

Design and processing of low-range piezoresistive LTCC force sensors

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Piezoresistive thick-film sensors:

TFR structure

conducting paths
glass

1 micron

TFR conduction

glass
RuO₂
strain - dependant tunneling barrier

20 nm

Resistor (TFR) microstructure

DP 2041
glass
RuO₂
1 µm

"MilliNewton" force sensor: 400 - 2000 mN

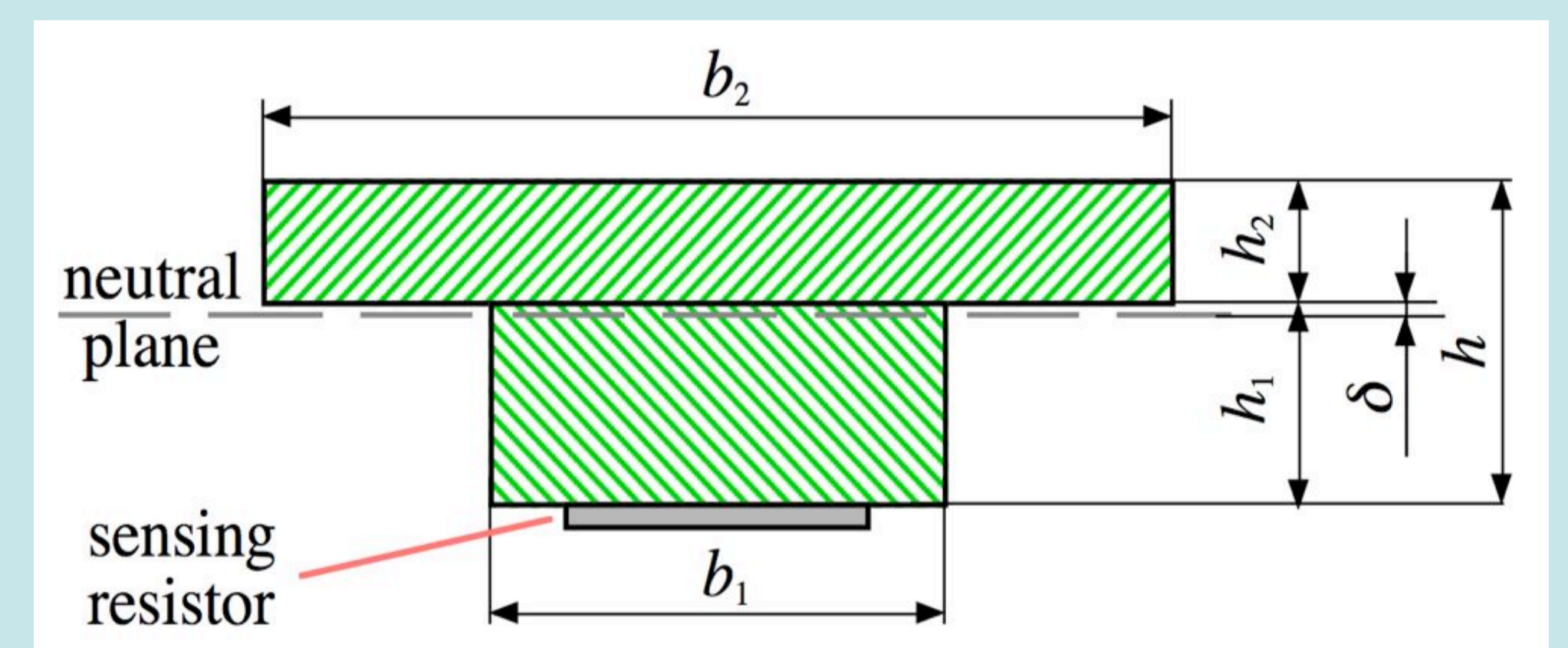
Force sensor principle

Force & pressure sensors @ EPFL

Improving sensitivity & quality with LTCC

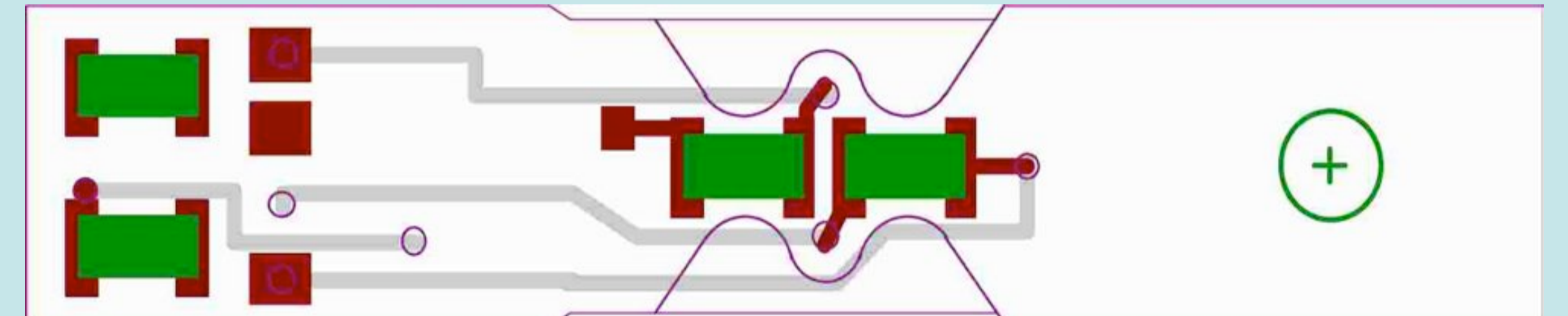
Material	LTCC	Al ₂ O ₃
Min. thickness [mm]	0.04	0.17
Strength [MPa]	320	600
Young's modulus [GPa]	110	320
Rupture strain [ppm]	2'100	1'900
Flexural sensitivity [kN ⁻¹]	5.7	0.1

Principle: locally narrowed cross section on bottom side to improve signal

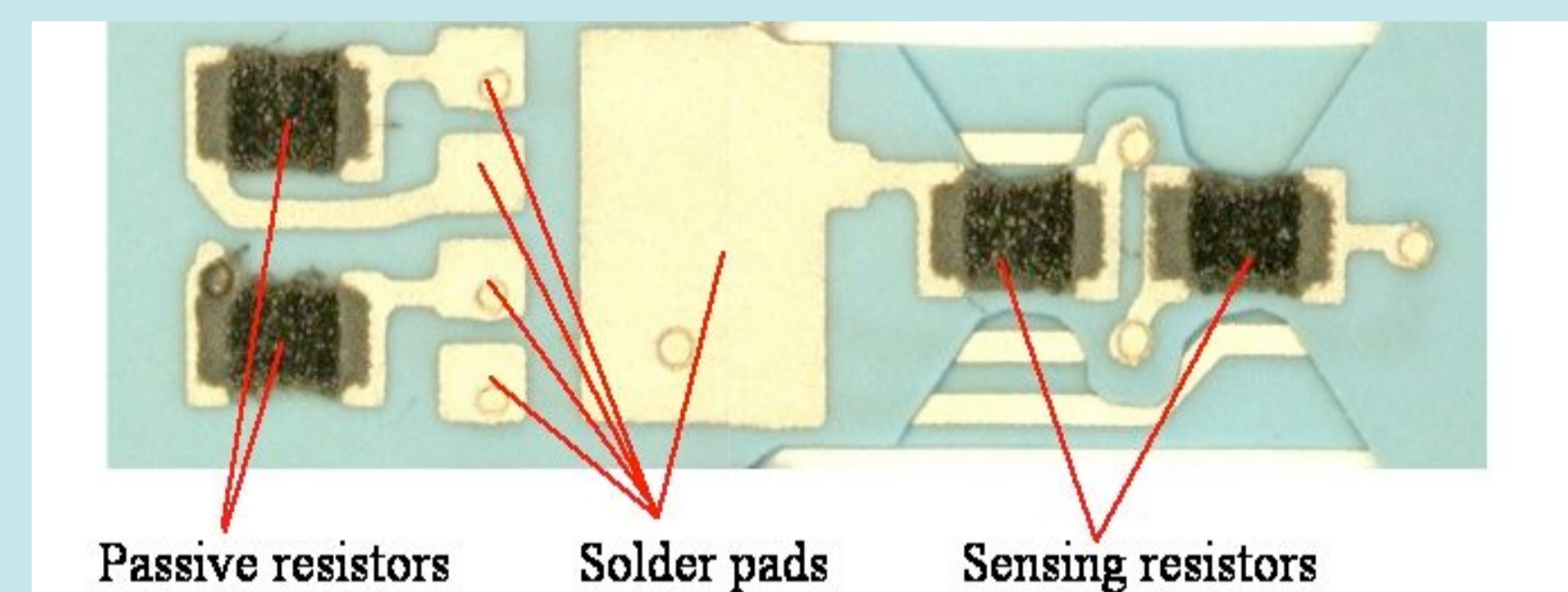
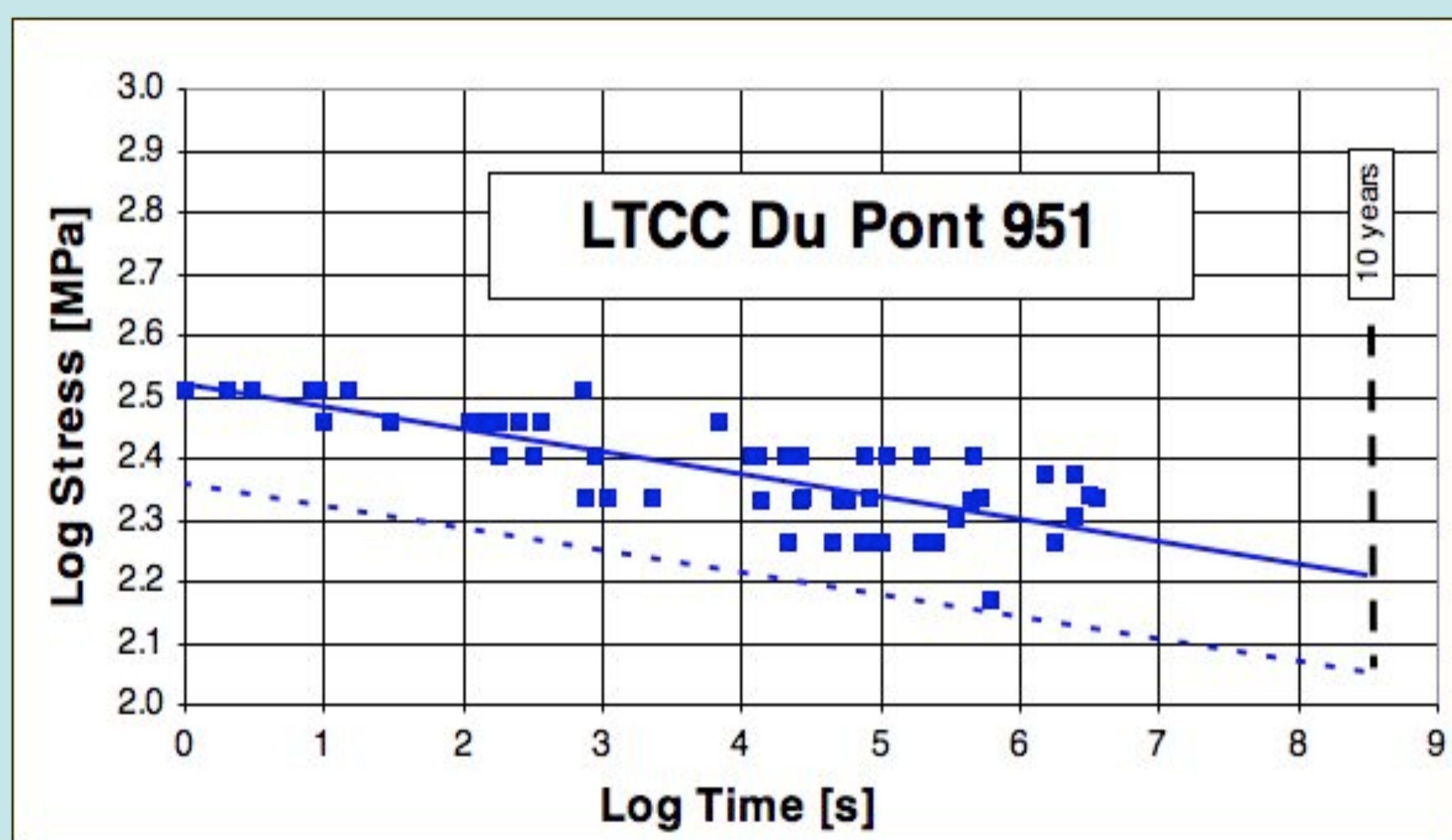


LTCC vs. alumina properties

LTCC sensor layout (all resistors on bottom side)

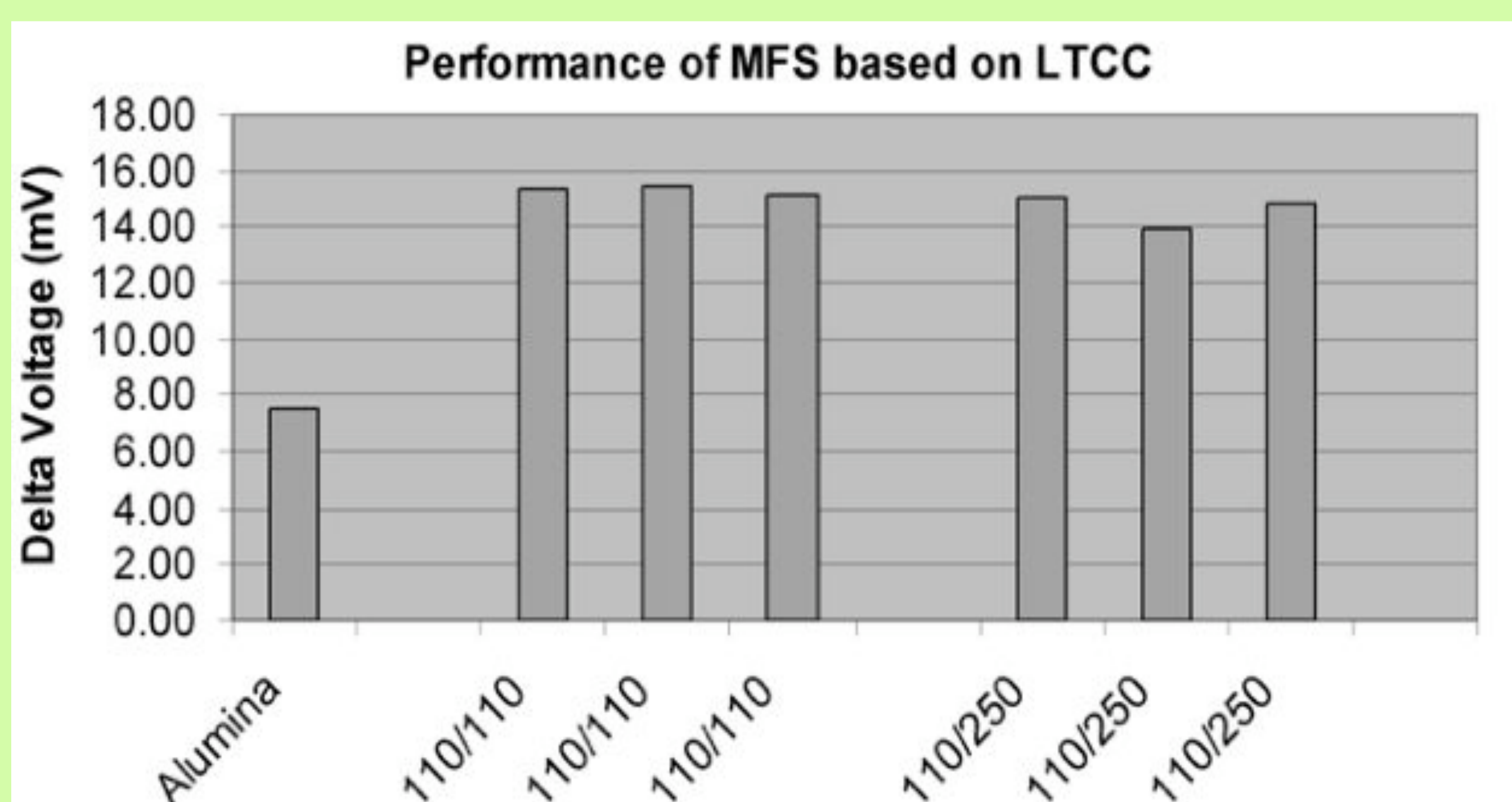


LTCC material long-term static fatigue



Close-up of the assembly & sensing parts of the LTCC cantilever

Results



Comparison of sensitivity of LTCC sensors (top thickness / bottom thickness in µm) with 250 µm alumina cantilever

Conclusions

LTCC as a piezoresistive sensing material

- Max. elastic strain comparable to alumina **but** better quality due to 3D structuration.
- Much lower force ranges / higher absolute sensitivity possible due to lower modulus & available thicknesses.

Advantages of 3D structured LTCC sensor

- High sensitivity, yet high stiffness possible.
- Better sensitivity of half bridge LTCC than full bridge alumina.
- Easier fabrication: fewer layers and better matching of the piezoresistive bridge.