High performance thick-film pressure sensors on steel

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Goal

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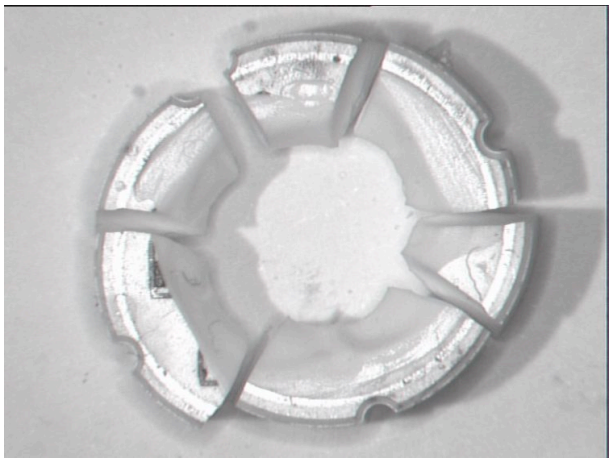
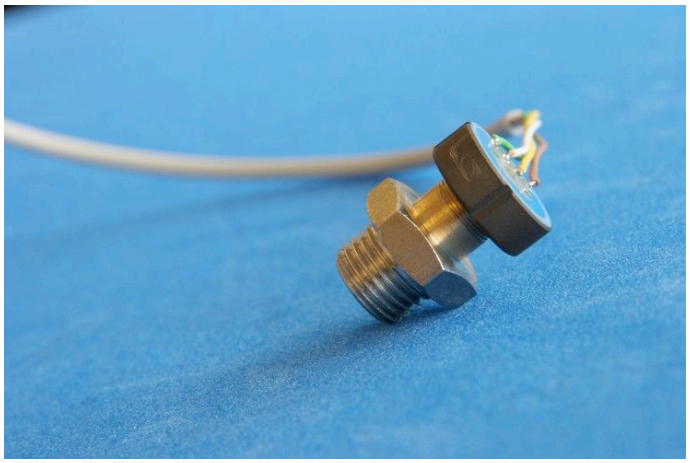
- To develop high pressure sensors



Ceramic membrane



Metallic membrane assembly by welding

Standard thick-film (TF) technology

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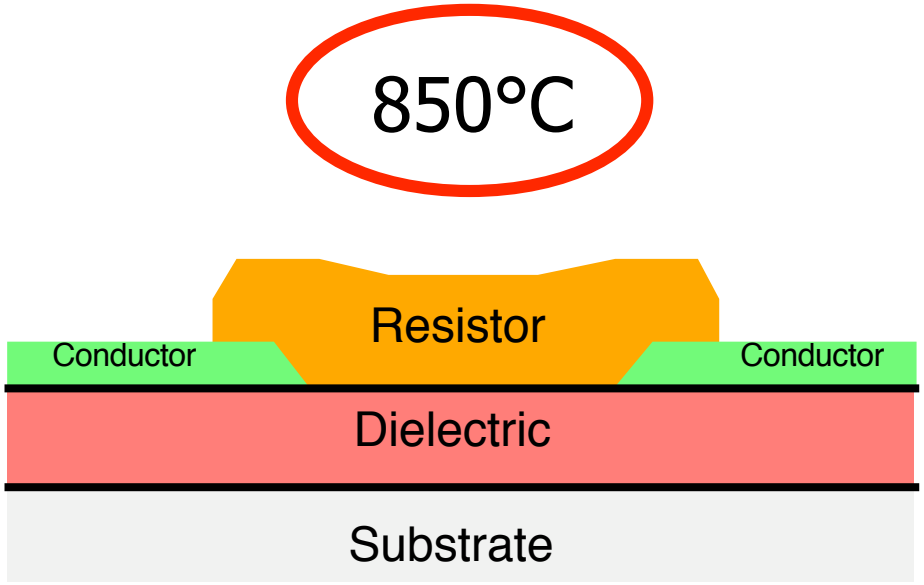

Standard TF deposited on common steel

2 routes

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- High temperature resisting steel suitable with standard TF process

- High temperature TF system → low temperature TF system

Issues with low-temperature thick-films

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- Compatibility of thermal expansion
- Dielectric-resistor compatibility
- Adhesion
- Stability of the resulting circuits

The substrates

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	HT steel	A 286	17-4 PH	17-4 PH
manufacturing	machining	machining	-Machining(TP) -MIM(membrane), sintered@1340°C	-Machining(TP) -MIM(membrane), sintered@1350°C
Thermal treatment	-	solution treated:1h30@ 900°C Quenched:16h @730°C	-	-
Temperature process for Thick-system	850°C	625°C	625°C & 525°C	625°C & 525°C

Thick-film system

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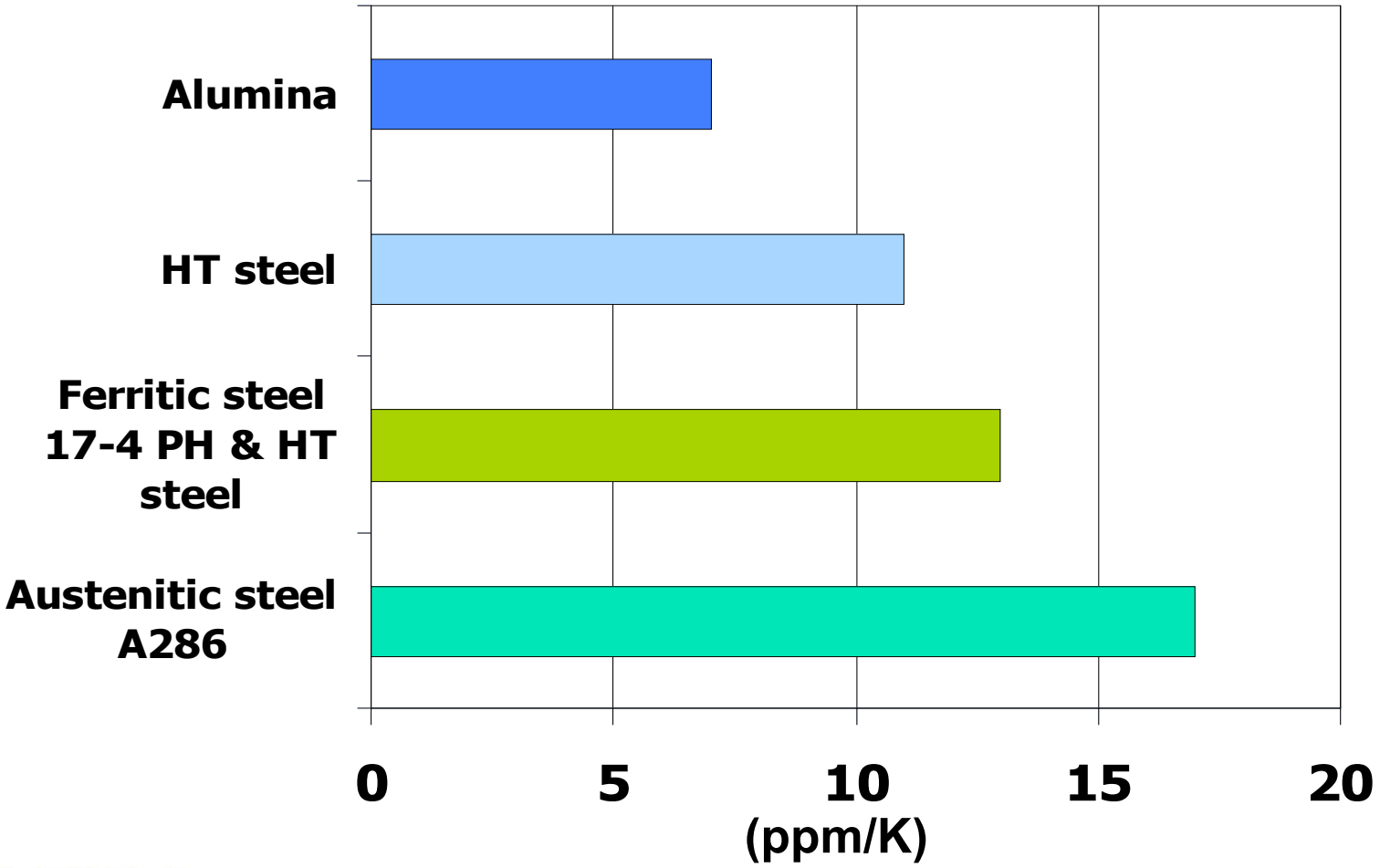
TCE of tested Substrates



Thick film system

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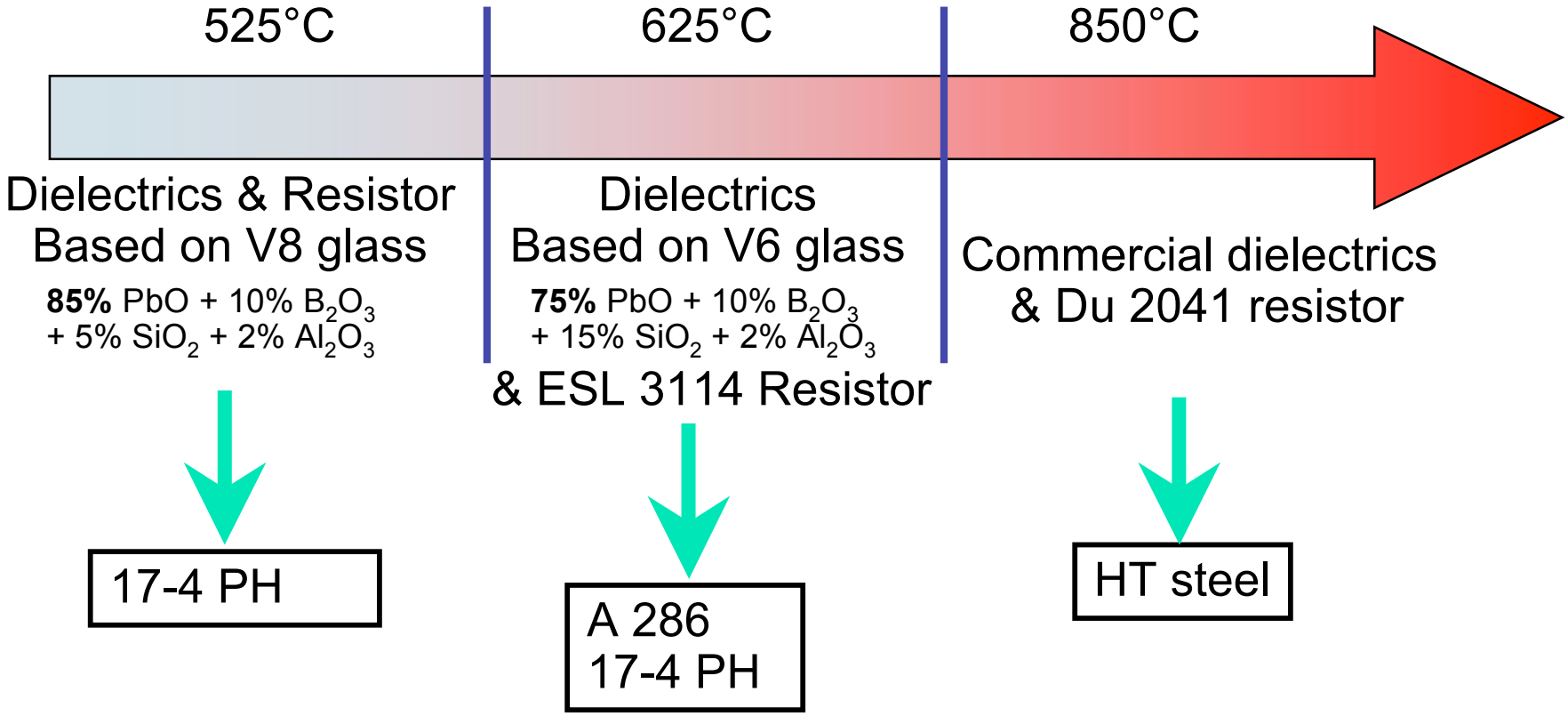
System Firing Temperature



Screen-printing sequence

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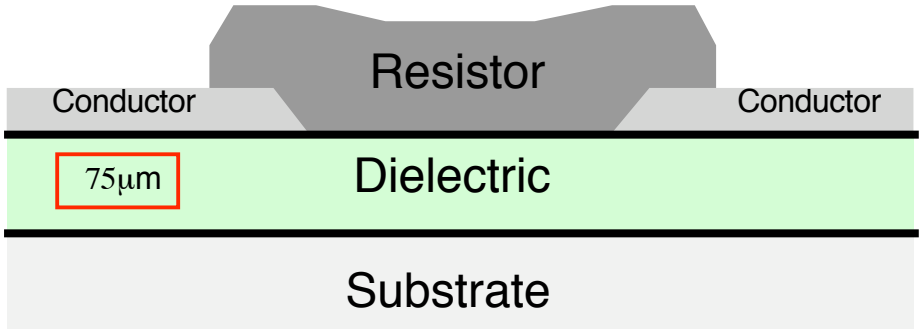
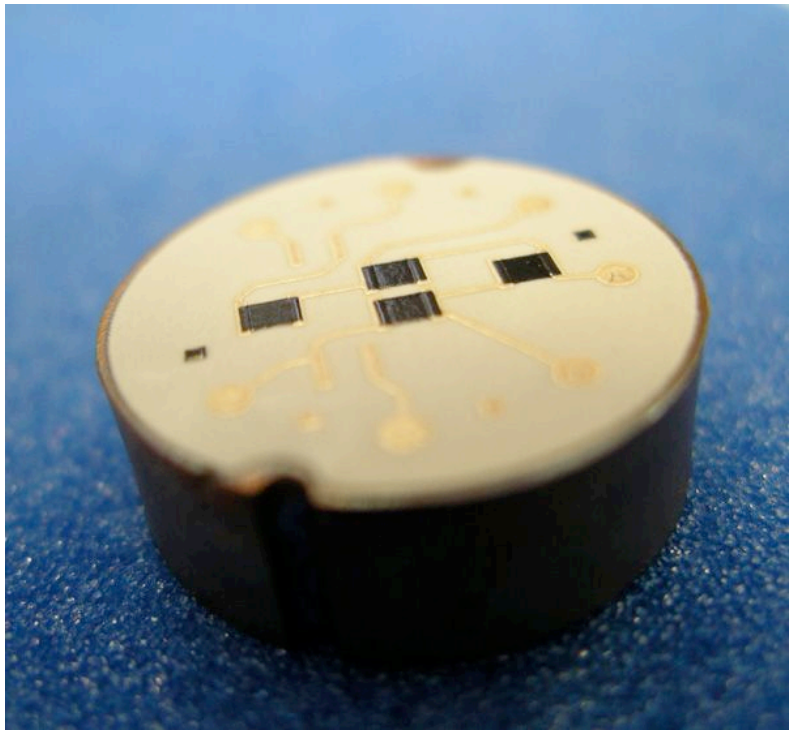
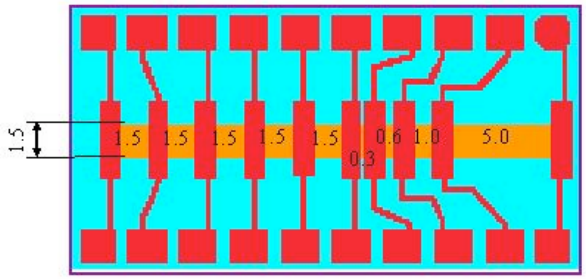


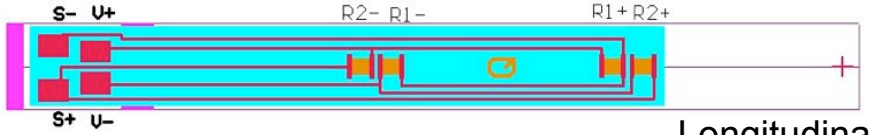


Basic structure

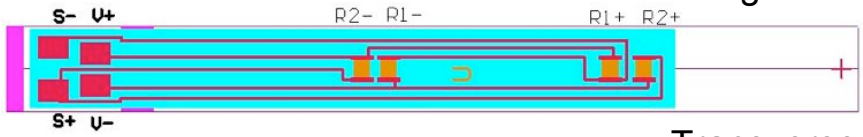
Samples for characterisation



- Sheet resistance
- TCR measurement

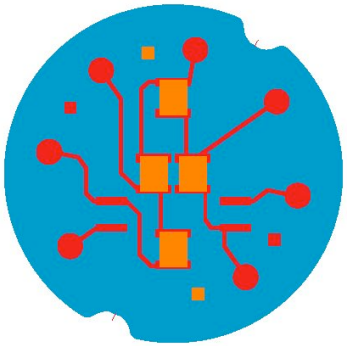


Longitudinal resistors



Transverse resistors

- Gauge Factor measurement



- Response
- Drift

Electrical results

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Dielectric Conductor Resistor	V6Q55 ESL 9912A ESL 3114	V8Q40 ESL 9912A:V8 V8 resistor
Res. Firing temperature	**625°C**	**525°C**
Sheet resistance (kΩ)	21±2 (Al_2O_3:11±1)	50±10 (Al_2O_3:19±5)
TCR (ppm/K)	13±6 (Al_2O_3:-220±15)	578±7 (Al_2O_3:363±8)
Gauge factor (longitudinal &transverse)	L:12.2±0.2 T:9.4±0.1 Al_2O_3: (L) 10.3±0.2 (T)7.7±0.2	L:23.5±0.2 T:18.9±0.2 Al_2O_3: (L) 23.0±0.3 (T)19.1±0.2

Performance of cells under pressure

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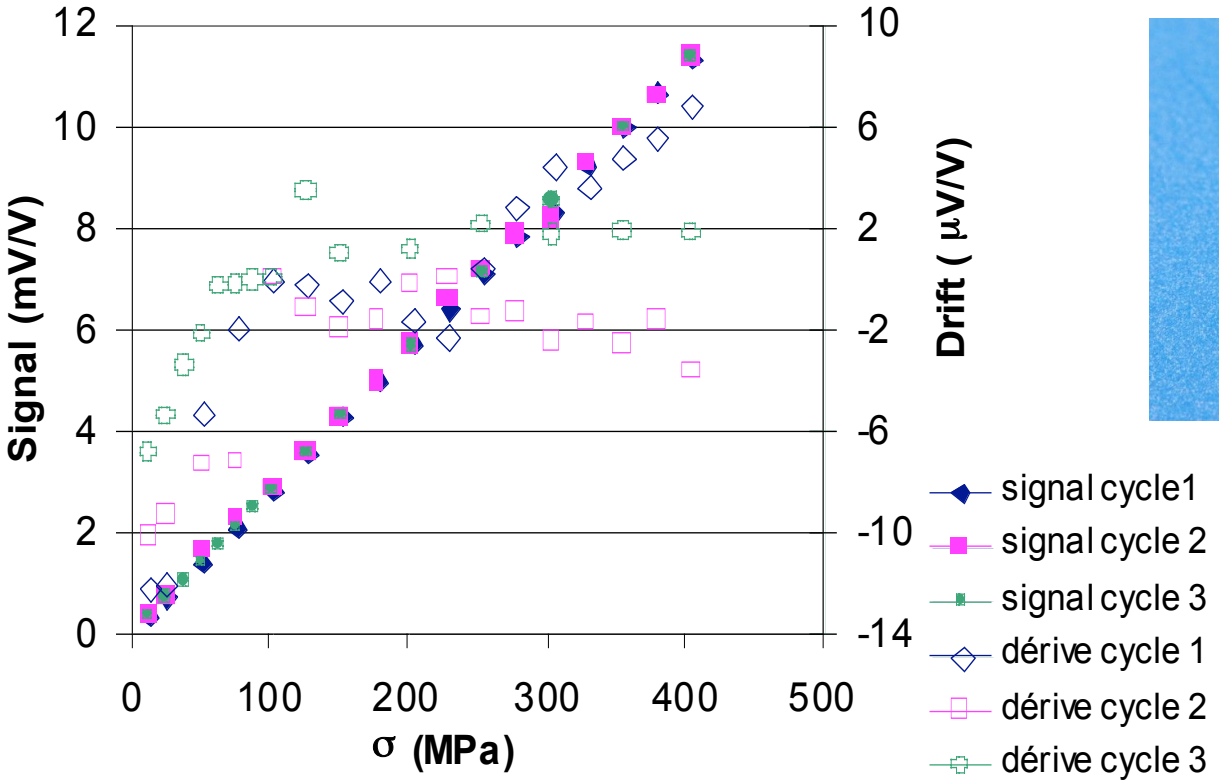
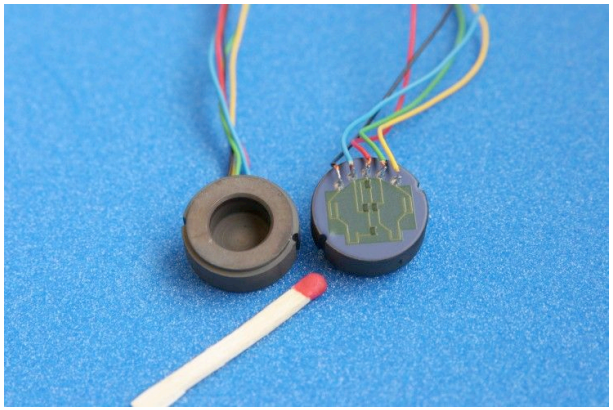
- HT cells (commercial TF system fired @ 850°C)





S = 2.839 ± 0.007 mV/V
D = 0.06 % @140 bar

Performance of cells under pressure

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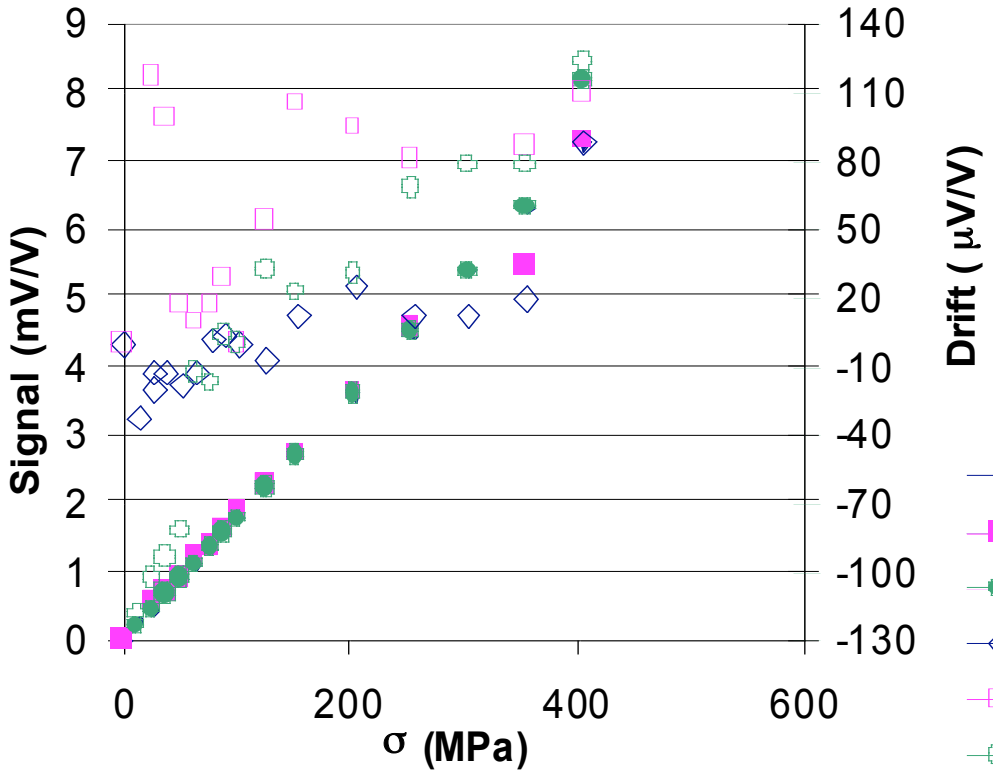
- A286 cells (commercial TF system fired @ 625°C)



S = 1.83 ± 0.05 mV/V
D = 6.9 % @140 bar

17-4 PH cells (625°C TF system)

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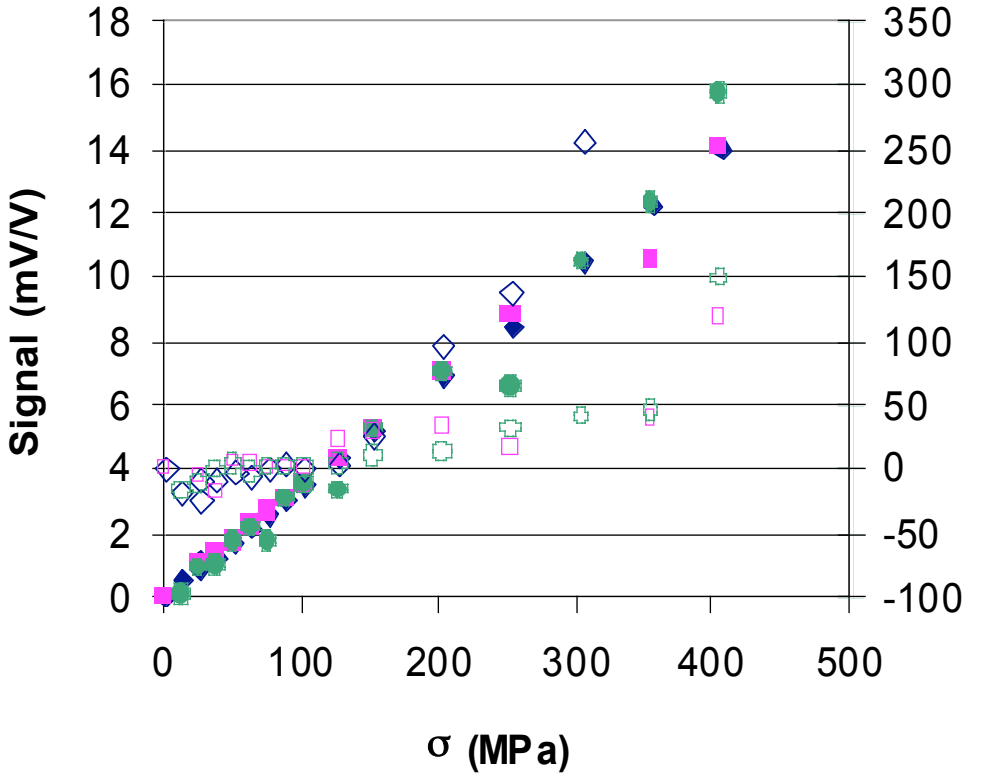
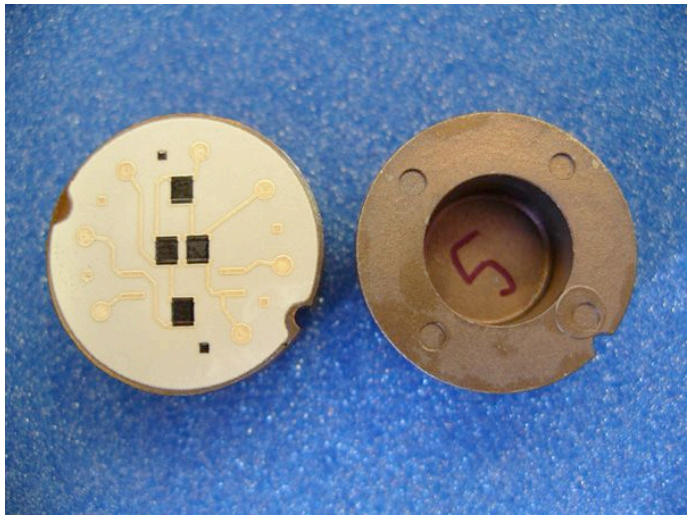
- 17-4 PH sintered @ 1340°C





S = 3.51 ± 0.02 mV/V
D = 4.2 % @140 bar

17-4 PH cells (625°C TF system)

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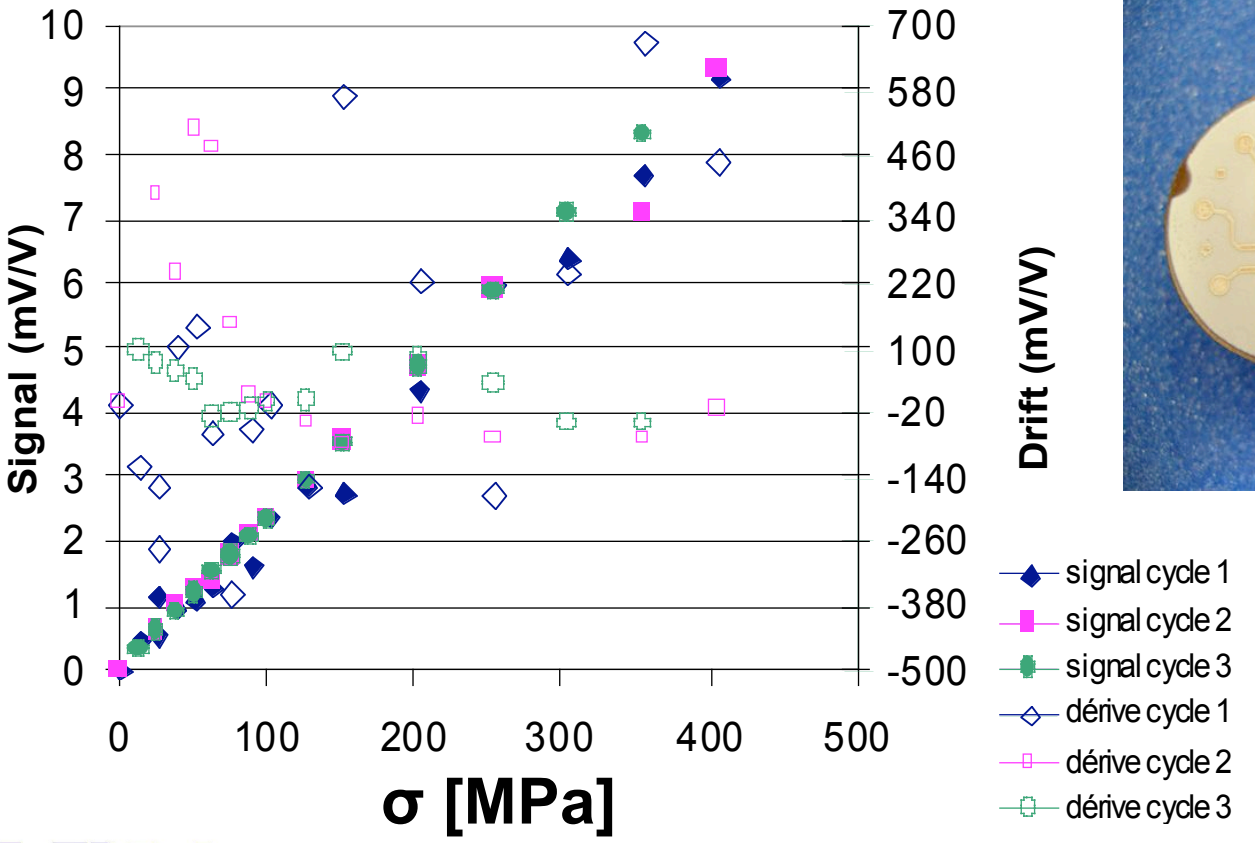
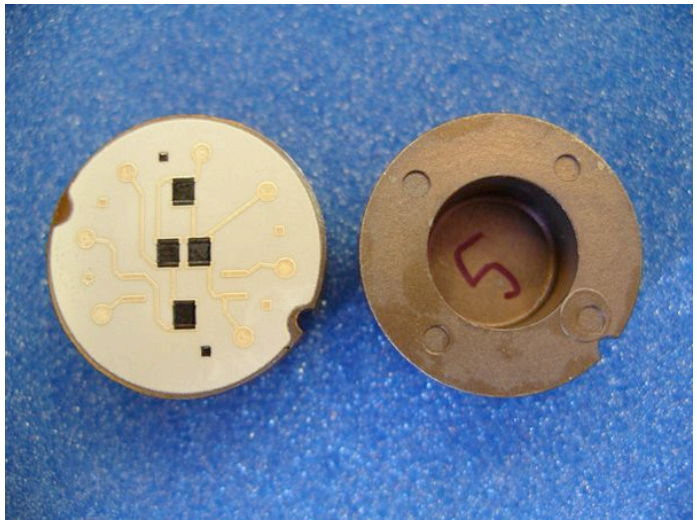
- 17-4 PH sintered @ 1350°C





S = 2.37 ± 0.02 mV/V
D = 1.7 % @140 bar

17-4 PH cells (525°C TF system)

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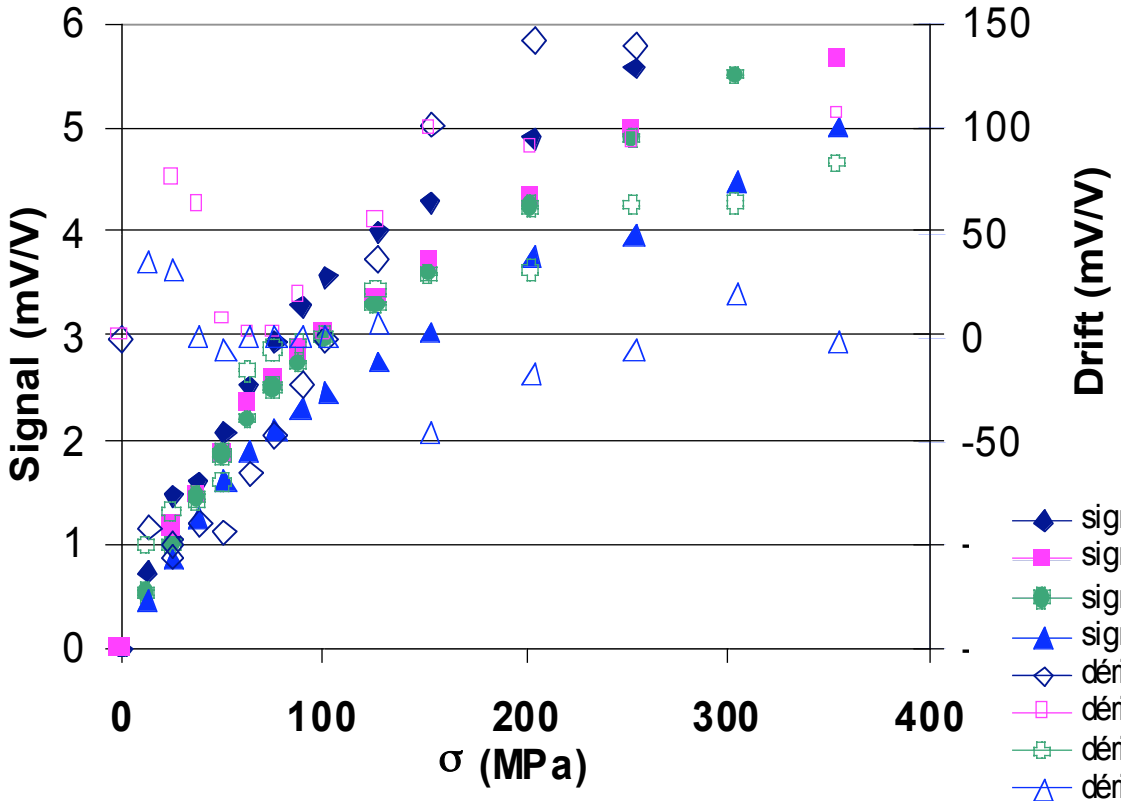
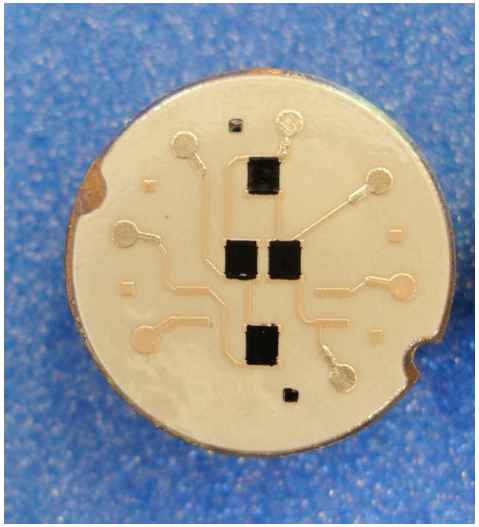
- 17-4 PH sintered @ 1340°C





S = 3.2 ± 0.03 mV/V
D =…

17-4 PH cells (525°C TF system)

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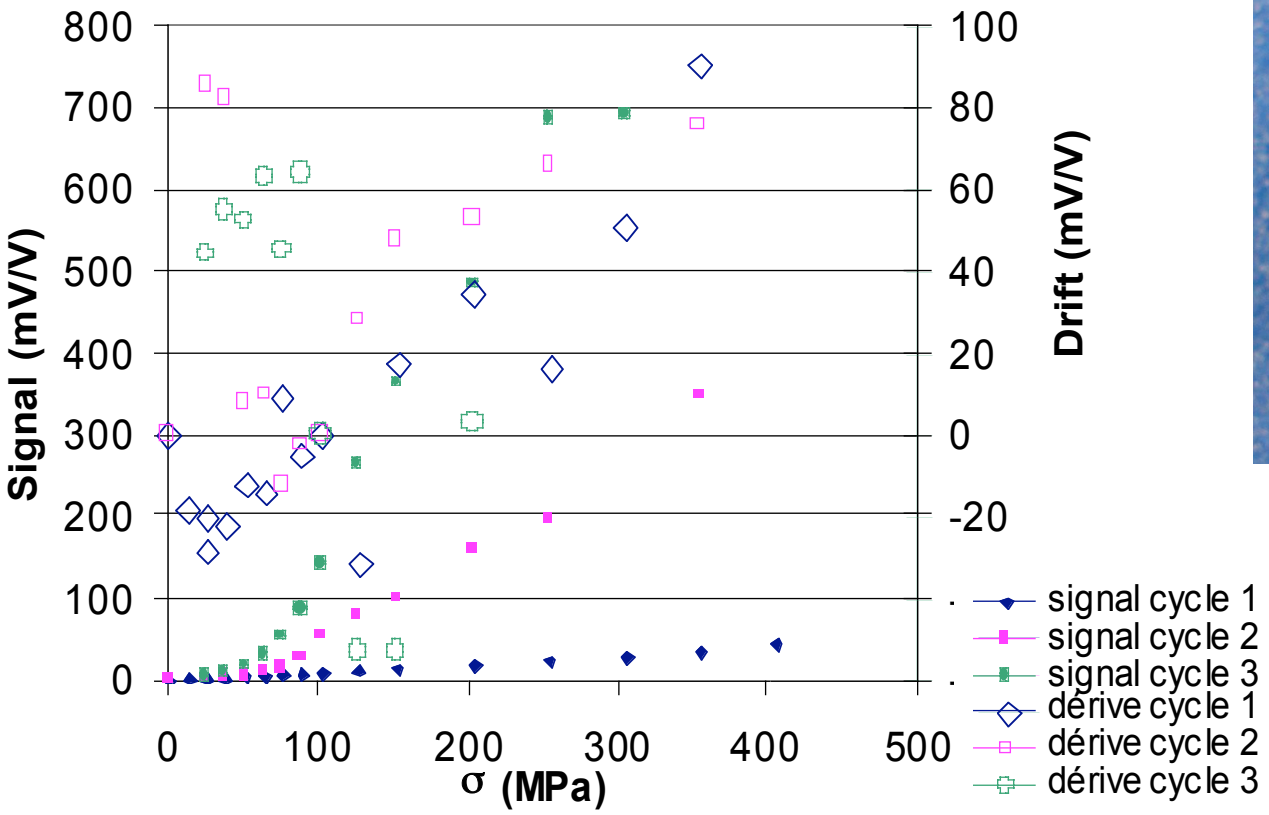
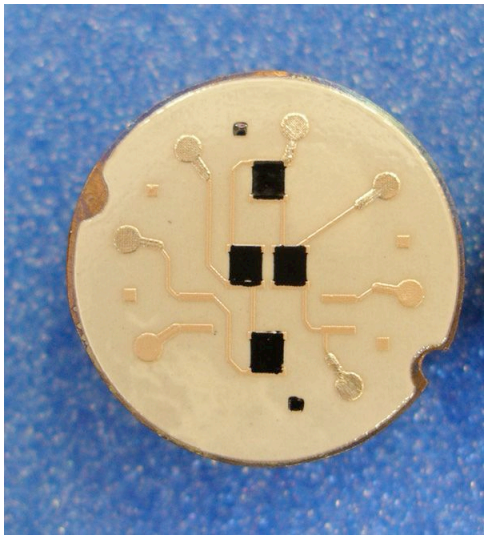
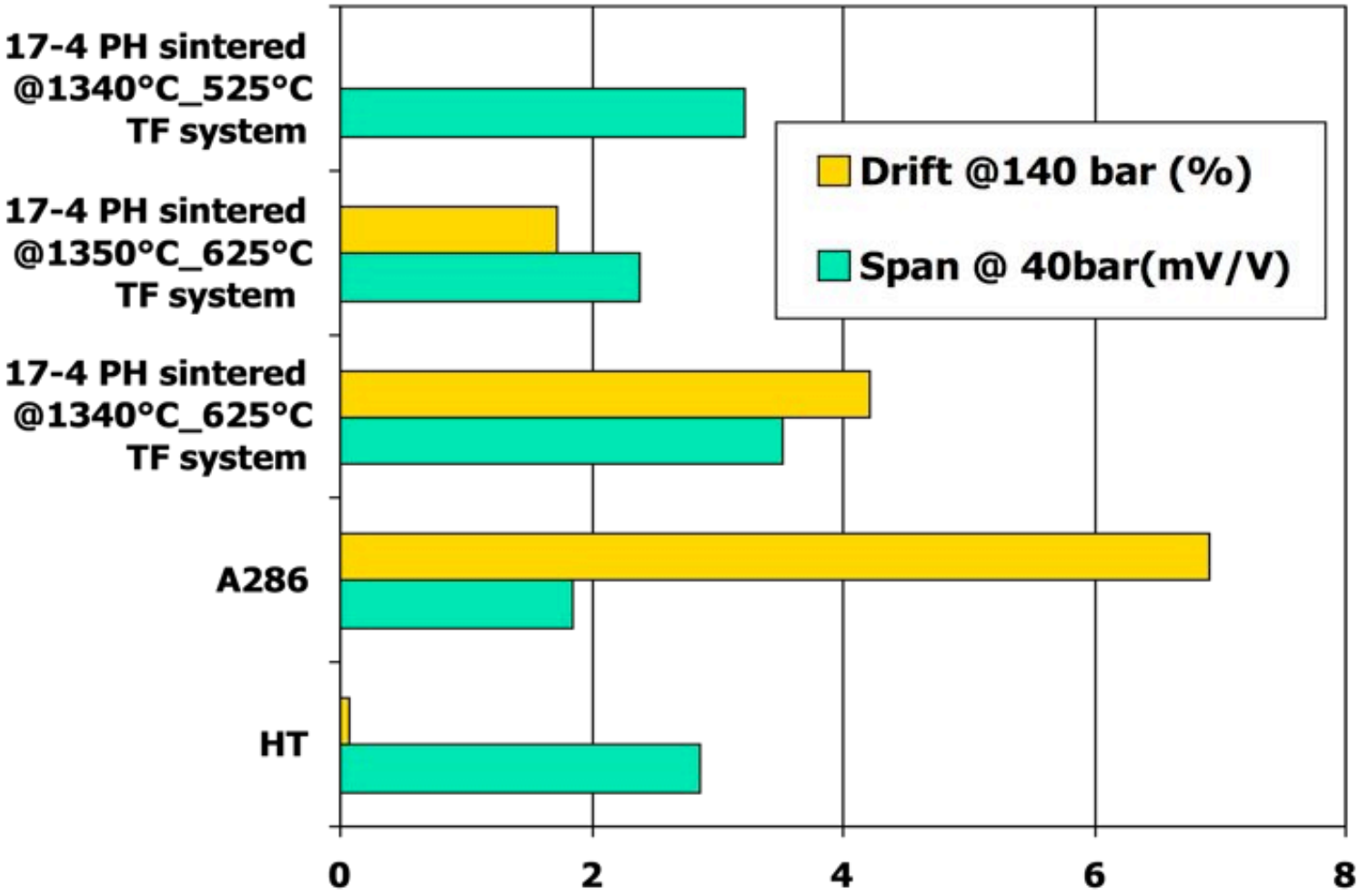
- 17-4 PH sintered @ 1350°C





Summary


17-4 PH sintered @1340°C_525°C TF system
17-4 PH sintered @1350°C_625°C TF system
17-4 PH sintered @1340°C_625°C TF system
A286
HT
Drift @140 bar (%)
Span @ 40bar(mV/V)
0
2
4
6
8

Conclusions and outlook

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- Excellent results on HT steel with commercial TF system but too expensive
- Excellent electrical properties for semi-custom 625°C firing system on common high-strength steels. But stability under high loads must still be improved.
- Control of TCR of our resistors through additives (CuO, NiO, TiO_2, Sb_2O_3)
- Improve adhesion promoters
- Materials without Pb or precious metals

Hvala!

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Thank you for your attention!