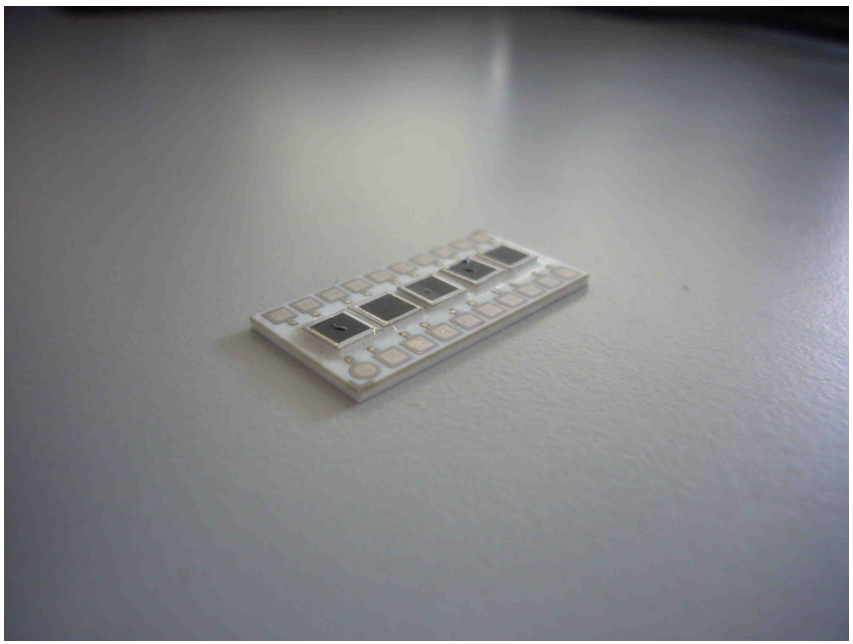




- Versions with both 50 μm and 114 μm
- High amount of deformation and cracking with 50 μm version

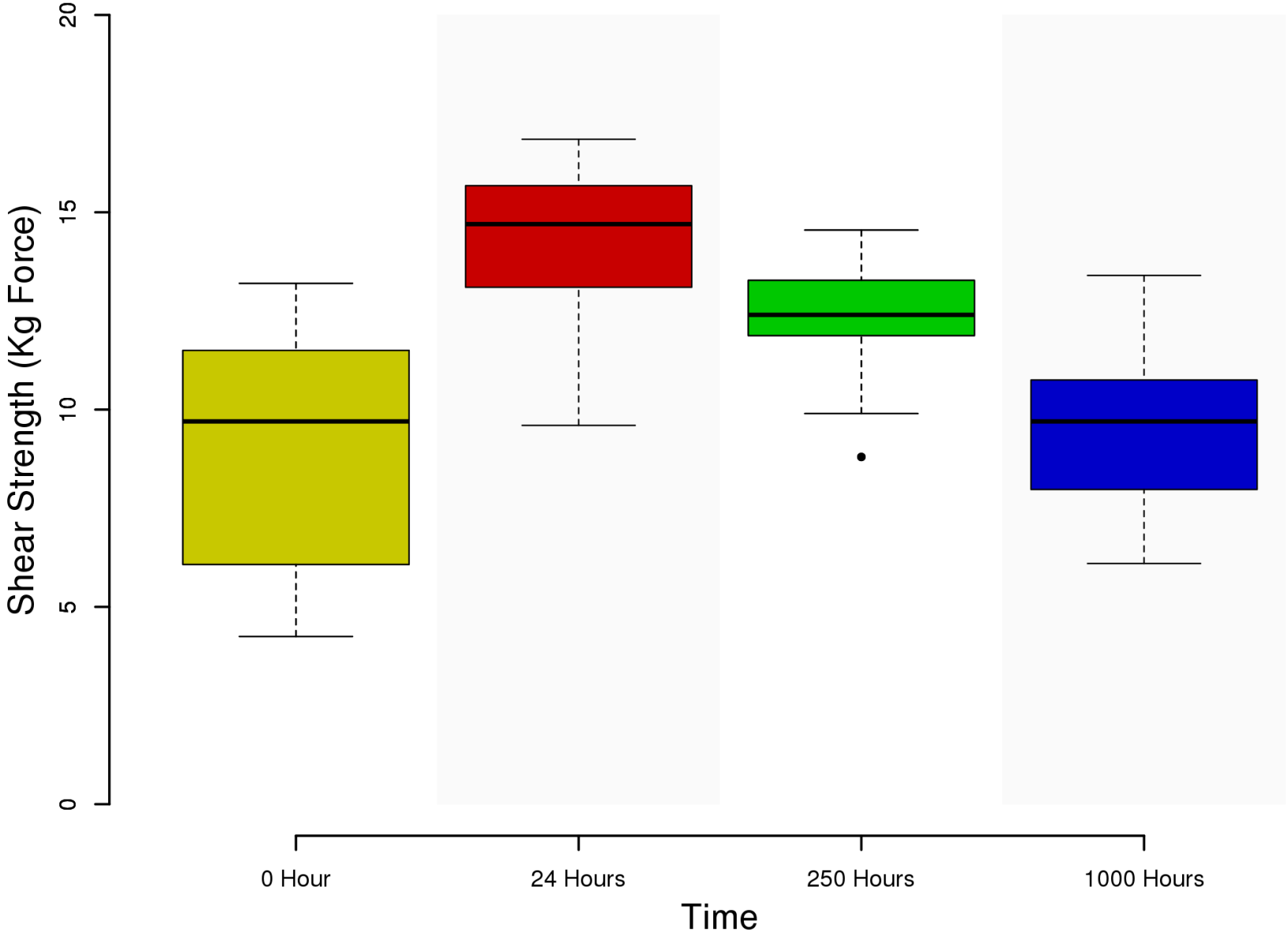
Outline

Test of Silicone

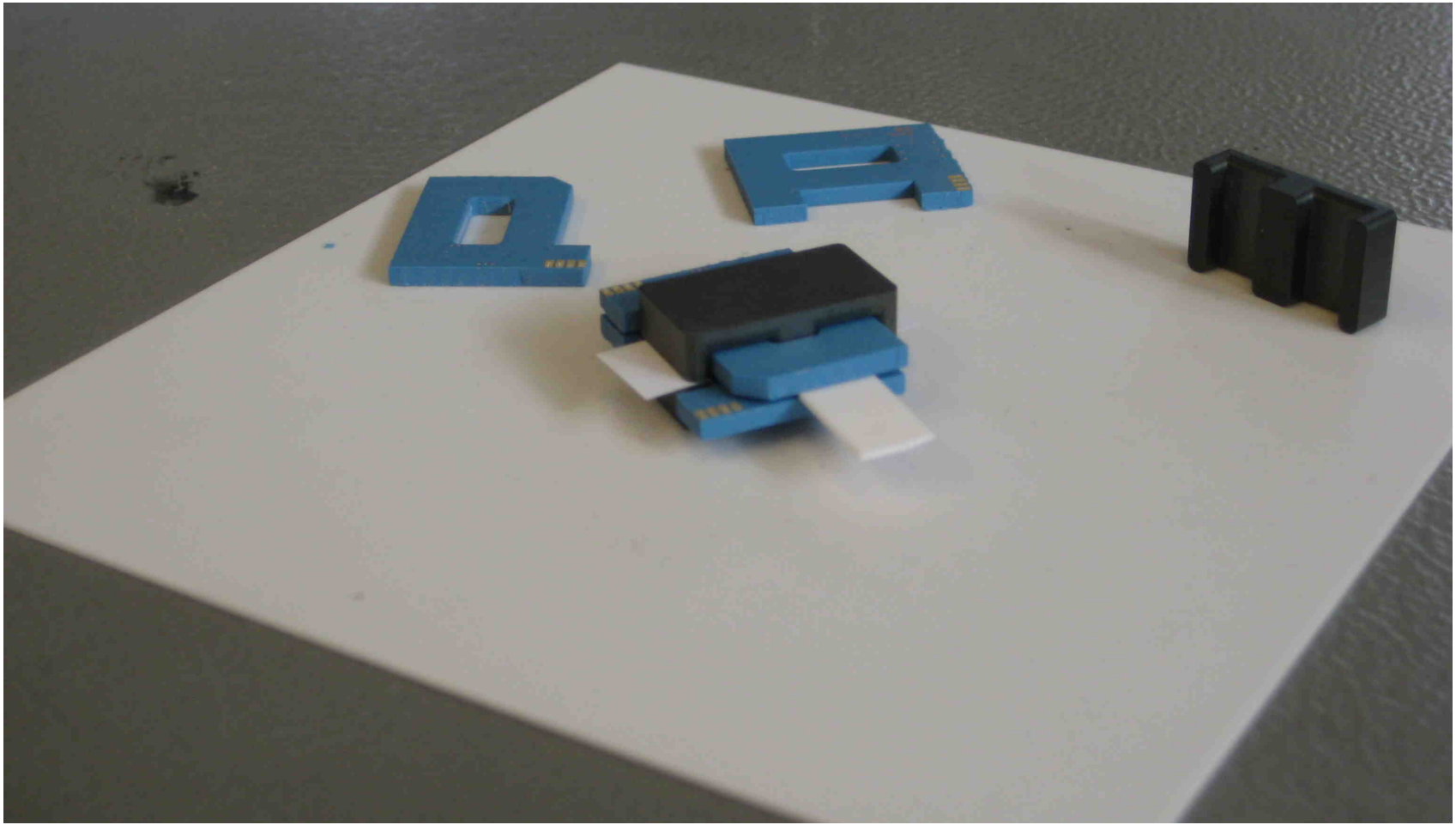


- Test vehicle for silicone attach
- 1000 hours at 210°C
- Shear tests at 0, 24, 250, 1000 hours

Test of Silicone



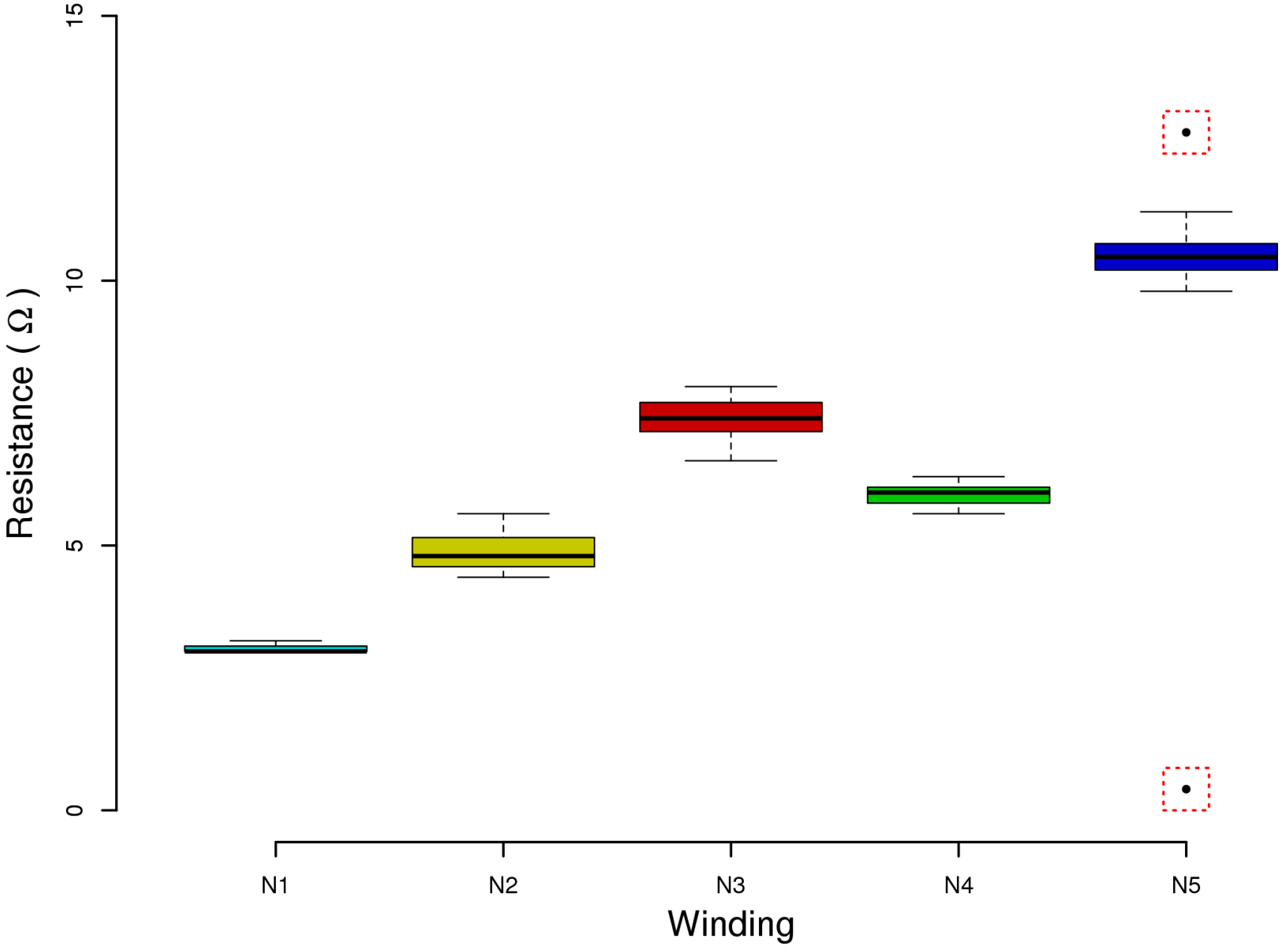
Transformer Assembly



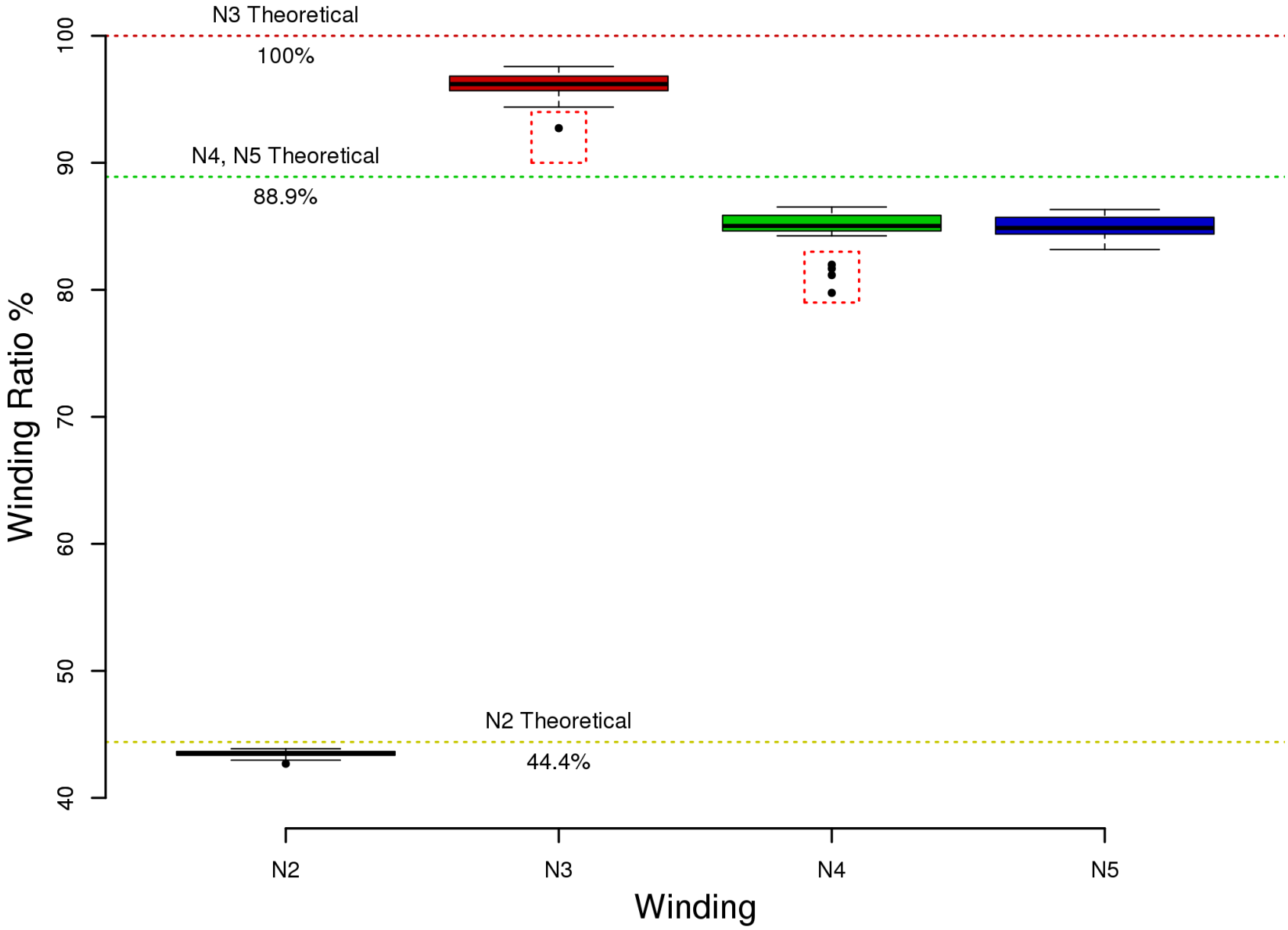
Completed Transformers

Outline

Resistance



Winding Ratio



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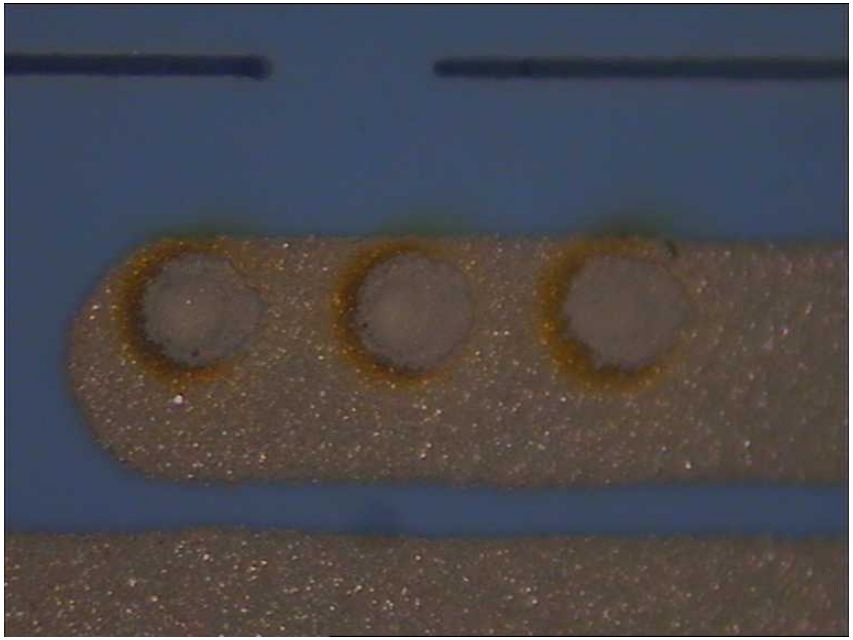
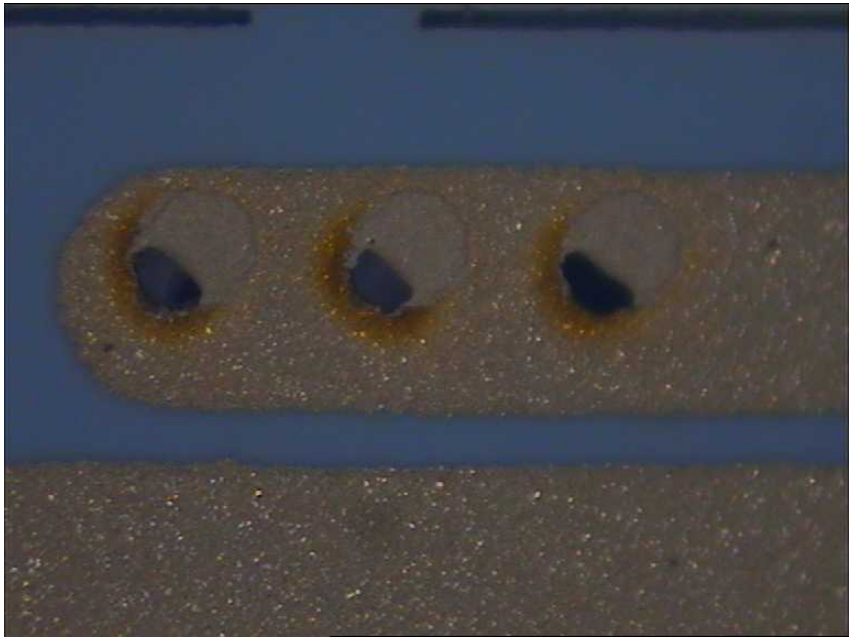
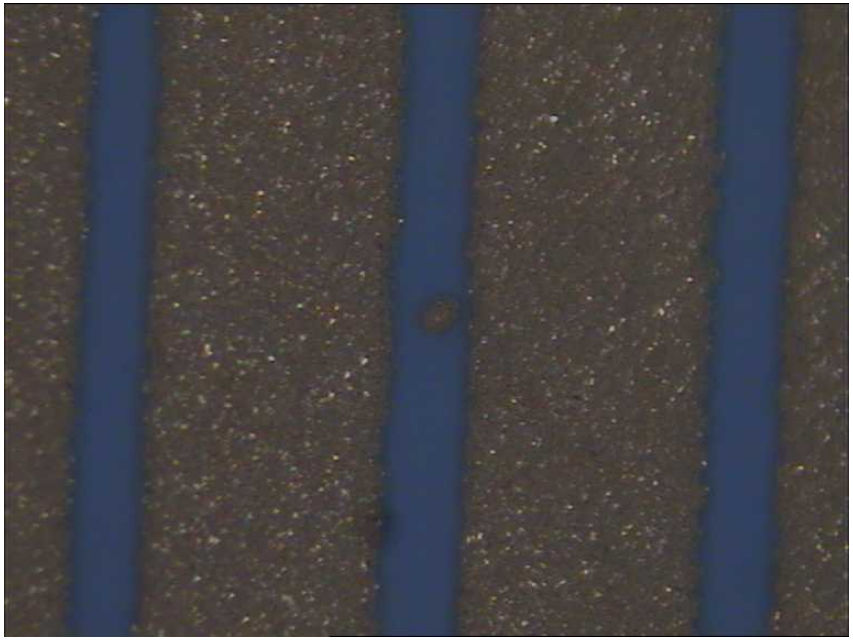
Vias

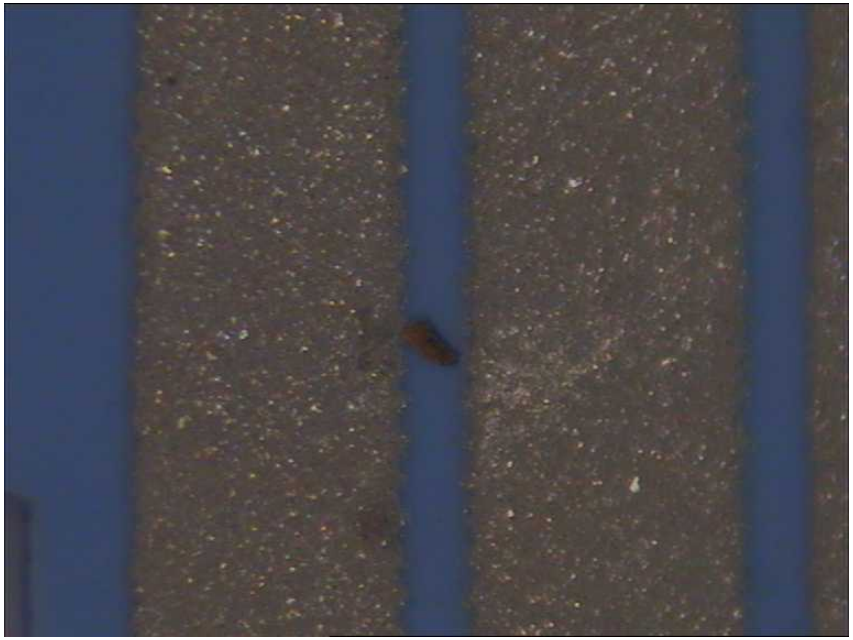




- Vias critical part of assembly
- Production yield to 66%

Conductors

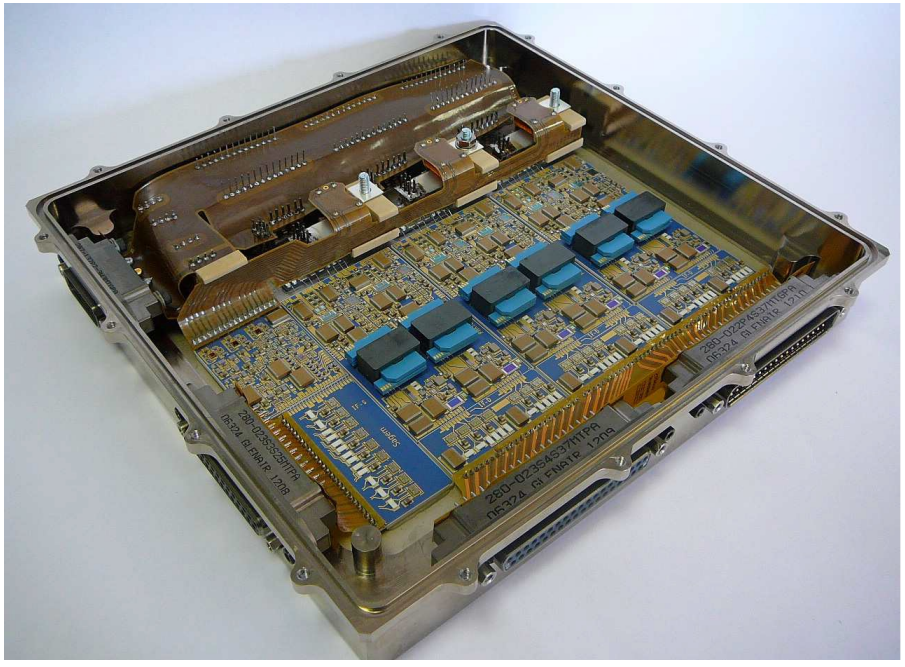




- Search possible short circuits
- Increase production yield to 77%

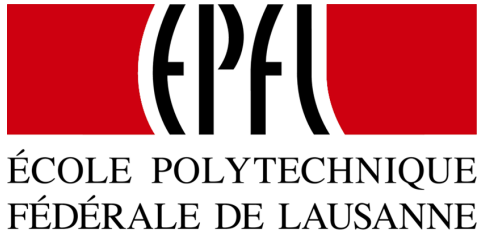
Outline

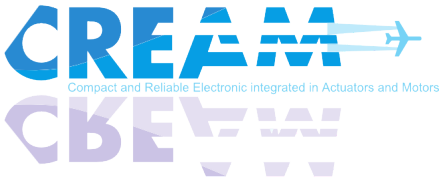
Conclusions



- Fabrication of transformer described
- Analysis of assembly materials
- Test of transformers
- Inspection of LTCC green tapes

Thank you for your attention





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