Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

EURAMET

EMPRESS
TEMPERATURE METROLOGY FOR PROCESS EFFICIENCY

EMPRESS Workshop

Advanced Forming Research Centre, March 22, 2017

Enhancing process efficiency through improved temperature measurement

WP1, Overview

“Low-drift contact temperature sensors to above 2000 °C”

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PTB, WG: “Thermoelectrics”

WP 1: Low-drift contact temperature sensors to above 2000 °C

Partners: **PTB[1]**, JV[1], NPL[1], Elkem[2], MUT[2], STRATH[2], CCPI[3]

[1] Internal funded partner (National Metrology Institutes (NMI))
[2] External funded partner (Industry, University)
[3] Unfunded partner

PTB	Physikalisch-Technische Bundesanstalt, Germany
JV	Justervesenet, Norway
NPL	National Physical Laboratory, United Kingdom
Elkem	Elkem AS Technology, Norway
MUT	MUT Advanced Heating GmbH, Germany
STRATH	University of Strathclyde, United Kingdom
CCPI	CCPI Europe, United Kingdom

WP 1

Objective: Development and characterisation of three novel sensors that have in-process *traceable* uncertainty of better than 3 °C at 1450 °C and better than 5 °C at T > 2000 °C.

- Conventional Pt/Rh thermocouples types S, R, B → thermoelectric instability (vapour pressure of Pt- and Rh-oxides) → historical „accidents“ rather than established on basis of optimisation → modelling Pt-/Rh oxide transport + experimental determination of optimum compositions
- Above 1800 °C refractory thermocouples (W/Re) → drifts of ten of degrees → **two approaches**

Optical contact thermometer:
Sapphire tube with dedicated optical readout components (1900 °C)

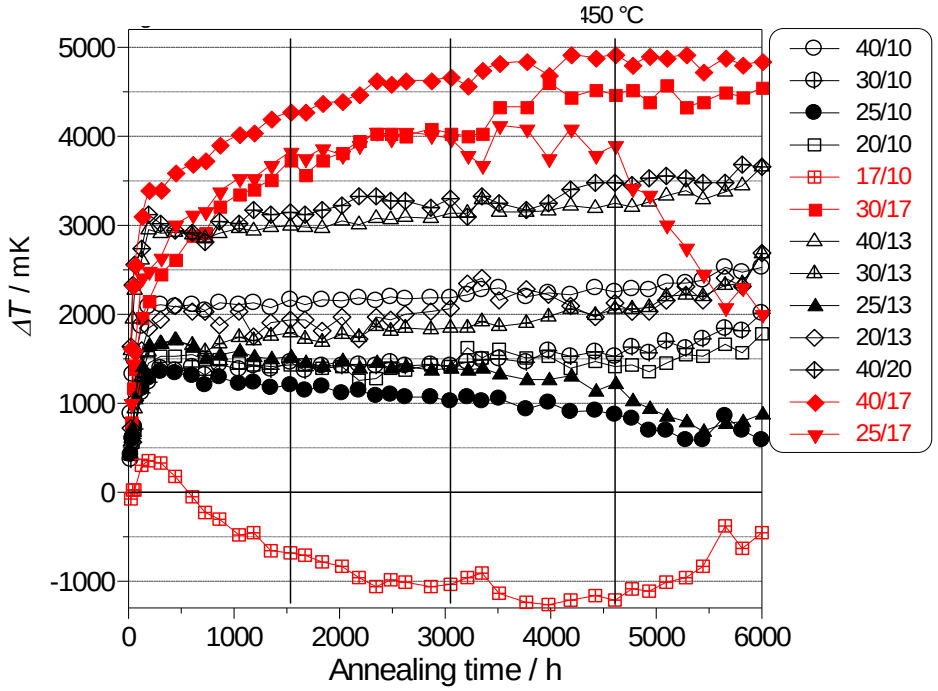
Carbon-based thermocouples
up to 2000°C

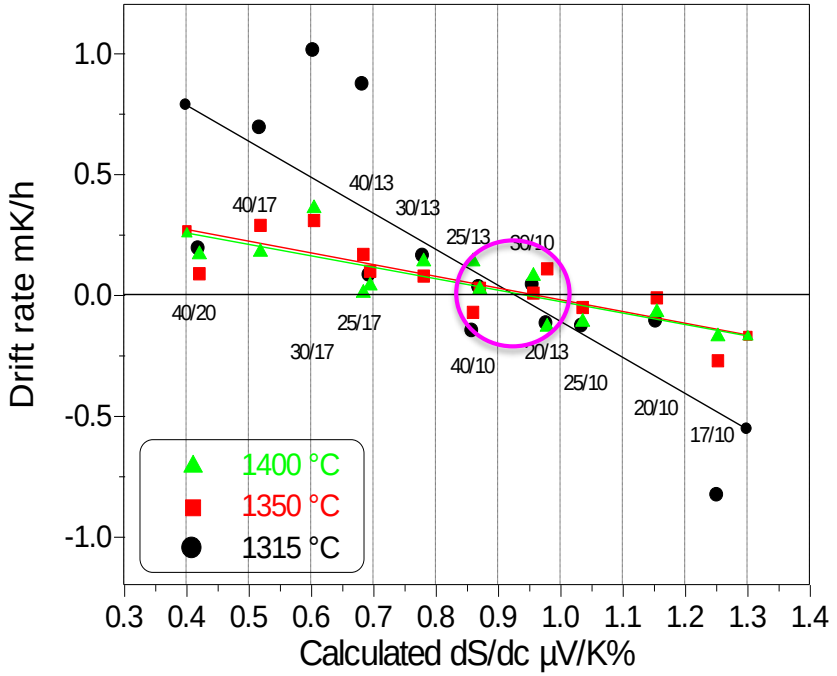
3 new or optimized sensors

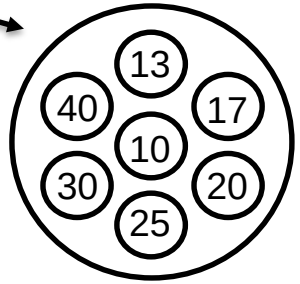
Task 1.1

Development of new and optimised Pt-Rh thermocouples (≈1450 °C)

- Developing of a model to characterise the influence of vapour transport of Pt and Rh oxides on the composition of the wires
- Annealing of multi-wire thermocouples with different Ptx%Rh-alloys: x = 5, 8, 10, 13, 17, 20, 25, 30, 40 at different temperature between about 1315 °C and 1480 °C (6000 hours)
- Determination of a draft reference function of Pt40Rh/Pt6%Rh



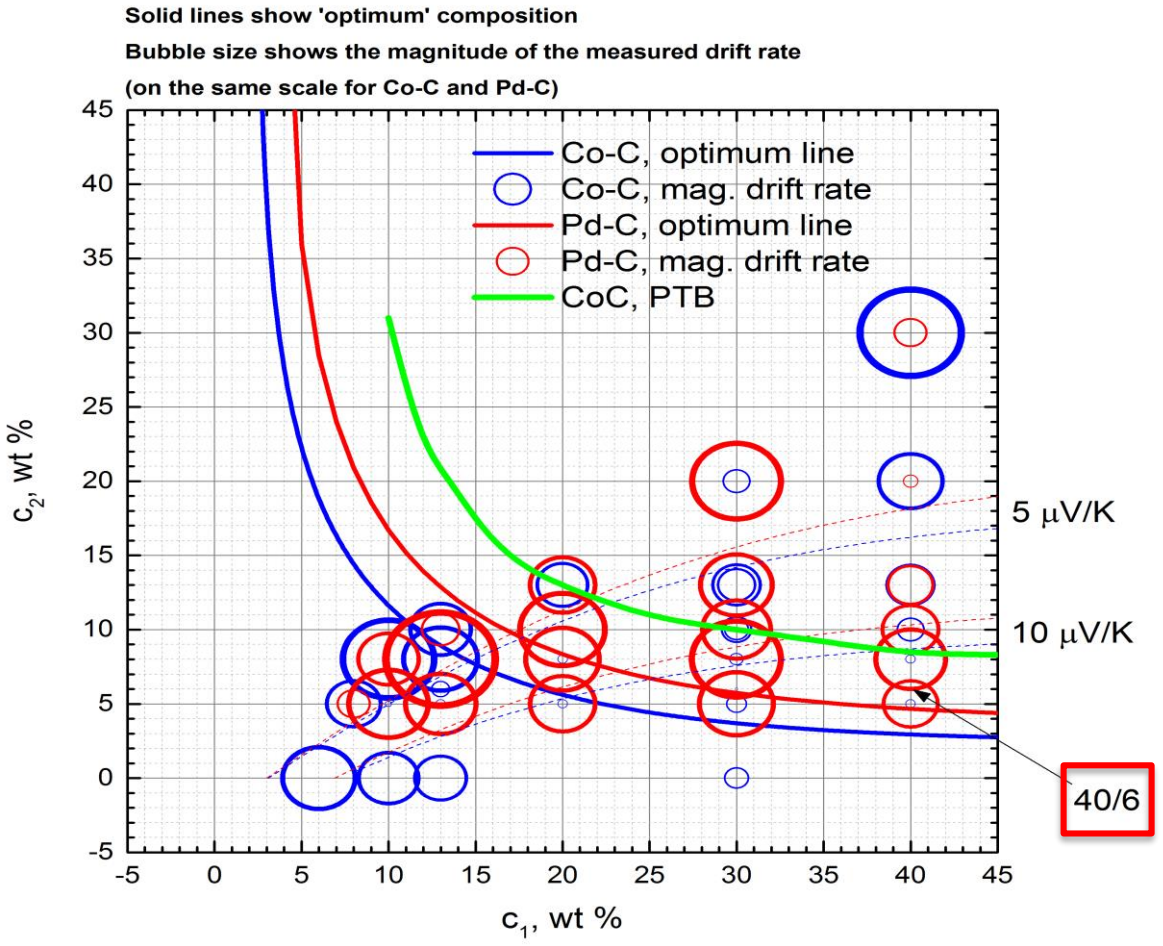




Drift rates at Co-C (1324 °C)

Task 1.1

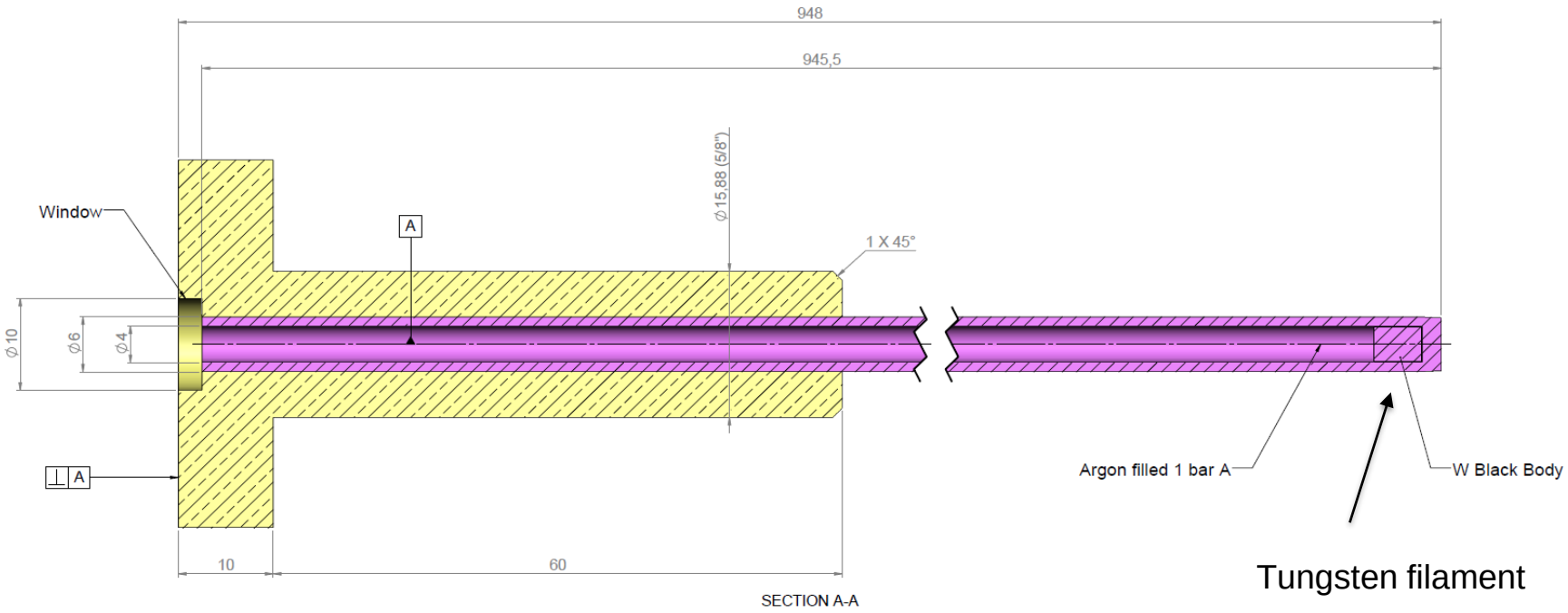
Development of new and optimised Pt-Rh thermocouples (≈1450 °C)



Task 1.2

Development of a sapphire tube thermometer (<1900 °C)

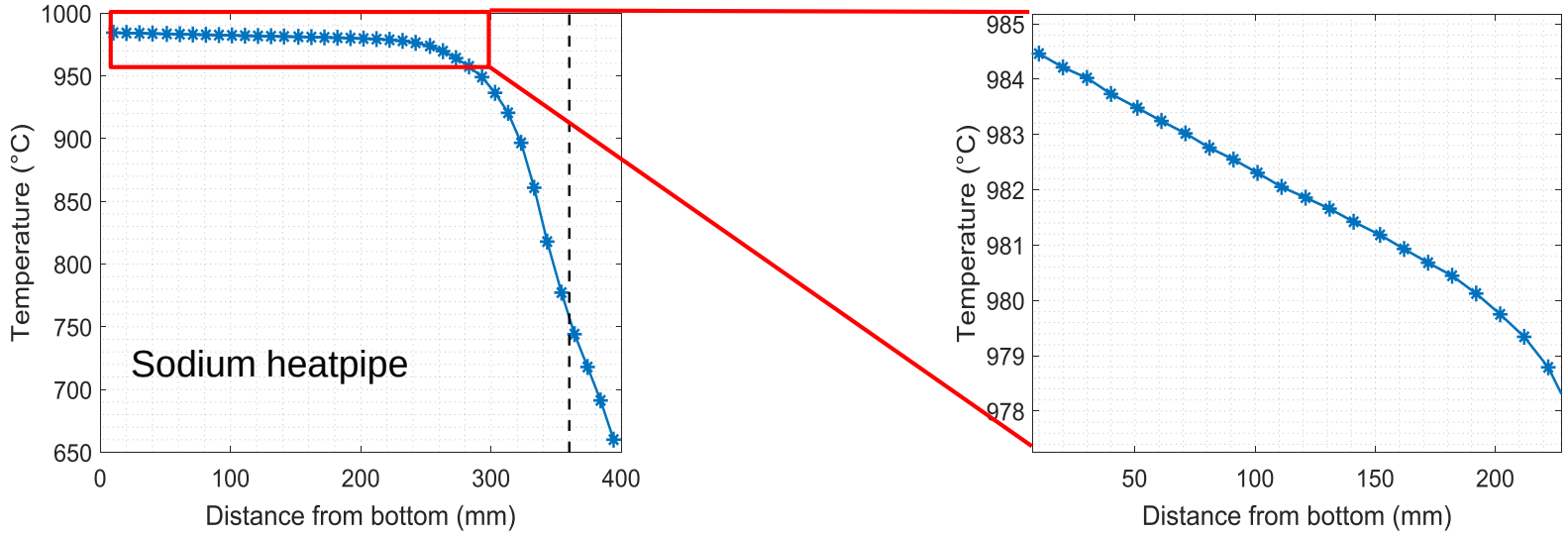
- A prototype thermometer was developed based on thermal radiation.
- It consists of a sensing element (blackbody), which is placed inside a sapphire tube with suitable optics channeling the thermal radiation on to a light detector (electronics)
- Based on the Planck radiation law, a model for the signal as a function of temperature was developed.

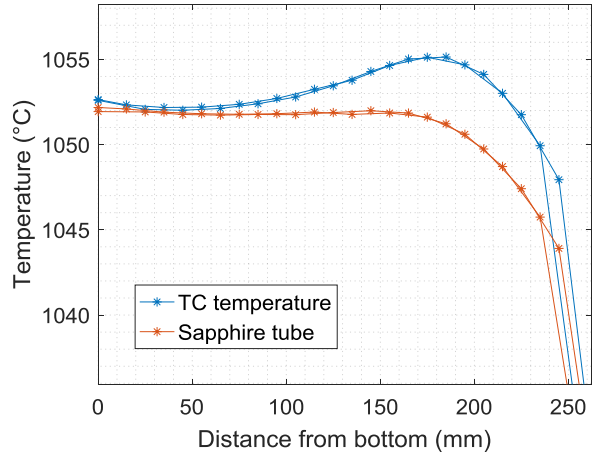


Task 1.2

Development of a sapphire tube thermometer (<1900 °C)

Main problem:
the temperature profile along the tube disturbs the signal



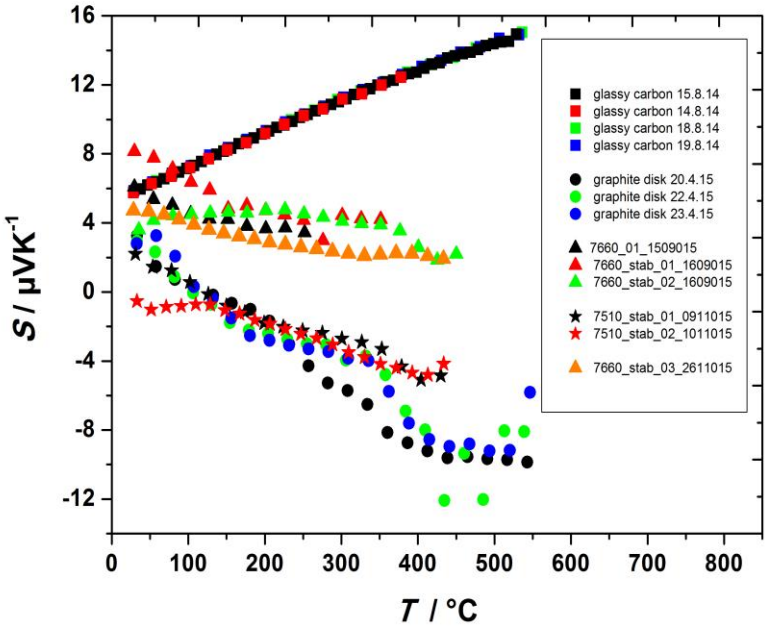


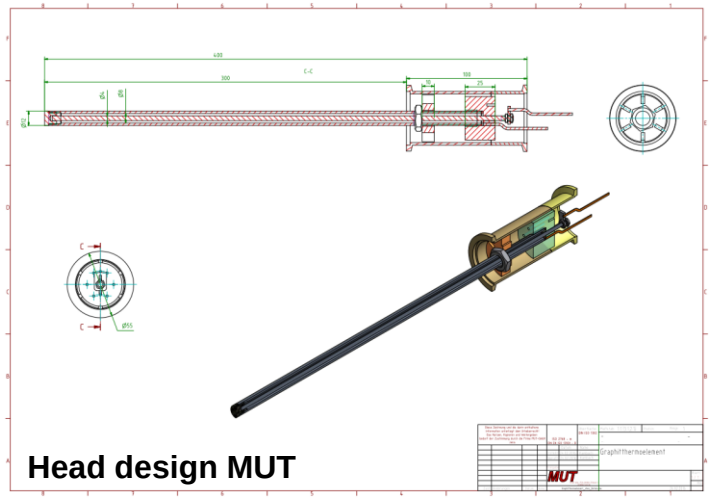
more modelling work to compensate the influence of the immersion profile

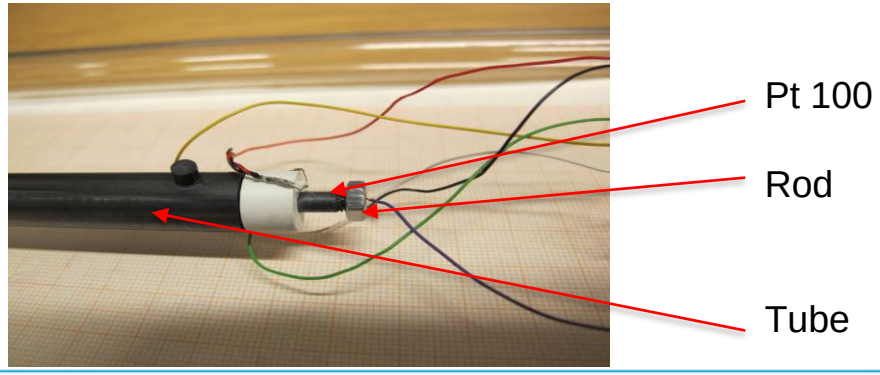
Development of carbon thermocouples

- Selection of suitable carbon thermocouple materials (3 graphite materials + glassy carbon)
- Solving constructional problems due to the use of non-metal thermoelements
- Metrological characterization to about 2000 °C

Absolute Seebeck coefficients

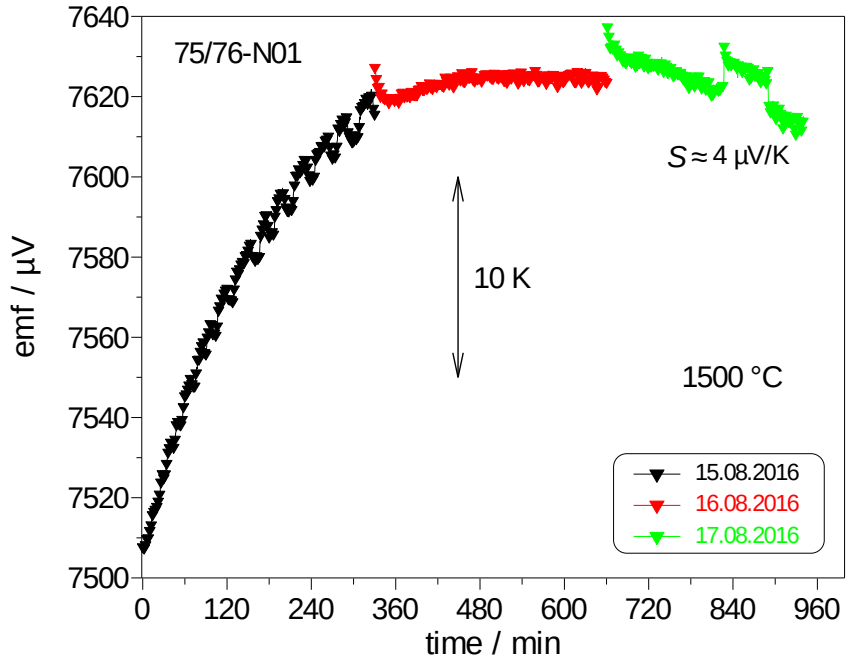




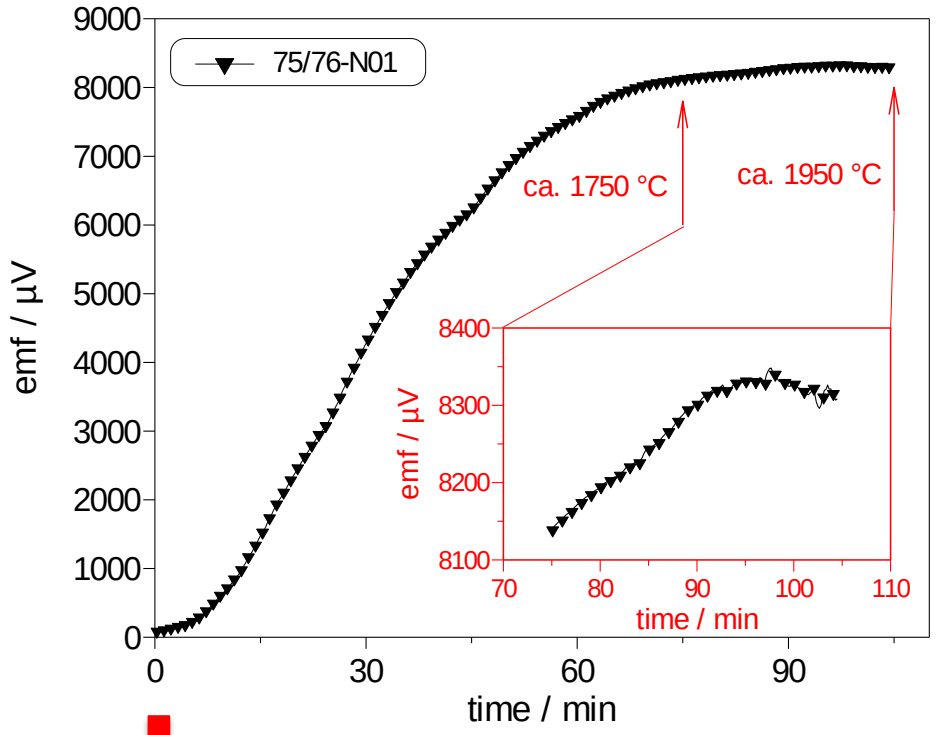


Thermocouple: C/C 76/75-N01 (after annealing)

1500 °C ⟶ 1950 °C



R7660/R7510 not suitable above ≈1700 °C

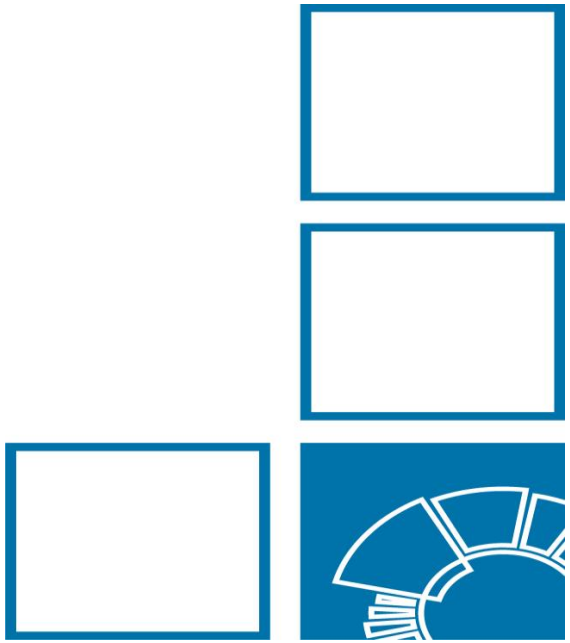


Task 1.4

Testing of the three new temperature sensors under industrial conditions

Nov 17 – Apr 18

Questions?



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