

# OPTICAL TEMPERATURE MEASUREMENTS IN ELKEM

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22.03.2017



# Elkem AS:

- Founded in 1904
- Owned by China National Bluestar since 2011
- 110 years of history as a technology provider

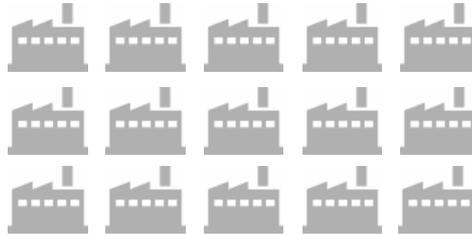
Global research centers  
in Kristiansand and Lyon, with

**370 R&D workers**



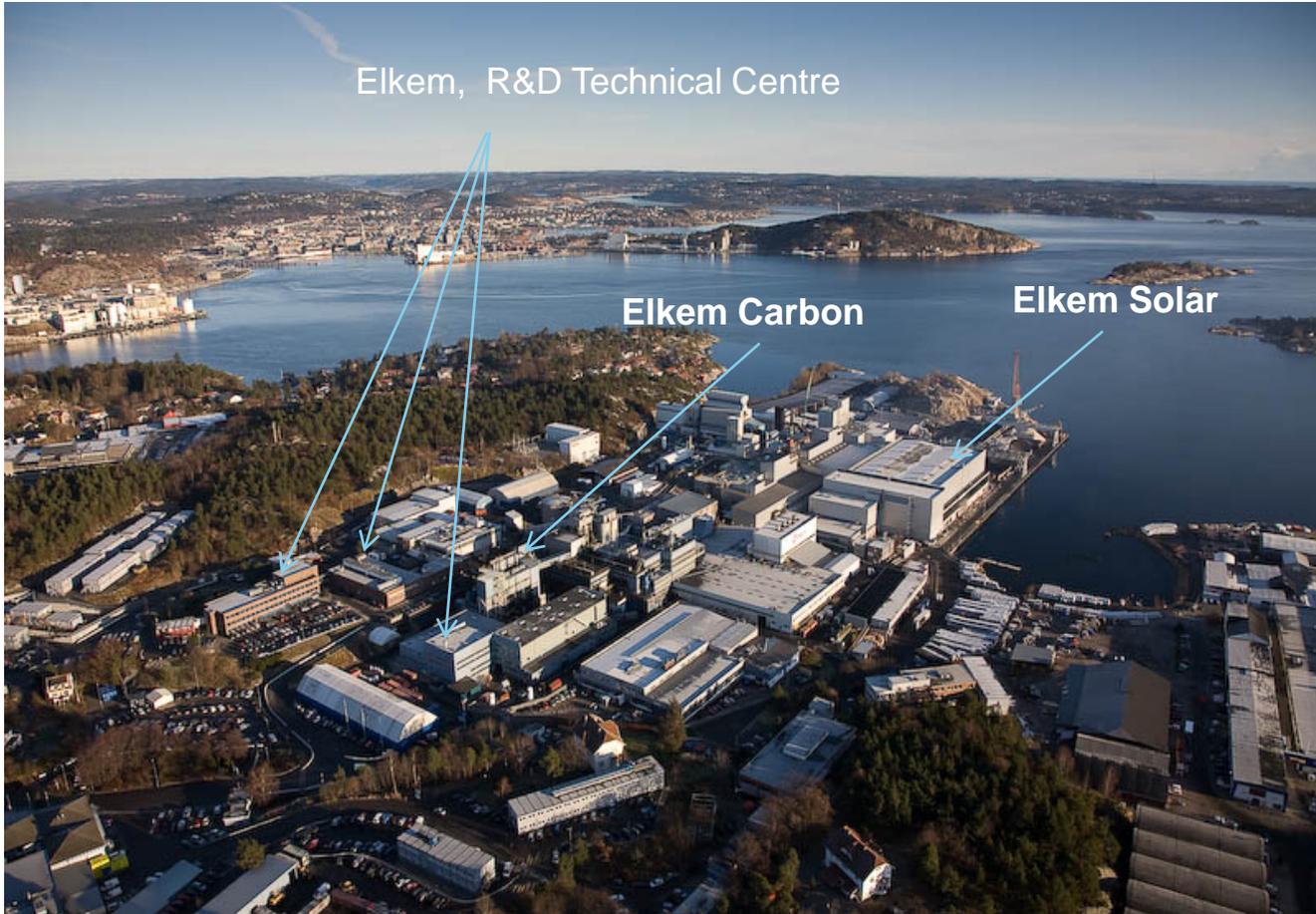
**3600 employees**  
(of which 1350 in Norway)

**24 plants** world wide,  
headquarter in Oslo, Norway



**NOK 14,5 bn**   
revenue in 2015.

# Elkem Fiskaa



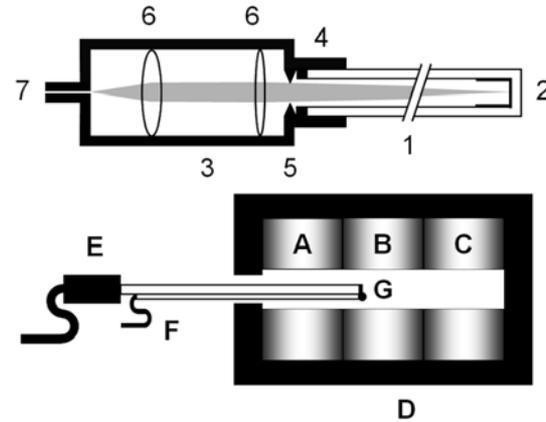
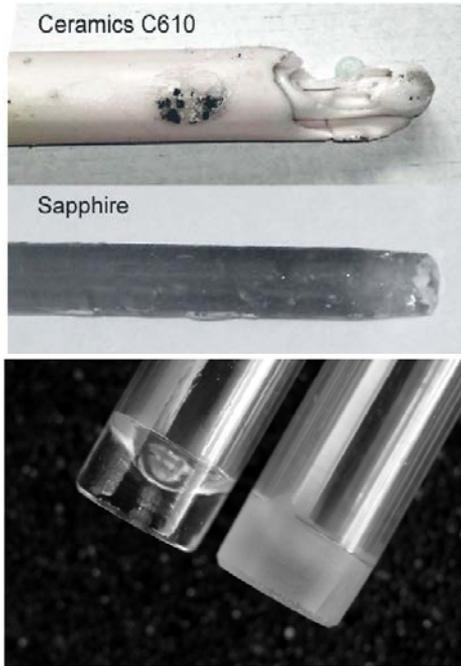
# Elkem Technology, R&D Technical Center.

- All in one place - open to internal and external research projects -



- 1 Pilot Plant
- 2 Laboratories and Instrumentation
- 3 Bench Scale Testings /Hydrometallurgical Testings
- 4 Solar Pilot Plant
- 5 Offices

# Background

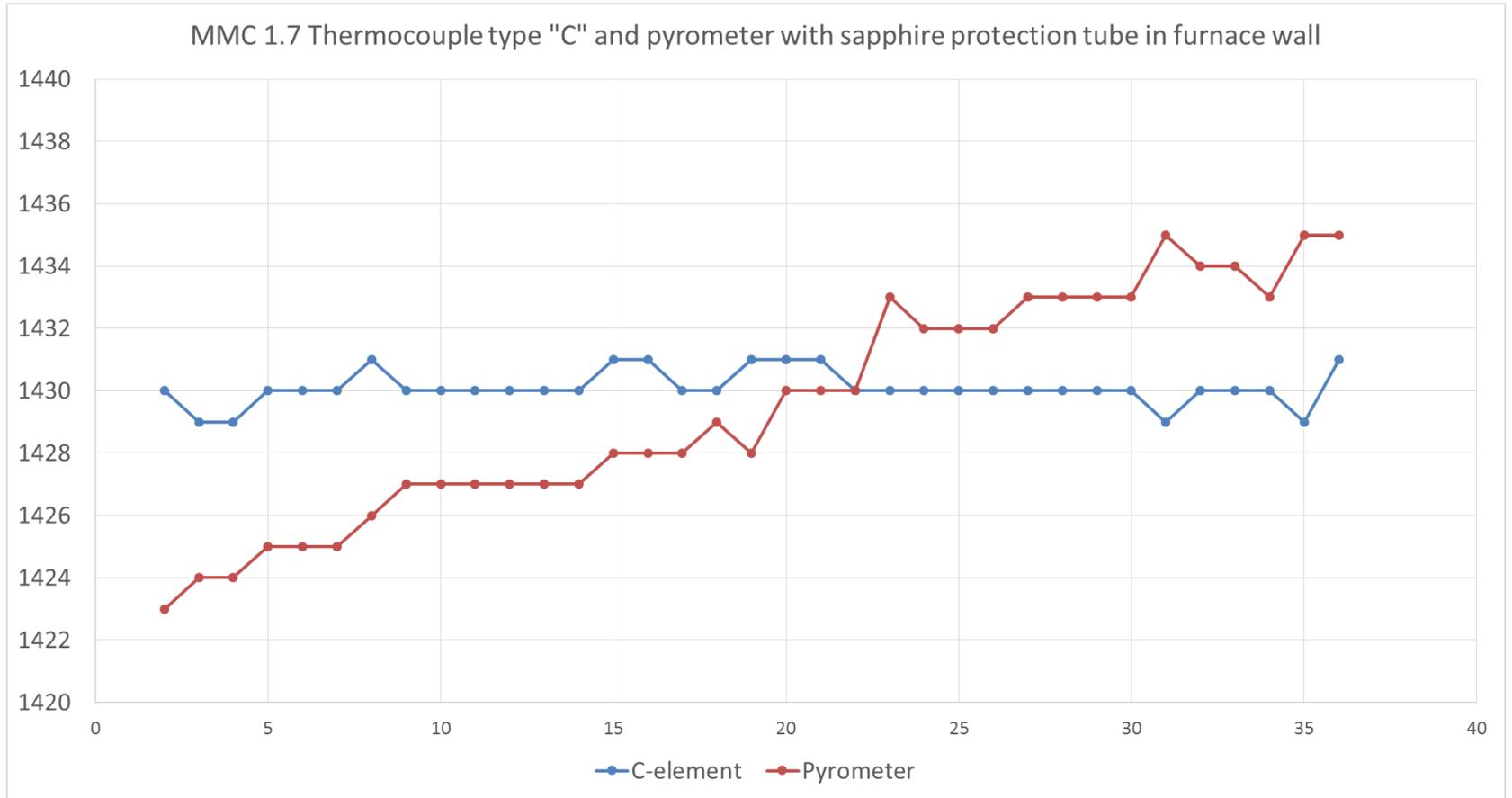


J. Růžička, J. Houžvička, J. Bok, P. Praus, and P. Mojzeš, "Single-crystal sapphire tubes as economical probes for optical pyrometry in harsh environments.," *Appl. Opt.*, vol. 50, no. 36, pp. 6599–605, Dec. 2011.

# Test of optical sapphire contact thermometer in Elkem Solar solidification furnace

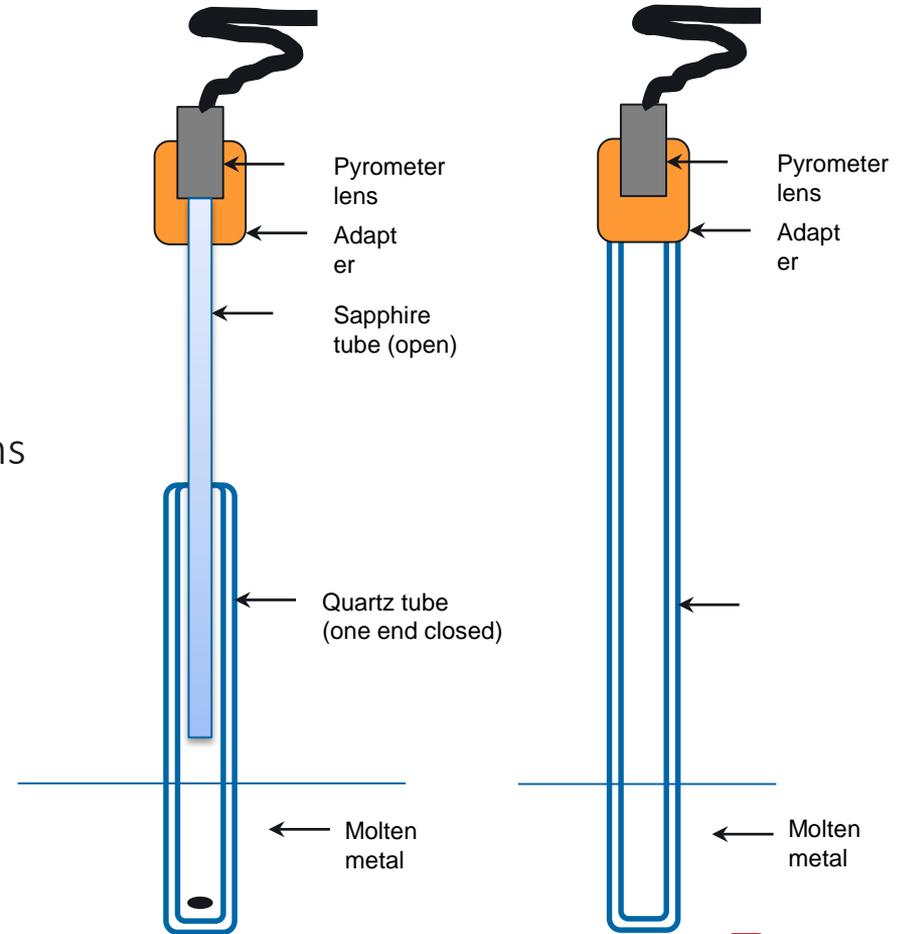


# Test of optical sapphire contact thermometer in Elkem Solar solidification furnace



# Test of pyrometer in quartz protection tube

- Open sapphire tube and quartz protection tube
- Non-focused lens
- Blackbody
  - SiC disc
  - Alsint disc
  - Empty
- Quartz tube
- Raytek 2-colour pyrometer
- Non-focused lens

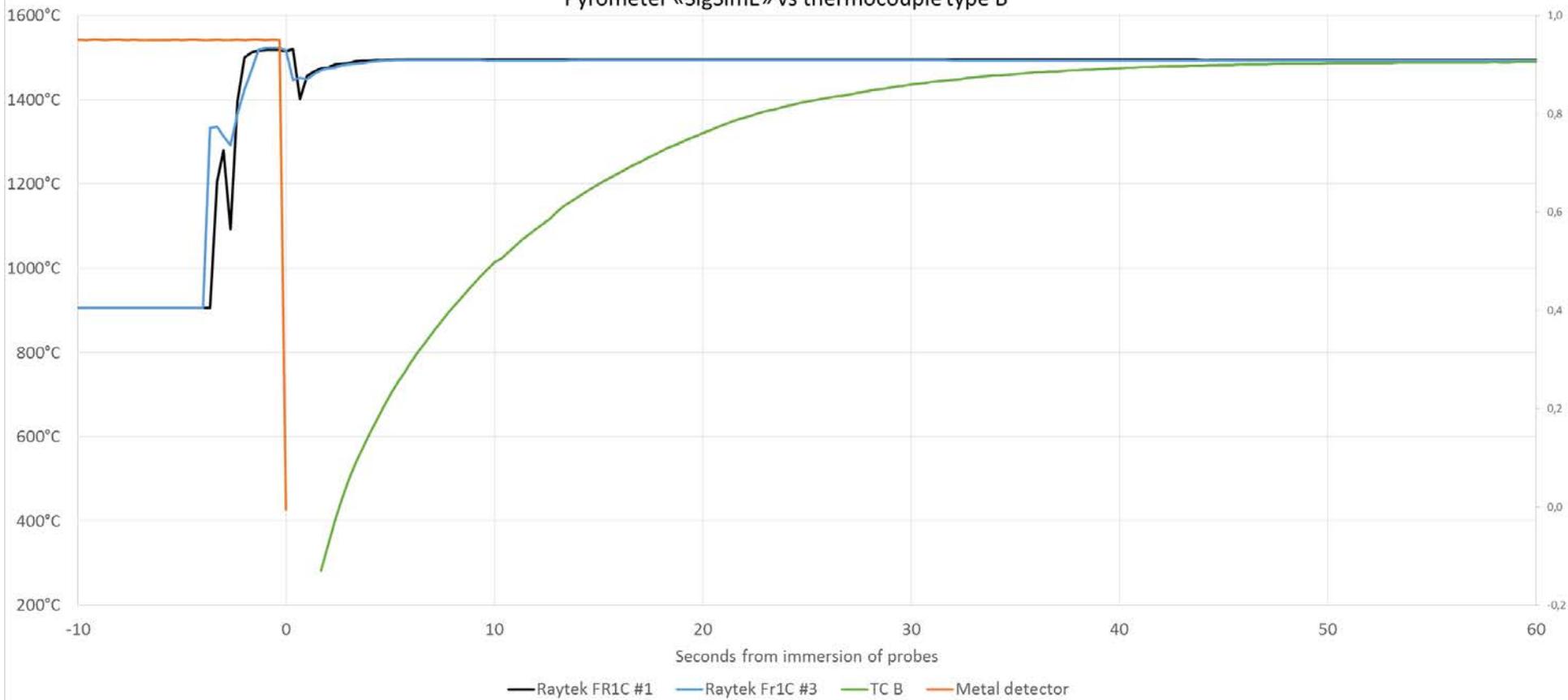


## Pyrometer «SigSimE» vs thermocouple type B

- Pyrometers: 2 Raytek 2-colour FR1 CSF003 with quartz protection tubes.
- Thermocouple: 0,5 type B, alumina insulator, q quartz protection tubes.
- Surface detector
- All mounted at the same level
- Immersed in molten silicon at 1450°C



Pyrometer «SigSimE» vs thermocouple type B

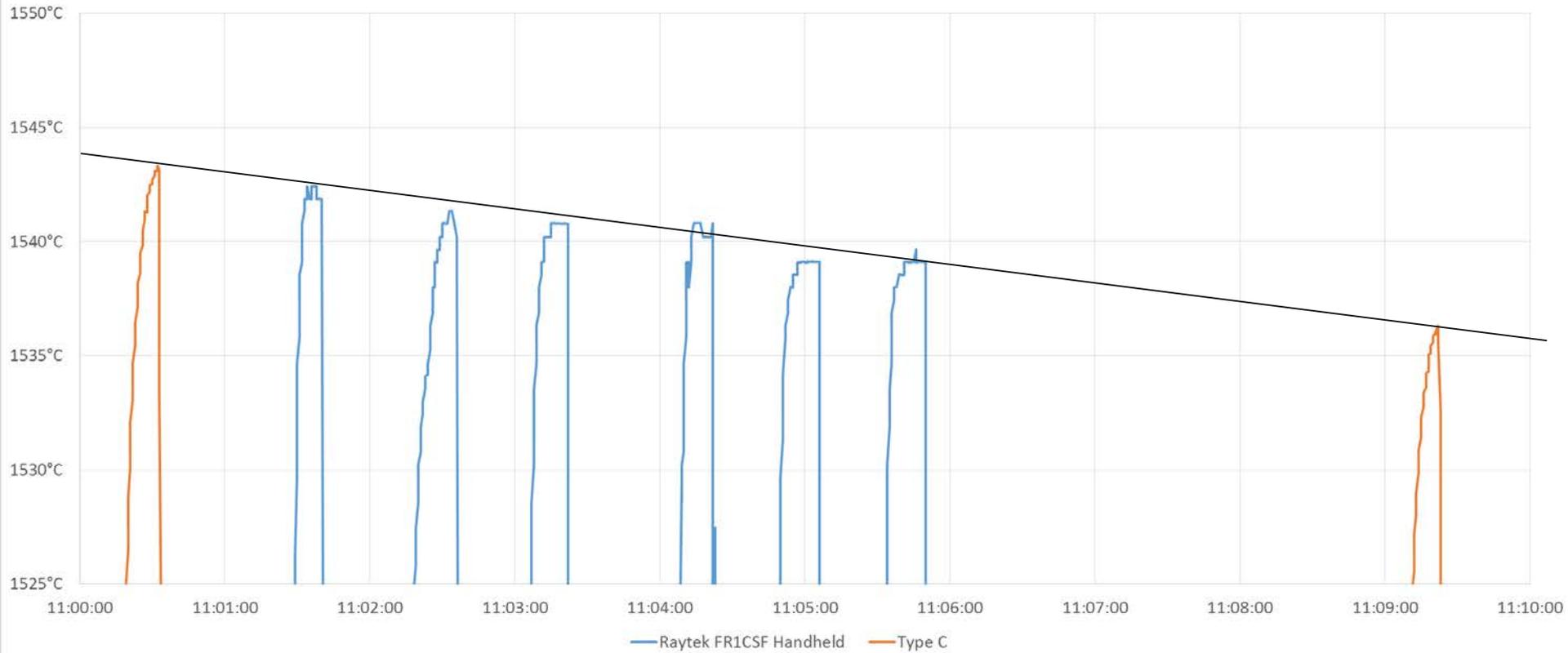


## Permanent installation of SigSimE

- Installed at small induction furnace
- Replaces TC type «C» and dip lance



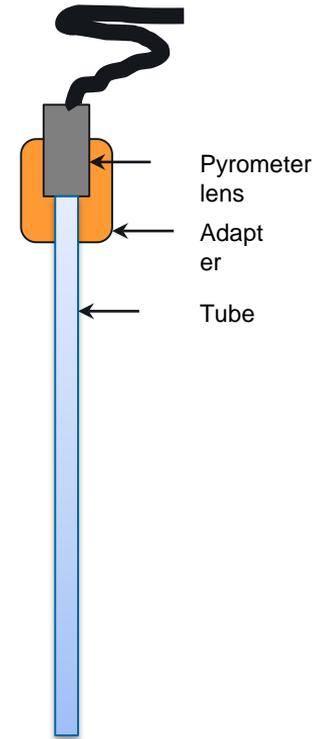
### 25.10.2016 Pyrometer test

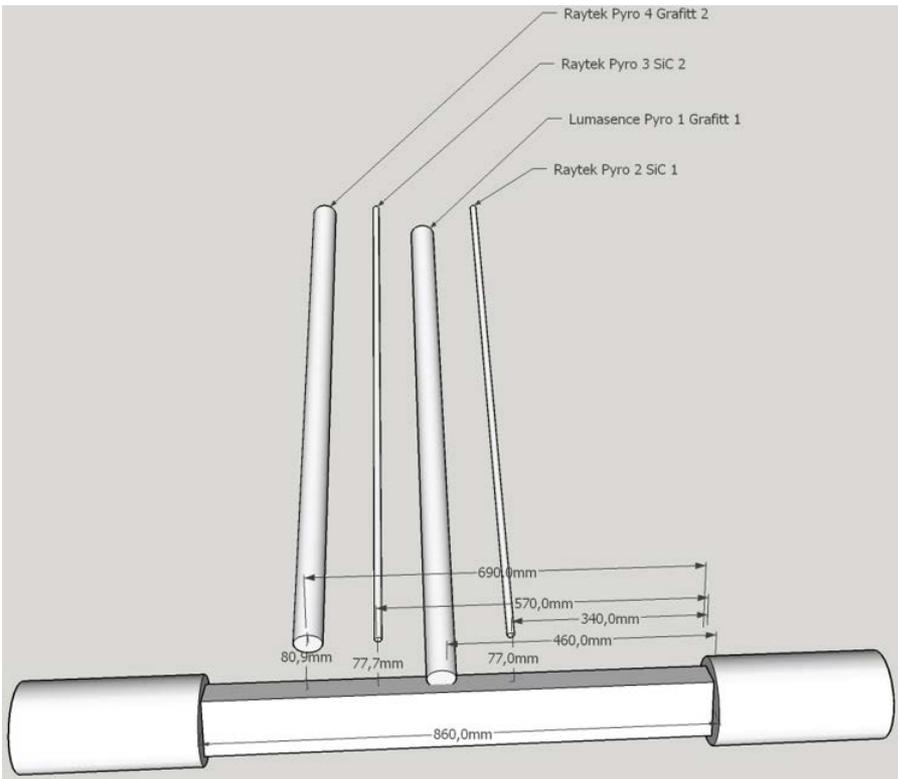


# Saint Gobain SiC test furnace

- Protection tube
  - Graphite (flushed with Ar)
  - SiC
- 2-color Raytek pyrometer
  - Marathon FR1C
  - 1000 – 2500 °C
  - 2-color bands:  
WB: 0.75 to 1.1  $\mu\text{m}$   
NB: 0.95 to 1.1  $\mu\text{m}$

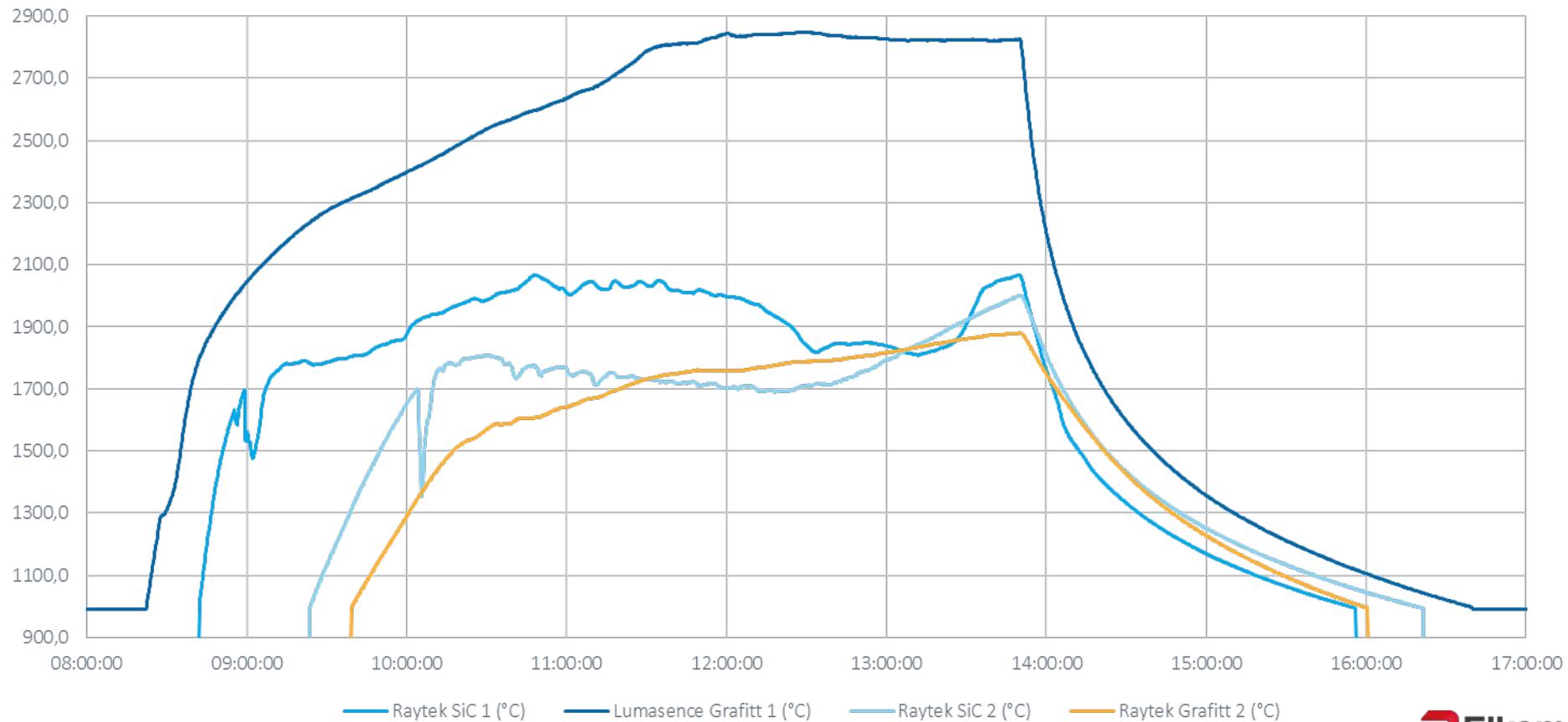
- 2-color Lumasence pyrometer
- IMPAC ISQ 5-LO
- 1000 – 3000 °C
- 0.9  $\mu\text{m}$ ; 1.05  $\mu\text{m}$





# Temperaturtest Saint-Gobain 25.02.2016

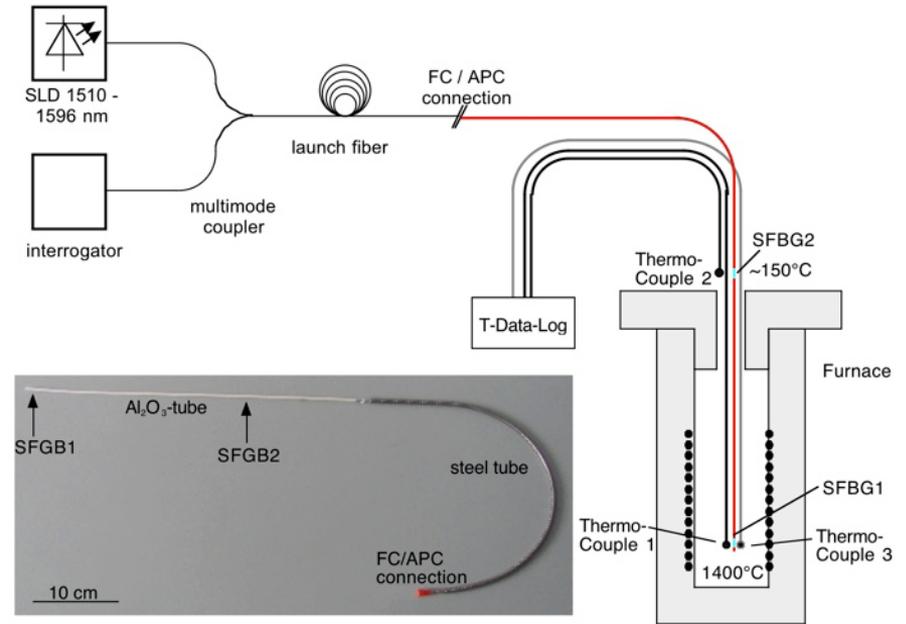
## Pyrometre



— Raytek SiC 1 (°C) — Lumasence Grafitt 1 (°C) — Raytek SiC 2 (°C) — Raytek Grafitt 2 (°C)

# Long-term stable Sapphire Fiber Bragg Grating sensors at 1400°C

- Tobias Habisreuther, IPHT Jena
- Katarina Grujic, Teknova
- Single crystalline sapphire fiber with diameter of 100 $\mu$ m and 1m length
- Air-clad fiber
- Two gratings multiplexed, 25cm apart
- 1400°C, 28 days
- $\pm 2^\circ\text{K}$  compared to type B thermocouple



ADVANCED MATERIALS  
SHAPING THE FUTURE

