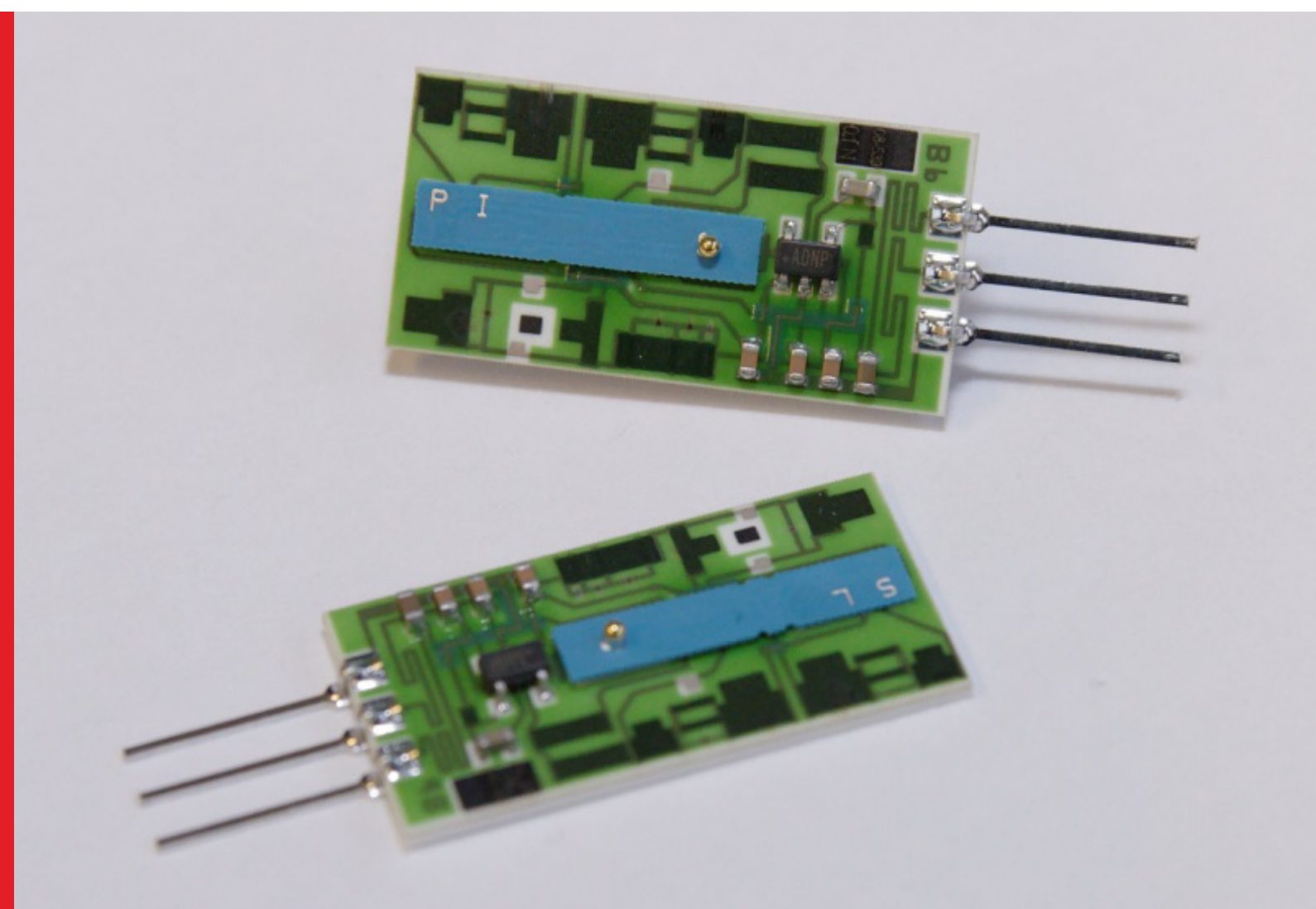


# Signal stability of LTCC cantilever force sensors

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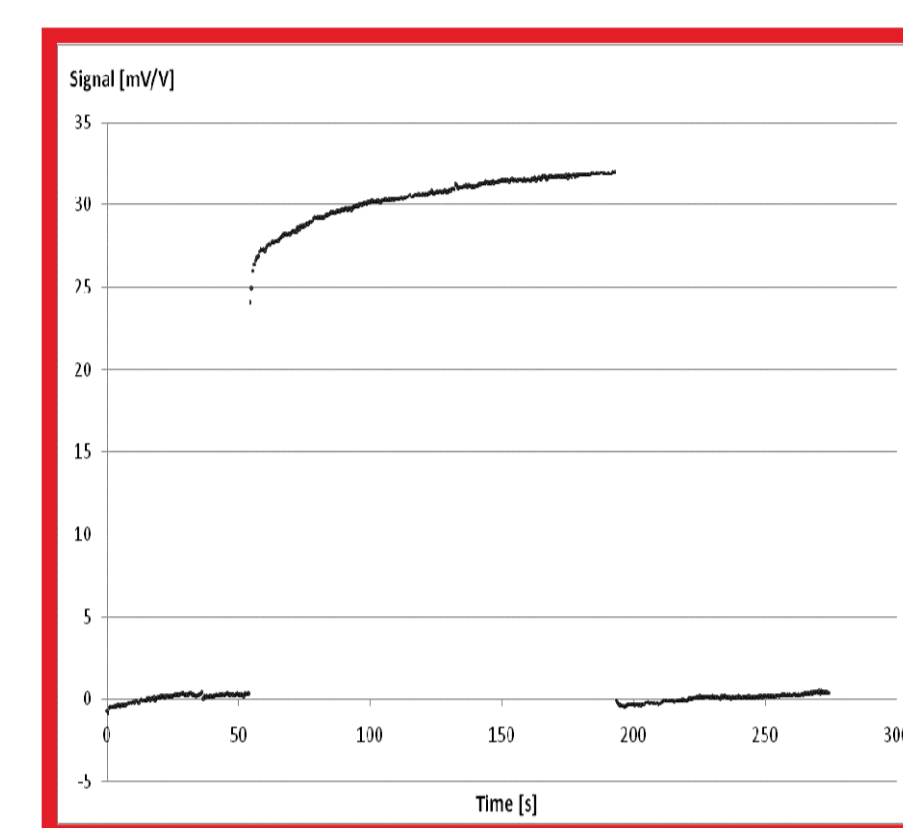


**Advantage of LTCC cantilever for force sensor** : much more sensitivity compared to classical alumina-based device due to:

- Young's modulus approx. 3 times lower than alumina
- Availability of thinner sheets
- 3D structured beam increases the sensitivity of the piezoresistive bridge

**Nevertheless abnormally large although linear response and drift of the signal have been sometimes observed:**

- Potential causes:**
- interaction of piezoresistor & conductor materials with LTCC tape
  - plastic deformation of conductor tracks & resistor terminations
  - defective bonding between the LTCC layers



## Experiments to elucidate the stability problem:

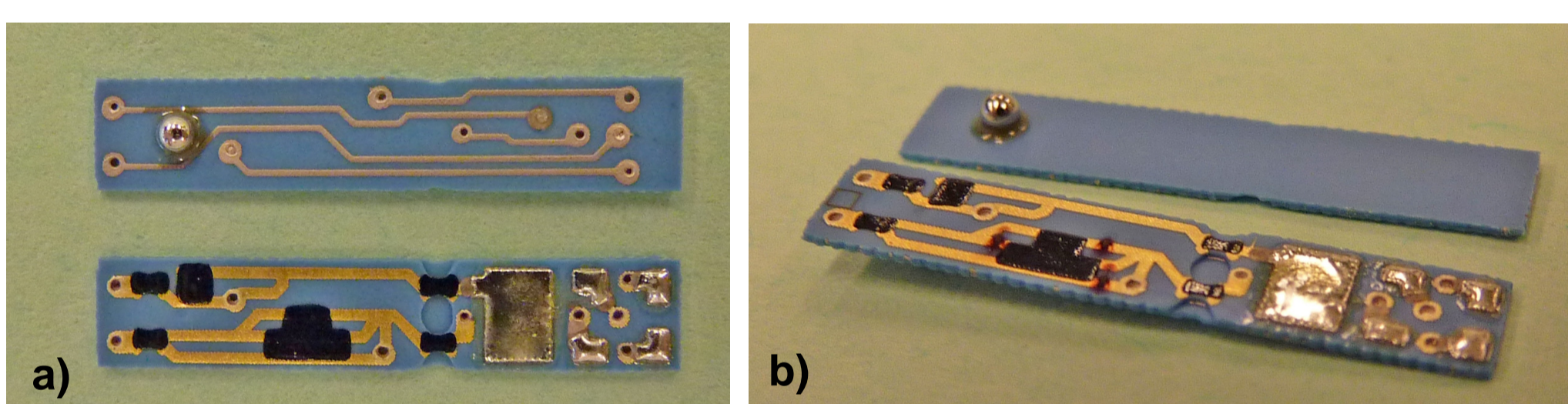
### Studied parameters:

- Cantilever thickness
- Placement of 2<sup>nd</sup> conductor layer: inner: (Cin) or top (Cout)
- Resistor firing process: co-firing (Rco) or post-firing (Rpost) with LTCC and conductor terminations
- Lamination mode: between rigid metal plates or with a rubber insert laterally constrained by an aluminium tube

Sample combinations

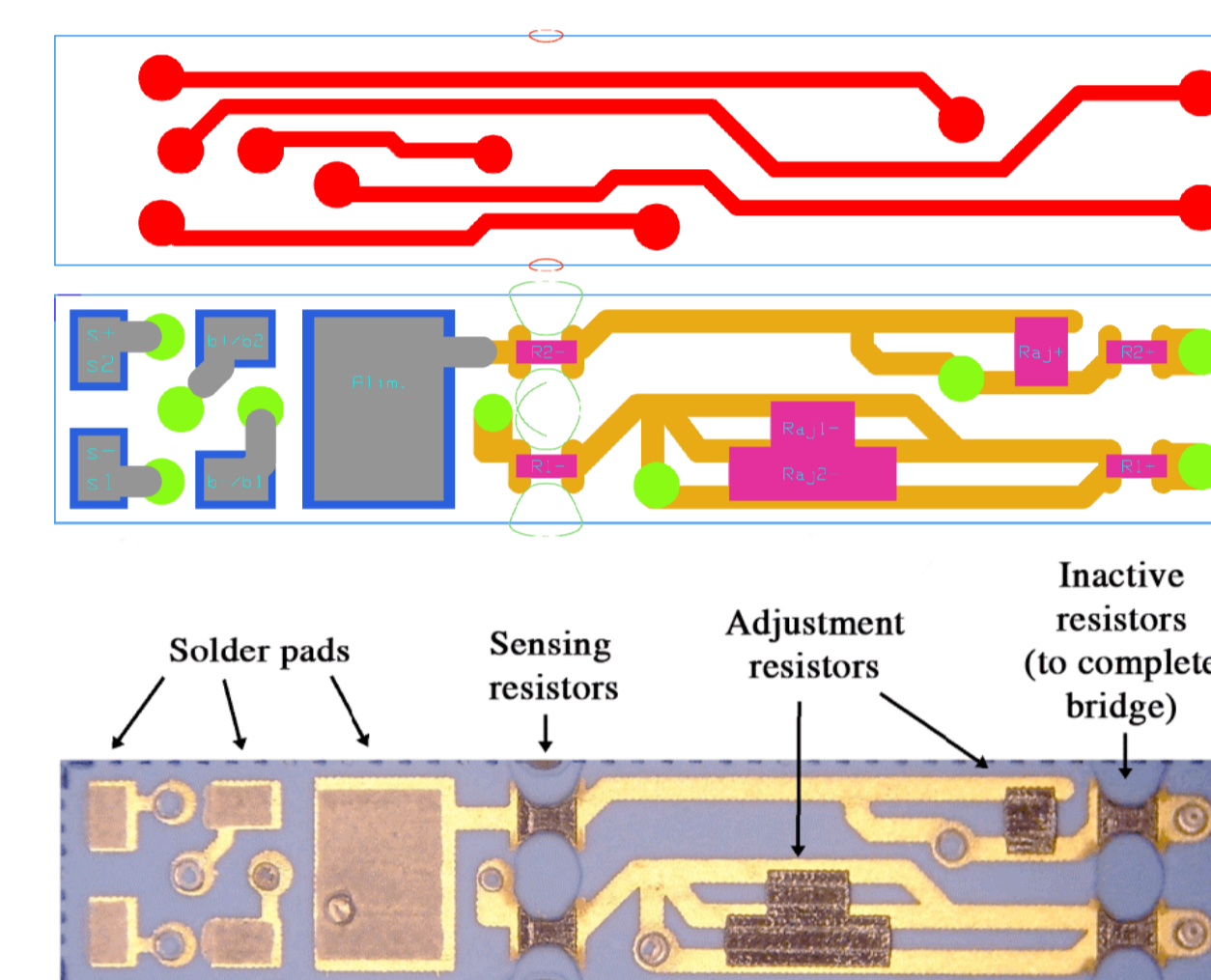
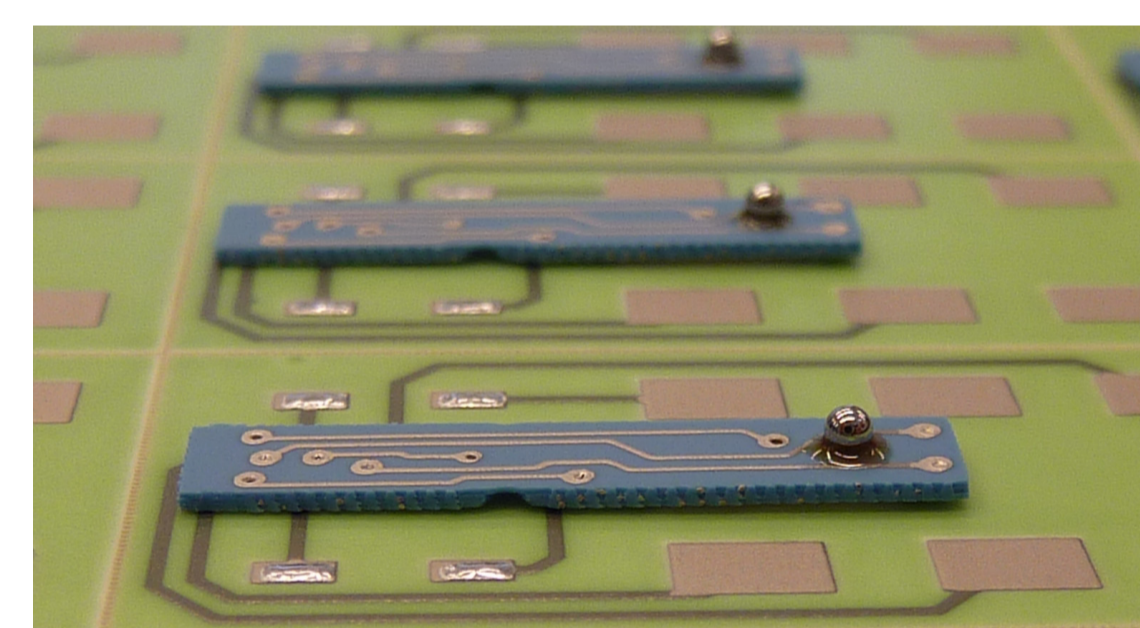
Tape	Fired thickness* [μm]	Cout + Rco	Cin + Rco	Cout + Rpost	Cin + Rpost
MM	280	metal/rubber	metal/rubber	metal/rubber	metal/rubber
ME	350	metal/rubber	metal/rubber	metal/rubber	metal/rubber
MMM	420	metal/rubber	metal/rubber	metal/rubber	metal/rubber

thickness after sintering

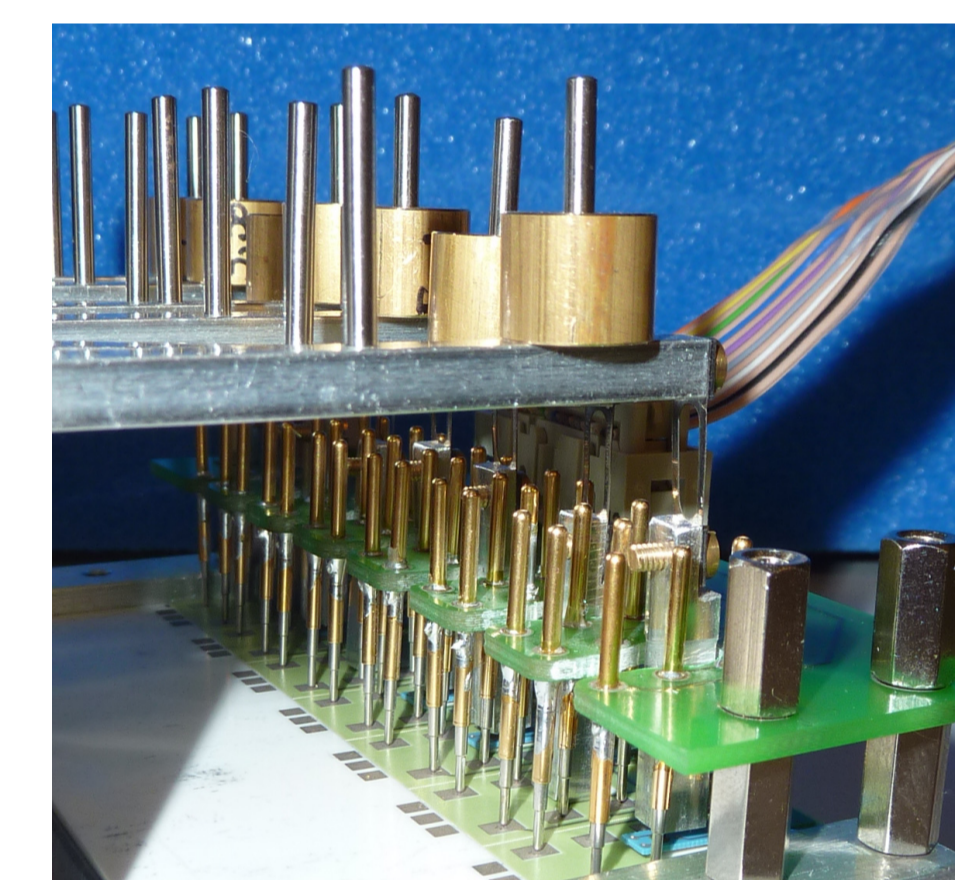


LTCC cantilevers (top & bottom) with both variants (a & b) of routing conductor layer positions (Cin & Cout).

Assembly on batch of the LTCC cantilever (in blue) on no-amplified base for active test. The sensing and structured side of the cantilever faces the base. The force is applied to the ball at the end of the cantilever.



Layout of the active face (bottom) where both sensing resistors lie side by side.

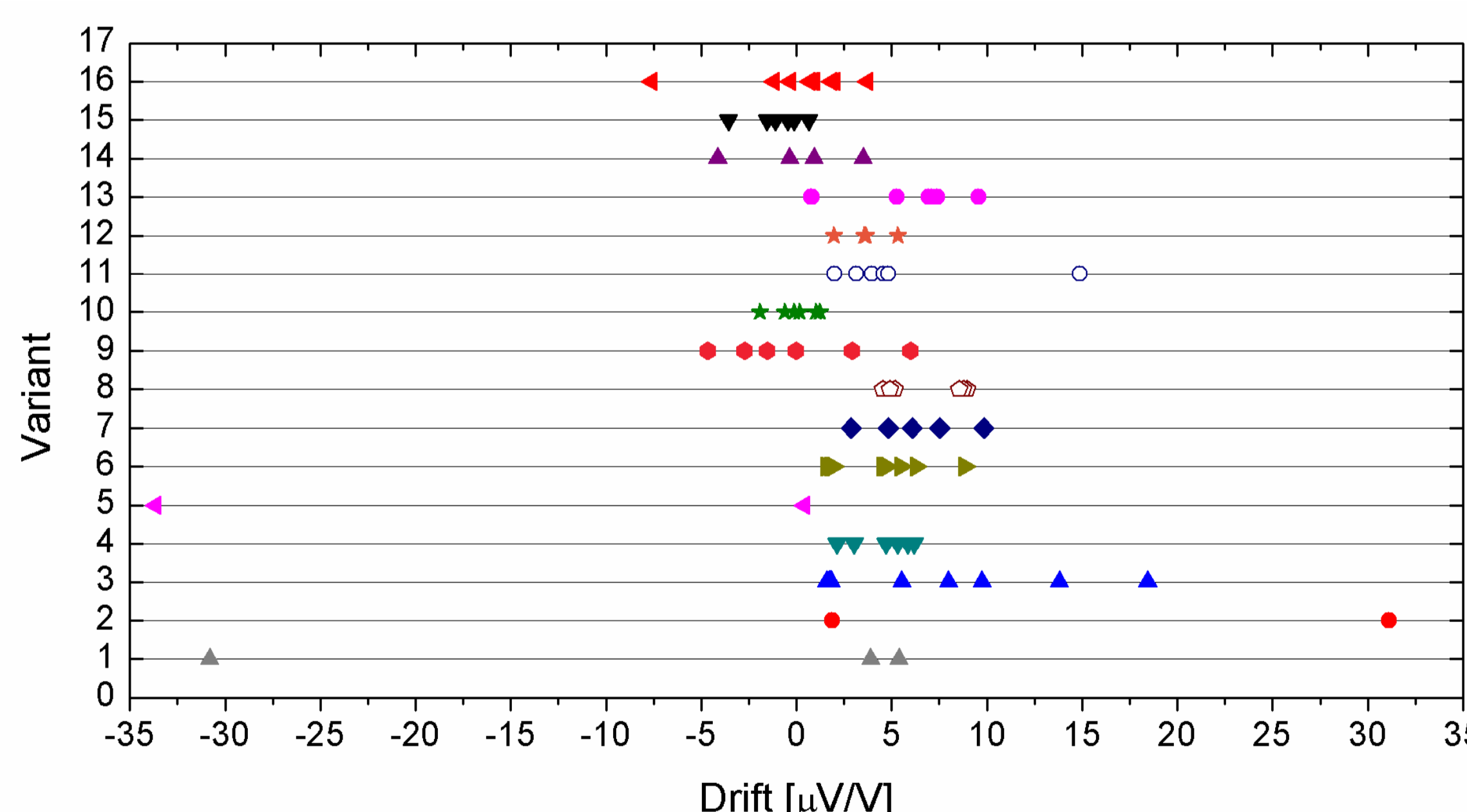
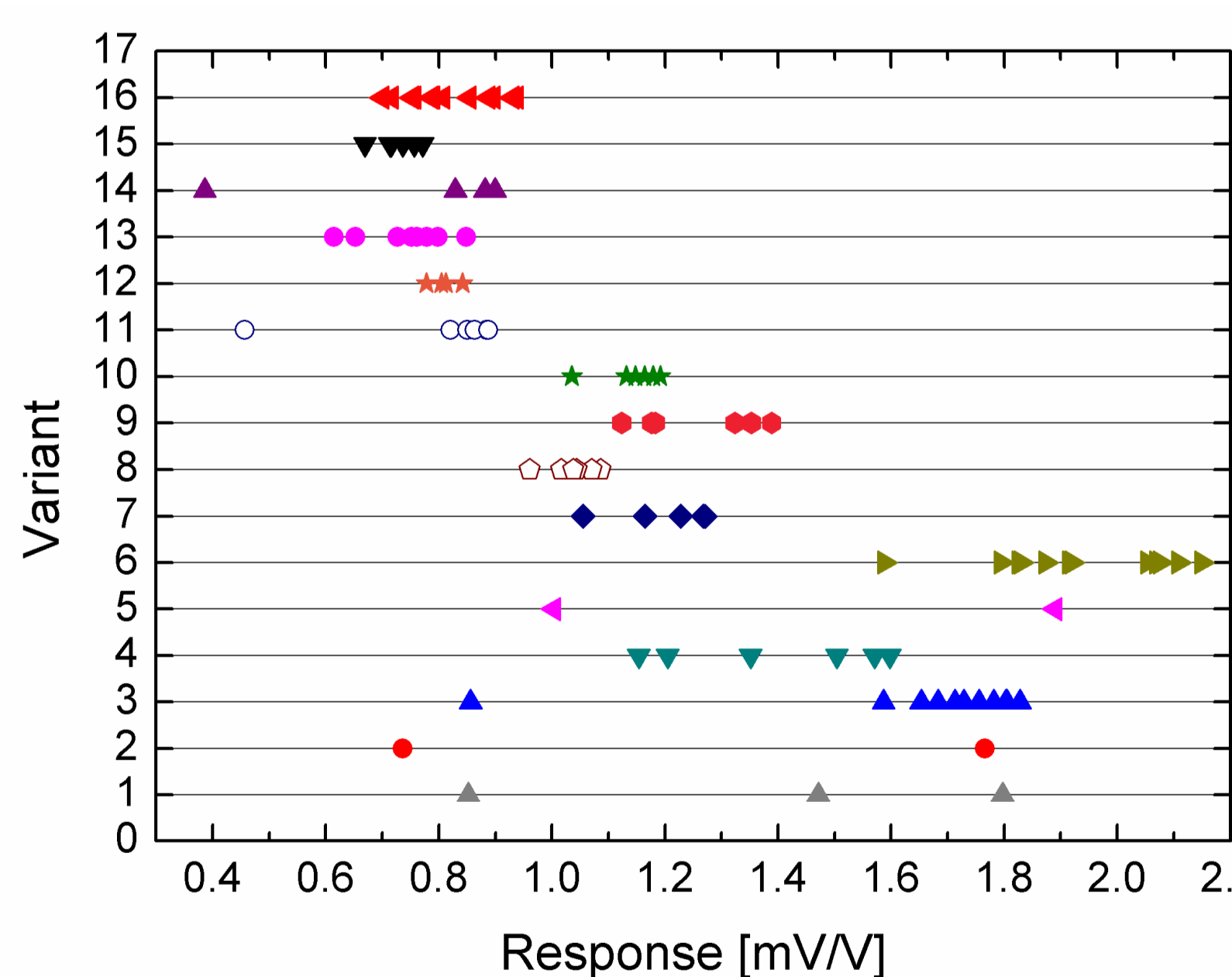


Test bench

## Results: Sensitivity & Drift after loading/unloading cycles

### Loading/unloading 15min cycles, F<sub>applied</sub> ~ 50mN

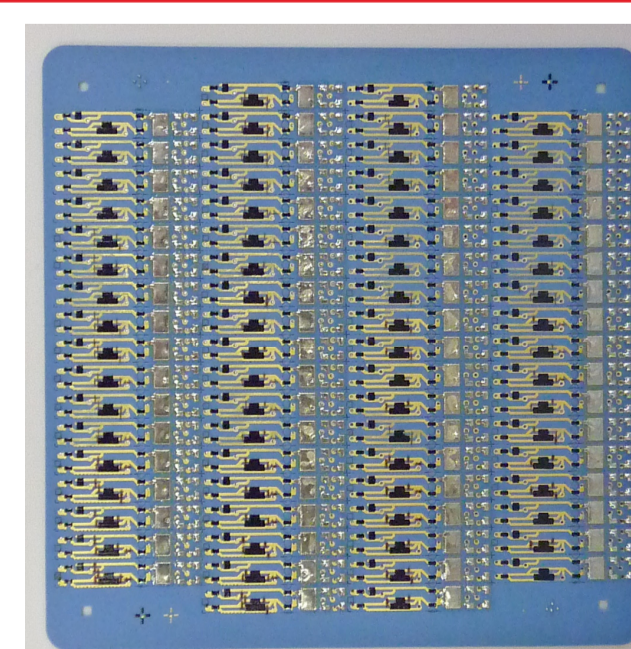
- Dominant response parameter: Thickness
- Lower drift with rubber lamination mode
- Conductor position parameter << thickness & lamination mode
- Tend to lower drift with Rco



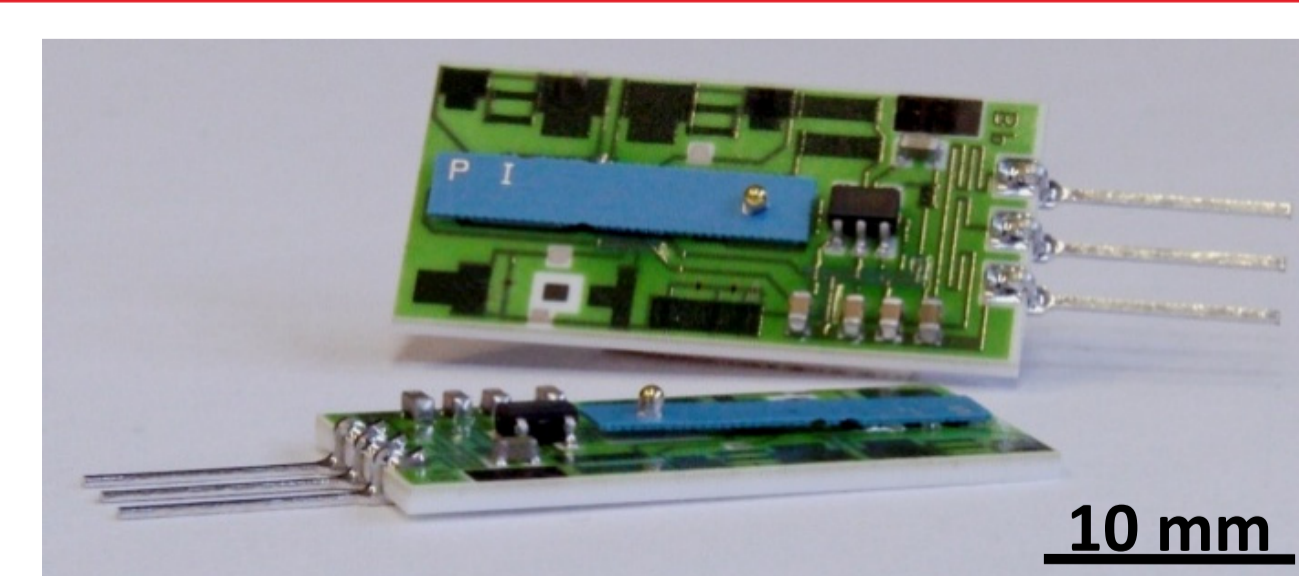
- ◀ 16) MMM Cout Rpost rubber
- ▼ 15) MMM Cout Rco metal
- ▲ 14) MMM Cout Rpost metal
- ◆ 13) MMM Cin Rpost rubber
- ★ 12) MMM Cin Rco rubber
- 11) MMM Cin Rpost metal
- ★ 10) ME Cout Rpost metal
- 9) ME Cout Rpost metal
- 8) ME Cin Rpost rubber
- ◆ 7) ME Cin Rpost metal
- ▲ 6) MM Cout Rpost rubber
- ▼ 5) MM Cout Rpost metal
- ▲ 4) MM Cin Rco rubber
- ▲ 3) MM Cin Rpost rubber
- 2) MM Cin Rco metal
- ▲ 1) MM Cin Rpost metal

## Conclusion:

- main parameters = Thickness & lamination mode
- Thinner cantilevers will be manufactured to achieve to 10 mN nominal force



LTCC Beam substrate



100mN force sensor

