# Low-cost LTCC-based sensors for low force ranges

N. Craquelin, T. Maeder, Y. Fournier, P. Ryser
Laboratoire de Production Microtechnique, EPFL
nicolas.craquelin@epfl.ch , http://lpm.epfl.ch

## Aim of the project : Develop rugged low-range force sensors for ≤ 100 mN range

- Switching from a classical $Al_2O_3$-based thick-film beam to LTCC (Young's modulus approx. 3 times lower)
- Using LTCC allows design of a 3D structured beam with increased sensitivity of the piezoresistive bridge

## Design choices and dimensioning

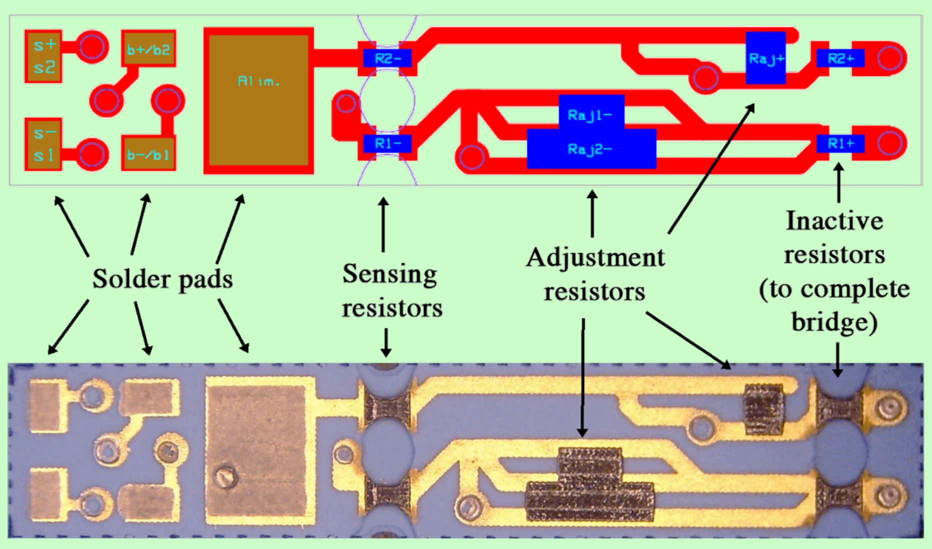


Fig.1: Layout and photograph of the active face (bottom) of the parallel variant, where both sensing resistors lie side by side.

Optimisation to find a compromise with :

- a good signal
- LTCC manufacturability
- screen-printing resolution limits
- a deflection sufficient to allow protection against overload by contact with the base

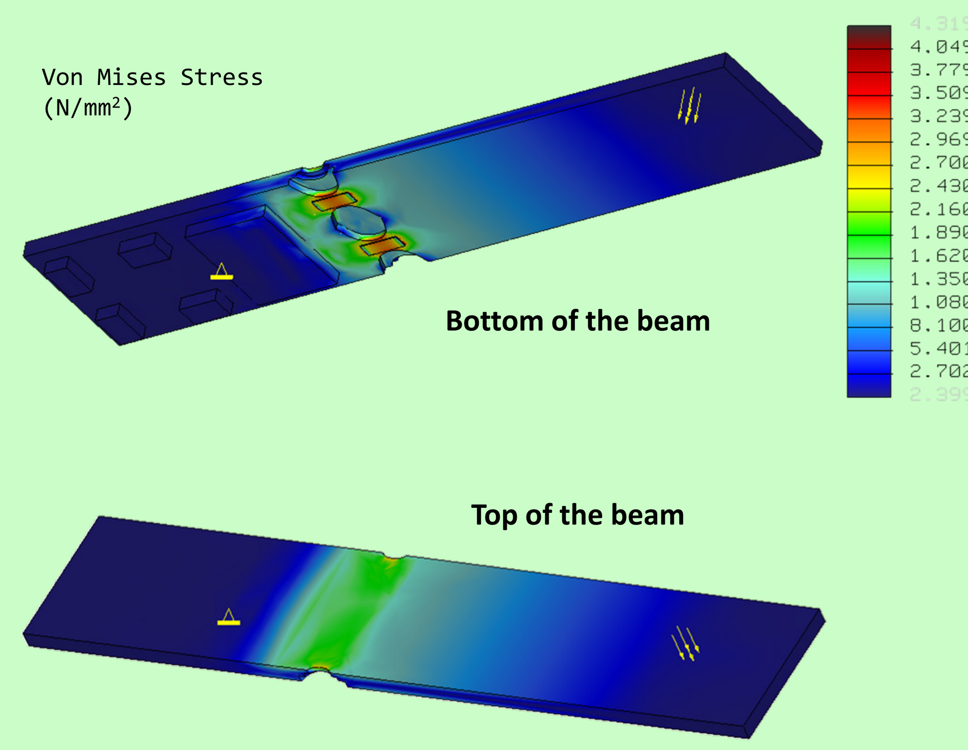


Fig.2: Result of a finite element modelling run: stress distribution on the beam when the nominal force is applied (100mN).

Principal available dimensional parameters are the following:

- Thickness of the beam (different combinations of thickness tested, Table 1)
- Width of the structure carrying the 2 sensing resistors (asymmetry)
- Distance between sensing resistors and solder pads
- Position of both sensing structures (in series or in parallel)

| References | 2 tapes (PX) | 2 tapes (P2) | 3 tapes (P2b) |
|---|---|---|---|
| Tape 1 (top) | 114 µm | 165 µm | 114 µm |
| Tape 2 (spacer) | - | - | 114 µm |
| Tape 3 (bottom) | 254 µm | 165 µm | 165 µm |

Table 1. Combinations of thickness of LTCC unfired tape (for 2-layer versions, we consider that tape 2 is omitted).

## Signal sensitivity

The tapes thickness is the predominant parameter defining the sensitivity.

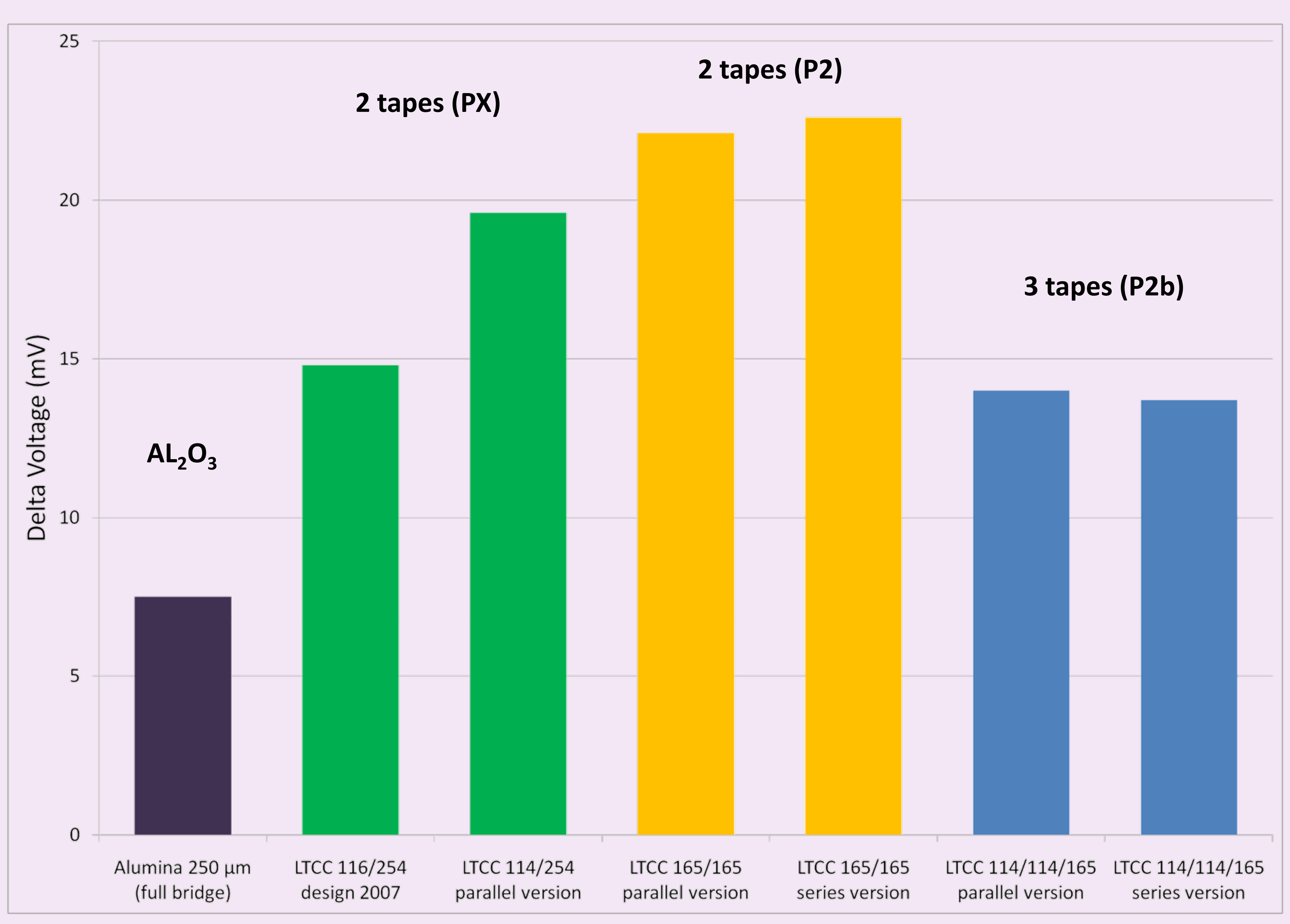


Fig. 3. Output signal response for a 200 mN load, measured on different beam types, at 5 VDC excitation. Values for Alumina and LTCC design 2007 (series version) are taken from a previous study.

Other aspects to consider (seeing that signals are sufficient) :

- Simplicity of the fabrication process (influencing cost production)
- Appropriate stiffness, to allow protection against overloads by contact with the base
- Reliability
- Signal stability

## Results

Several sensors, with different beam variants, gave good results in sensitivity and linearity.

For the future 100 mN sensors, we chose the LTCC 114/254 parallel variant. A 40 mN type would be tested with a thinner beam (LTCC 114/165 parallel version).

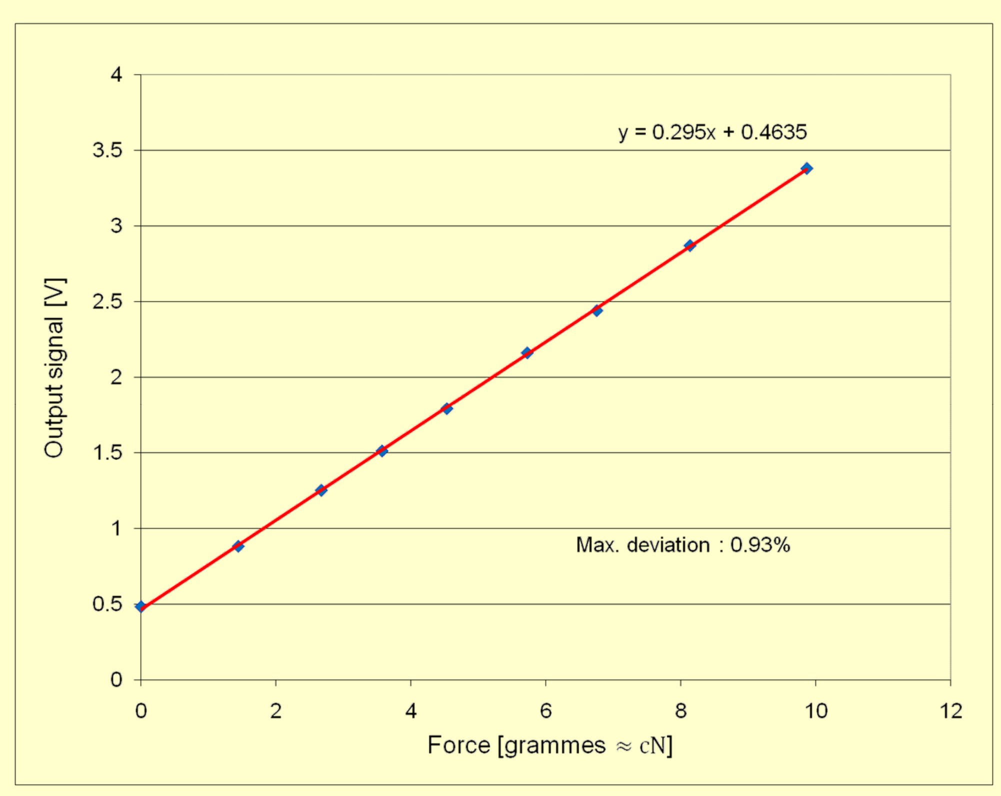


Fig. 4. Force response of a complete sensor (sensor + signal conditioning base).

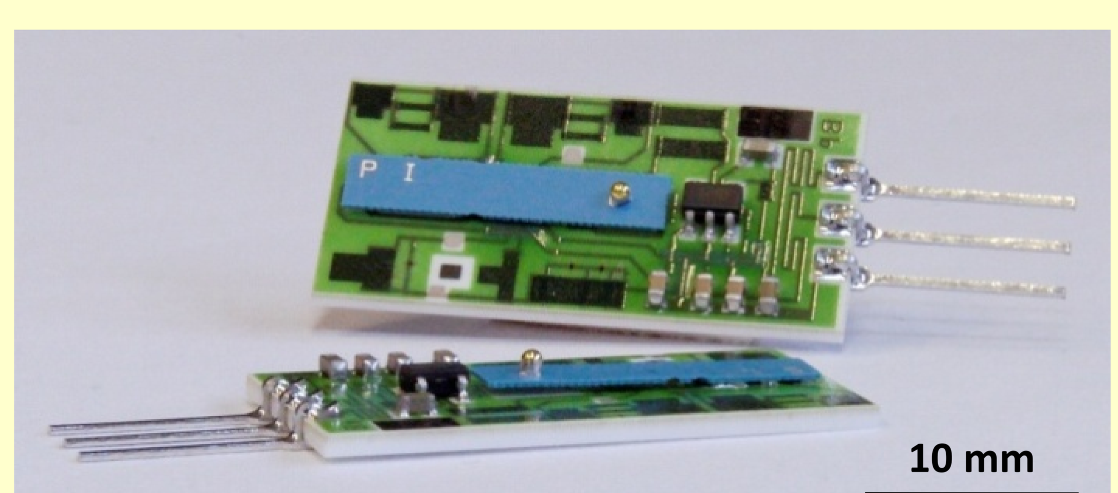


Fig. 5. Completed new low-range sensors using an LTCC beam (in blue). The sensing, structured face is not apparent, as it faces the base. The base dimensions are 25.4 x 12.7 mm and the force is applied onto the ball at the end of the cantilever.