Metal Oxide Based High Temperature Pressure Sensors for Diagnosis Purposes in Rocket Engines

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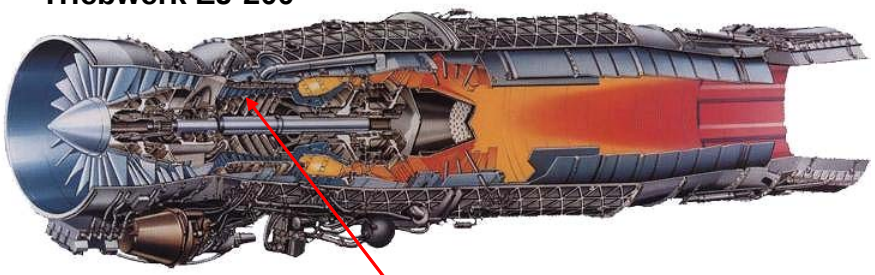
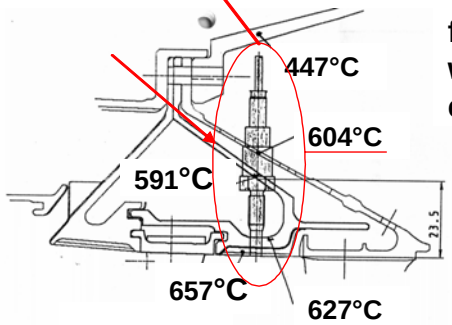
Requirements

Triebwerk EJ-200





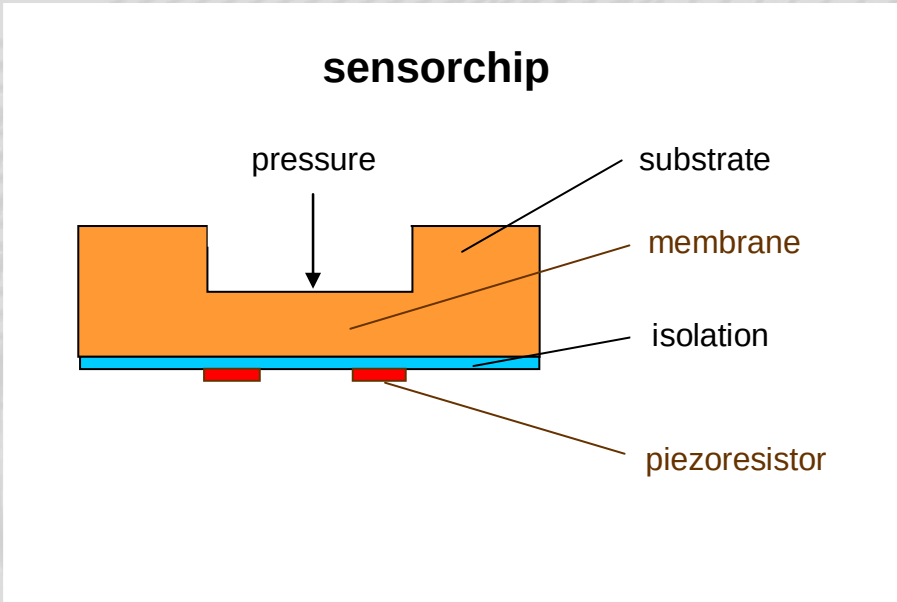
Requirement:

functionality up to 650°C with direct contact to corrosive media

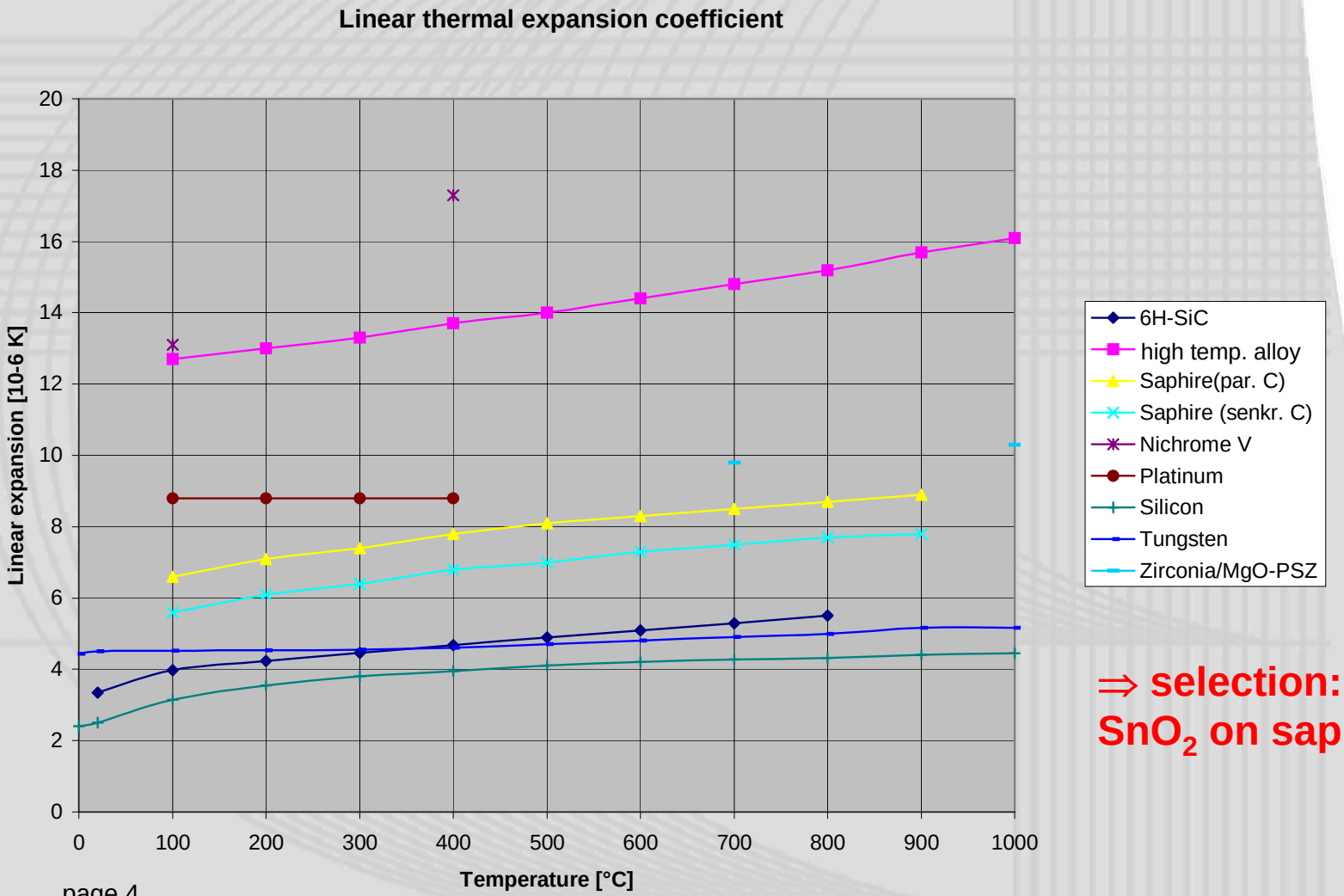
pressure sensing in rocket engines

- 600 - 800°C and even higher
- 40 - 300 bar
- static + dynamic measurement
- long time stability nice but not main necessity
- small + low weight
- cheap

Well Known Basic Structure

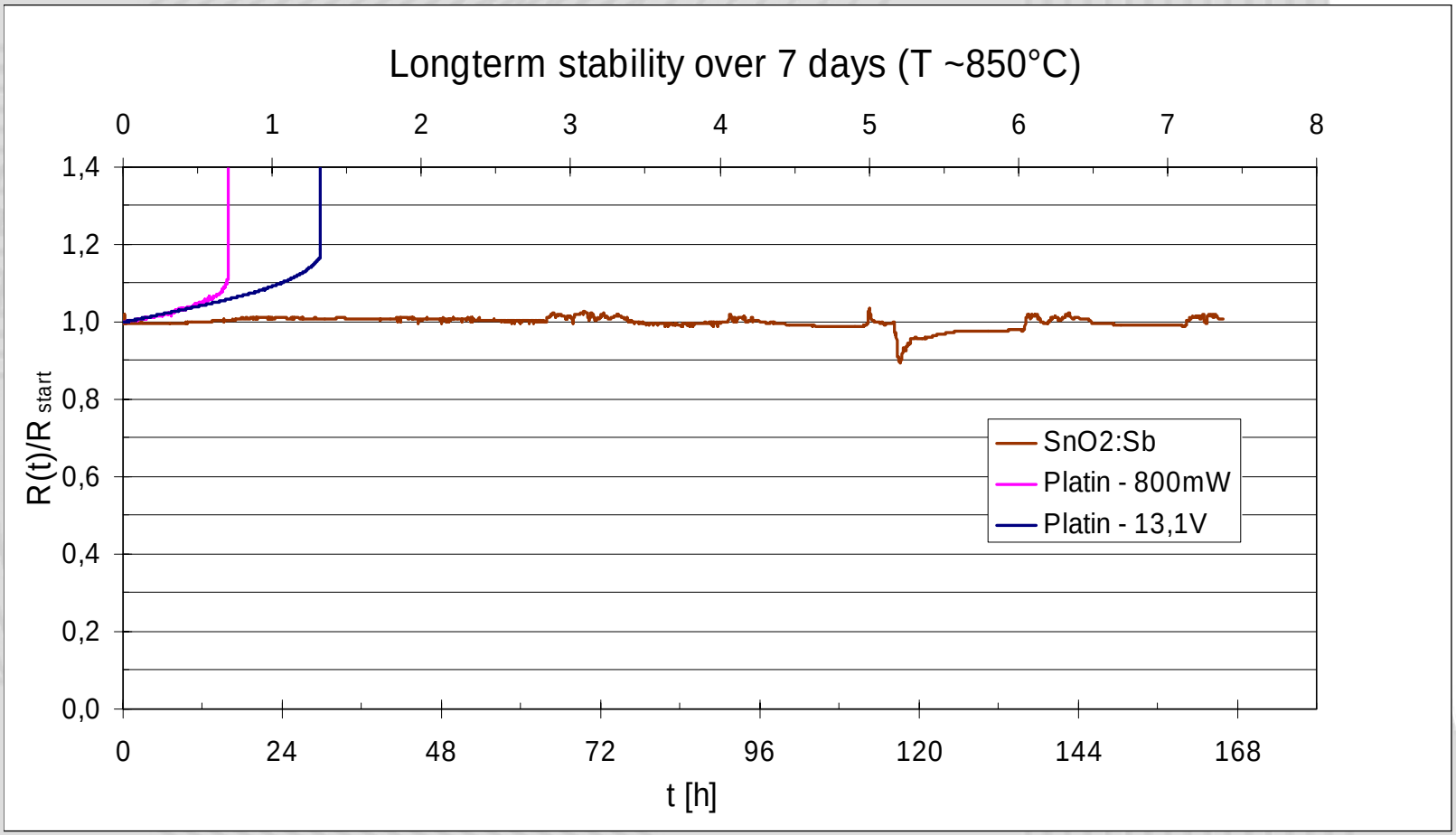


Optimization of Material Combination for Reduction of Thermally Induced Stresses



⇒ **selection:**
SnO_2 on sapphire

Active Heating of Metal Oxide Conductors (SnO_2:Sb) on Si/SiO_2



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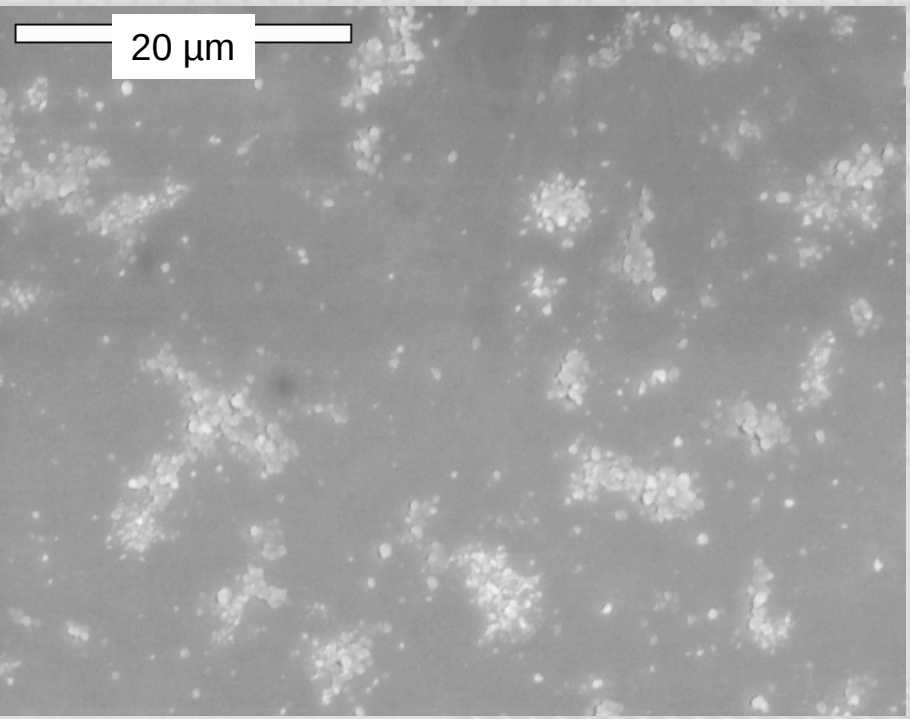
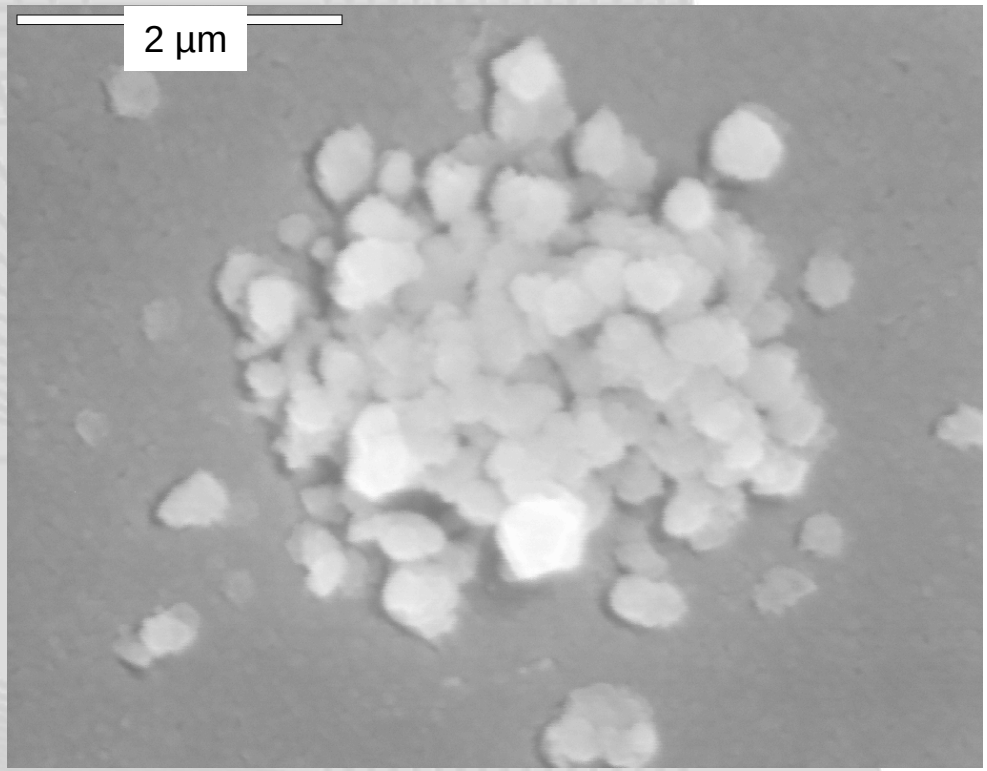
SnO_2:Sb Deposition on Sapphire

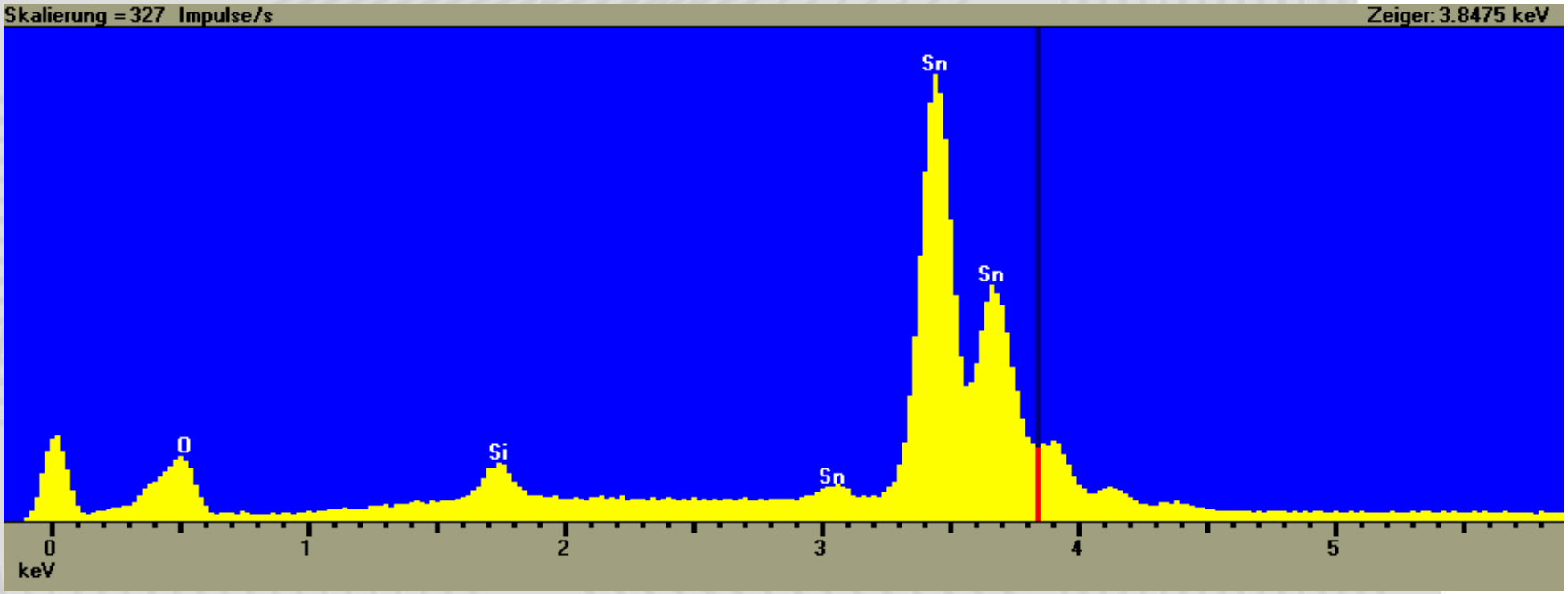
- doping: 5% Sb
- thickness: 850 nm
- annealing: 5 h ramp up to 1050°C (atmosphere); 4 h at 1050°C; 8 h ramp down
- deposition method: E-beam evaporation

→ small grains → much smoother surface than obtainable with evaporation of metallic Sn and subsequent oxidation → reduced gas sensitivity





EDX Analysis



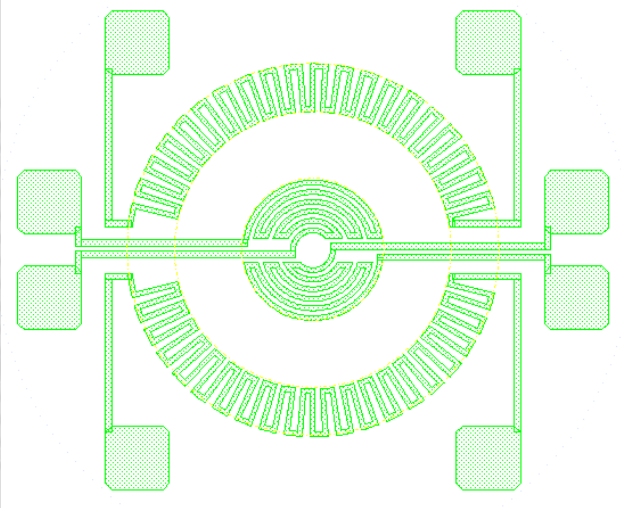
on smooth surface:

Sn 96.38 %
Sb 3.62 %

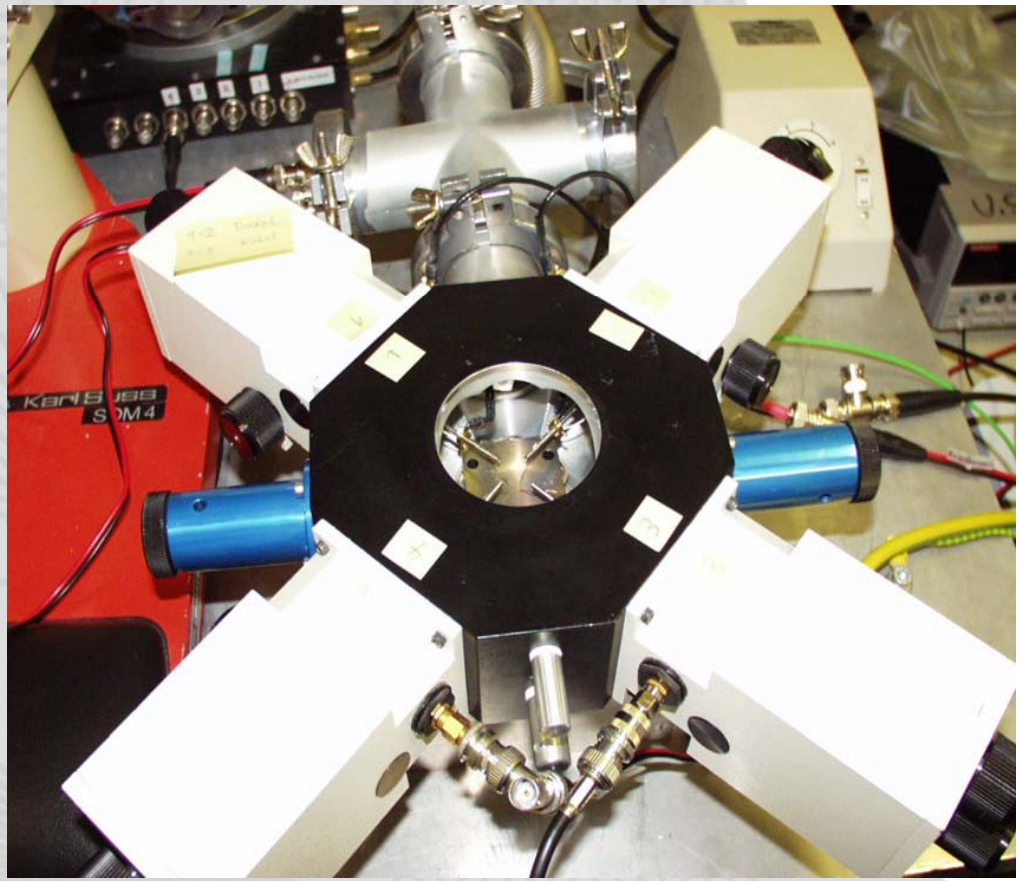
on agglomeration:

Sn 95.53 %
Sb 4.47 %

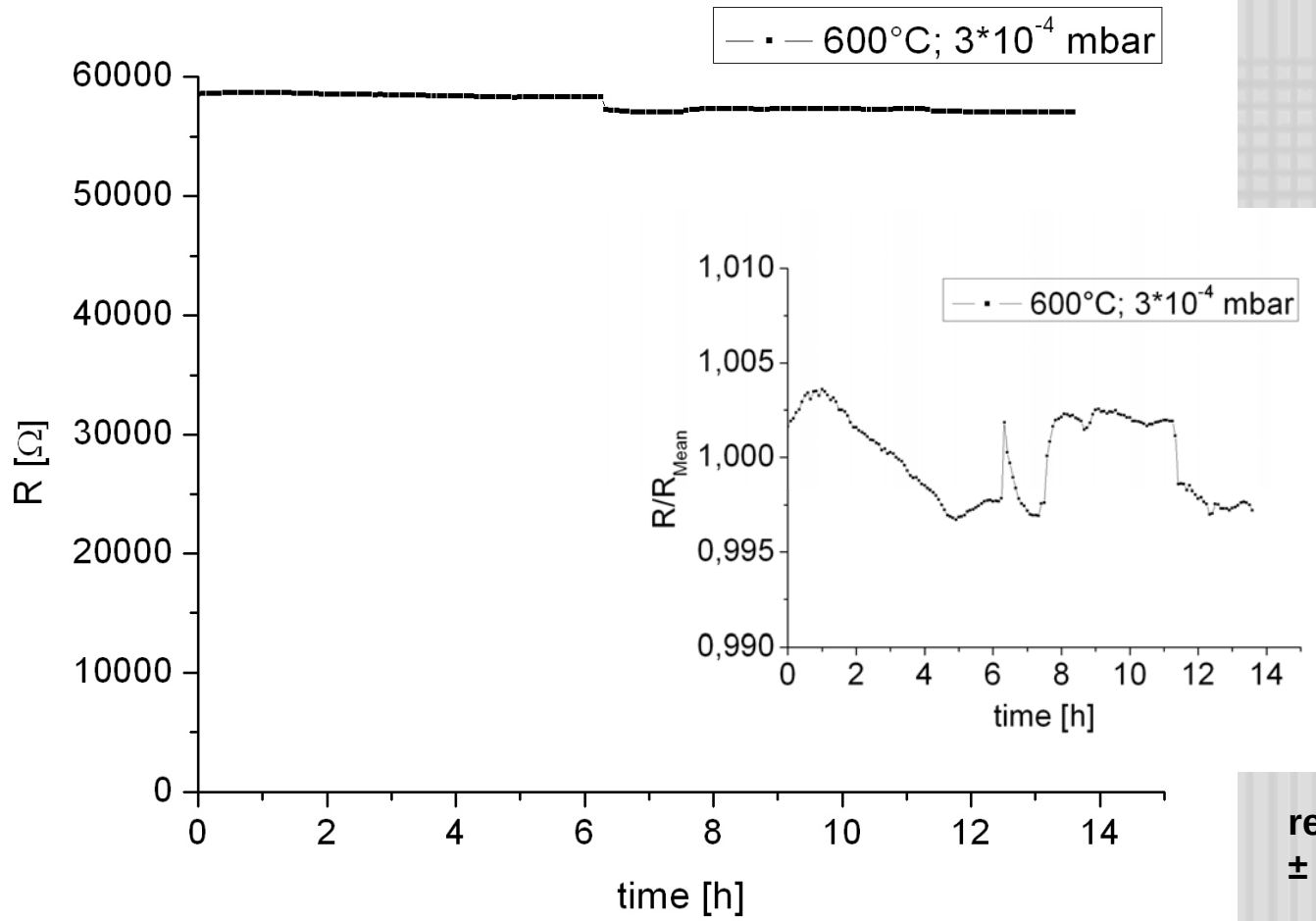
Layout



Four-Probe High Temperature Vacuum Test Setup for Characterization of Sensor Chips up to 630°C



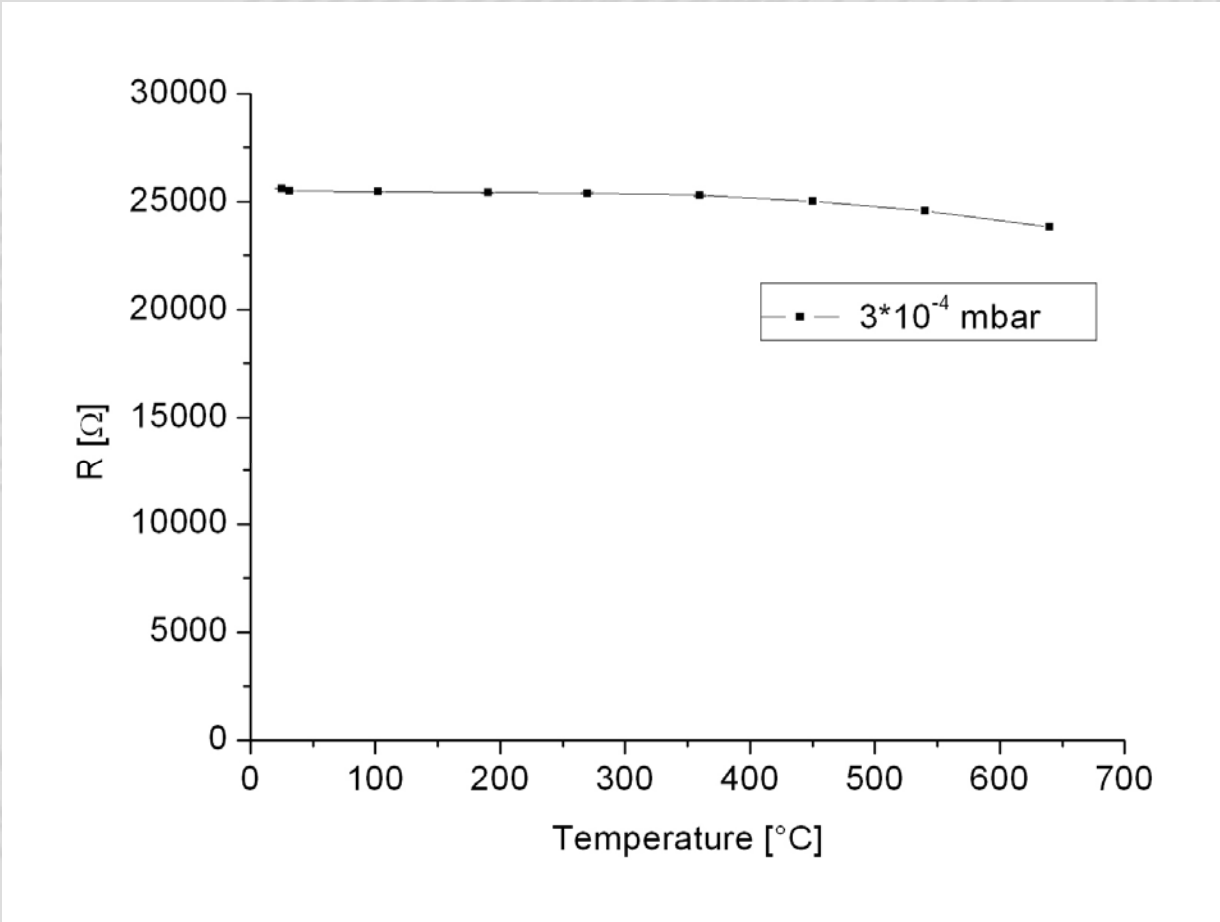
Temperature Stability



resistance stability: ± 0,35 %

standard deviation: 0,00223

Temperature Dependence of Electrical Resistance



⇒ TCR: $3.5*10^{-4}$ K^{-1}

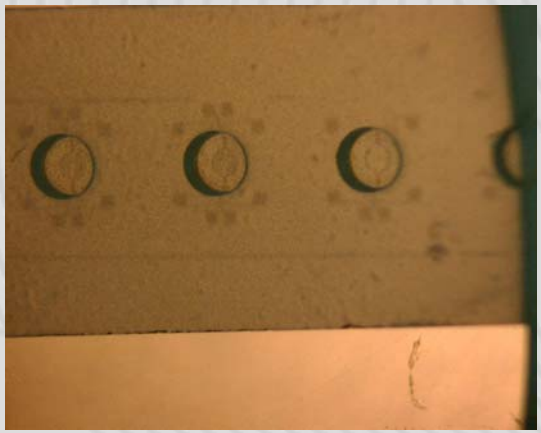
⇒ extremely low temperature dependence
⇒ simplifies temperature compensation of sensor signal

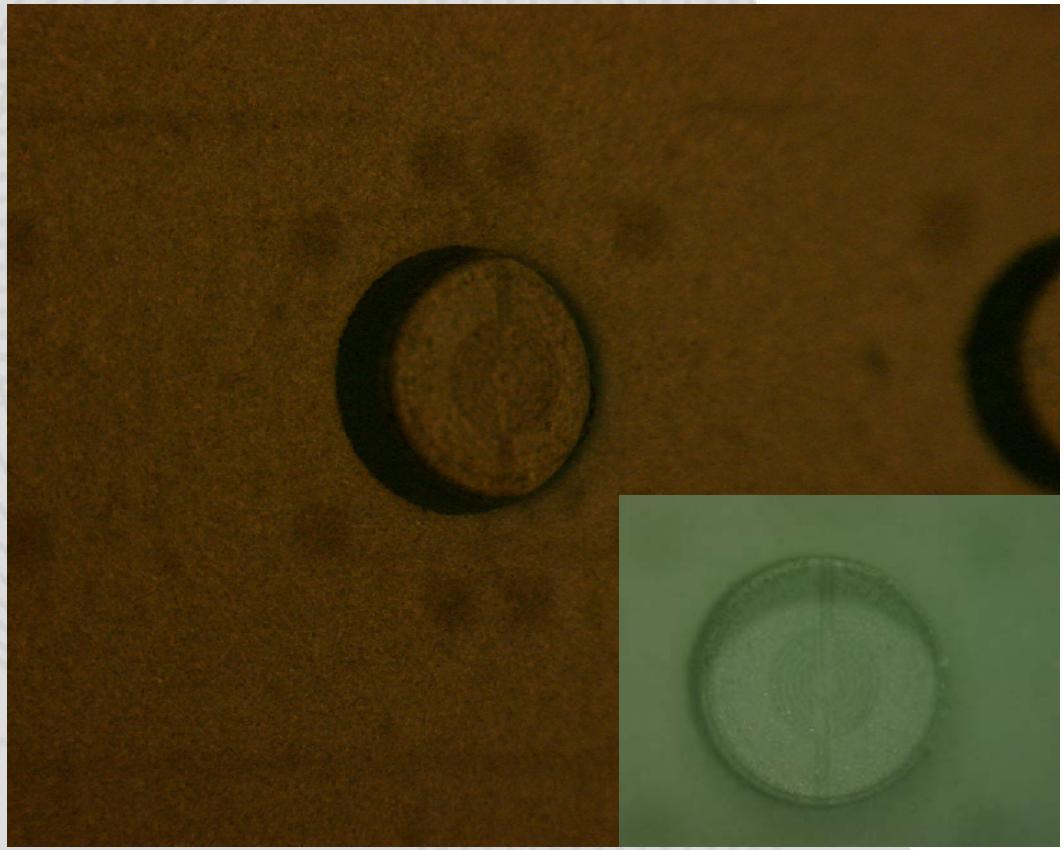
Membrane Formation in Sapphire

sapphire properties:

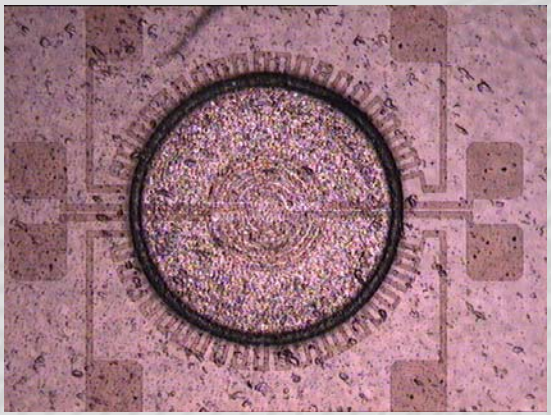
- very high chemical inertness
- extreme mechanical stability
- temperature stable up to almost 2000°C

membrane ∅: 2 mm
membrane thickness: 100 µm

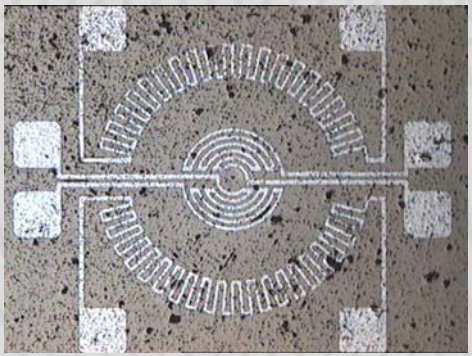


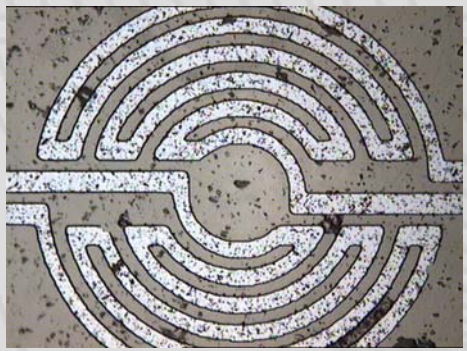


View from back side into the cavity of sensors, i.e. inside the cavities one can see the back side of the membranes. Through the transmitted light it is possible to see the resistors on the membrane front side.



Top view onto the membrane front side with the resistors. Due to transmitted light used in this photo it is possible to see that the alignment of the resistors to the cavity on the back side is very good.

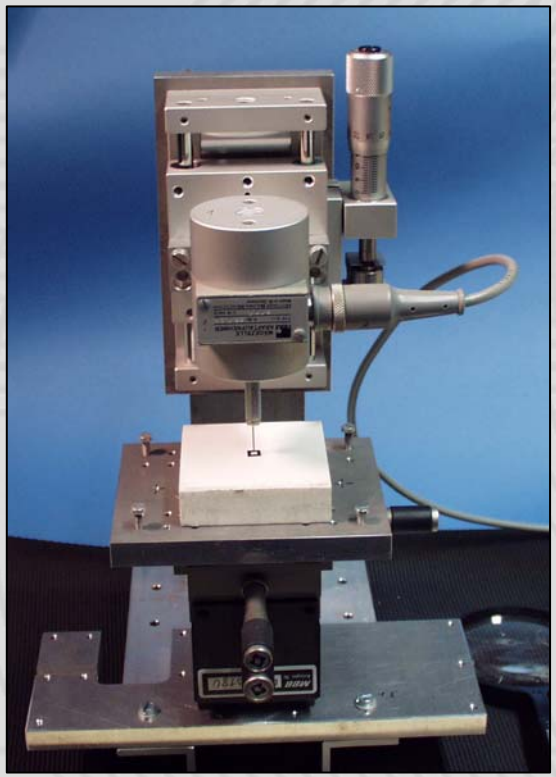


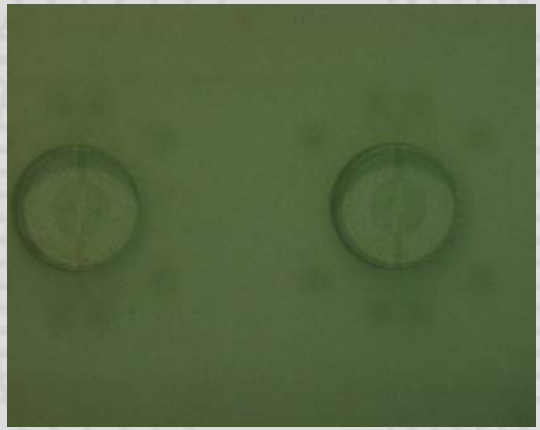


Top view onto the membrane front side with resistors (without transmitted light).

Sensor Signal Dependence on Membrane Deflection

deflection and force measurement



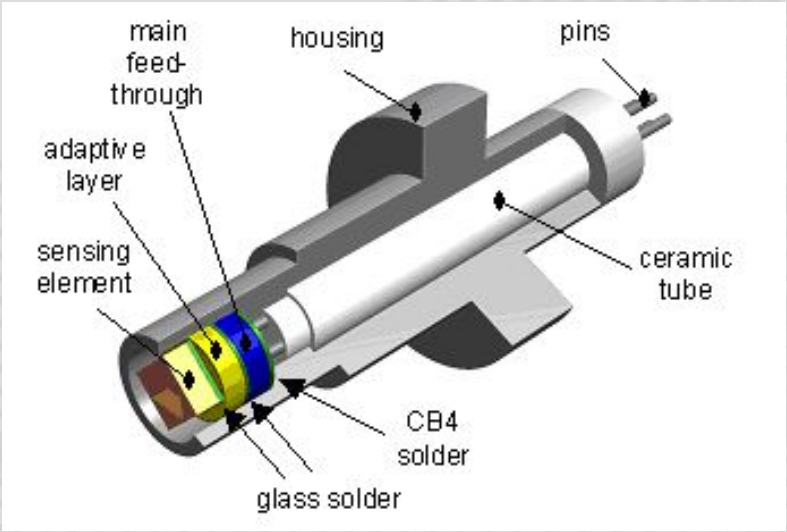


max. deflection: < 10 µm

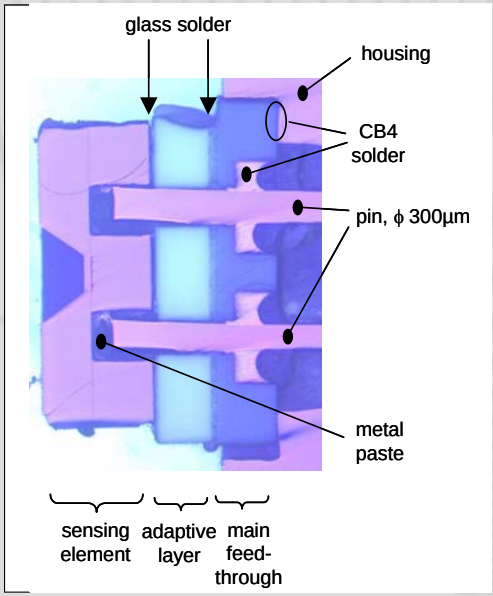
result:
≈ 2.5 % change in electrical resistivity at maximum membrane deflection
(for comparison: conventional metal strain gauges show about 0.1 % change)

⇒ Equipment for gauge factor measurement is currenctly being installed at EADS CRC for temperatures up to 800°C

High Temperature Sensor Packaging



picture of a packaged sensor used in car engine



cross section through heading part of packaging

High Temperature, High Pressure Test Rig (900°C, 300 bar) for Pressure Sensor Characterization and Sealing Tests Developed at EADS CRC

Acknowledgements

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