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Creep and Fracture of Oxide Dispersion Hardened Platinum with Improved Strength at High Temperatures

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Creep and Fracture of Oxide Dispersion Hardened Platinum with Improved Strength at High Temperatures

Structure:

- Application and properties of platinum structural materials

Superior properties of platinum group metals:

- Very good chemical stability
- Oxidation resistance at high temperatures
- Stability against oxidizing melts
- Applicability at extremely high temperatures near the melting point (1,769 ºC)
- Adequate mechanical strength at very high temperatures

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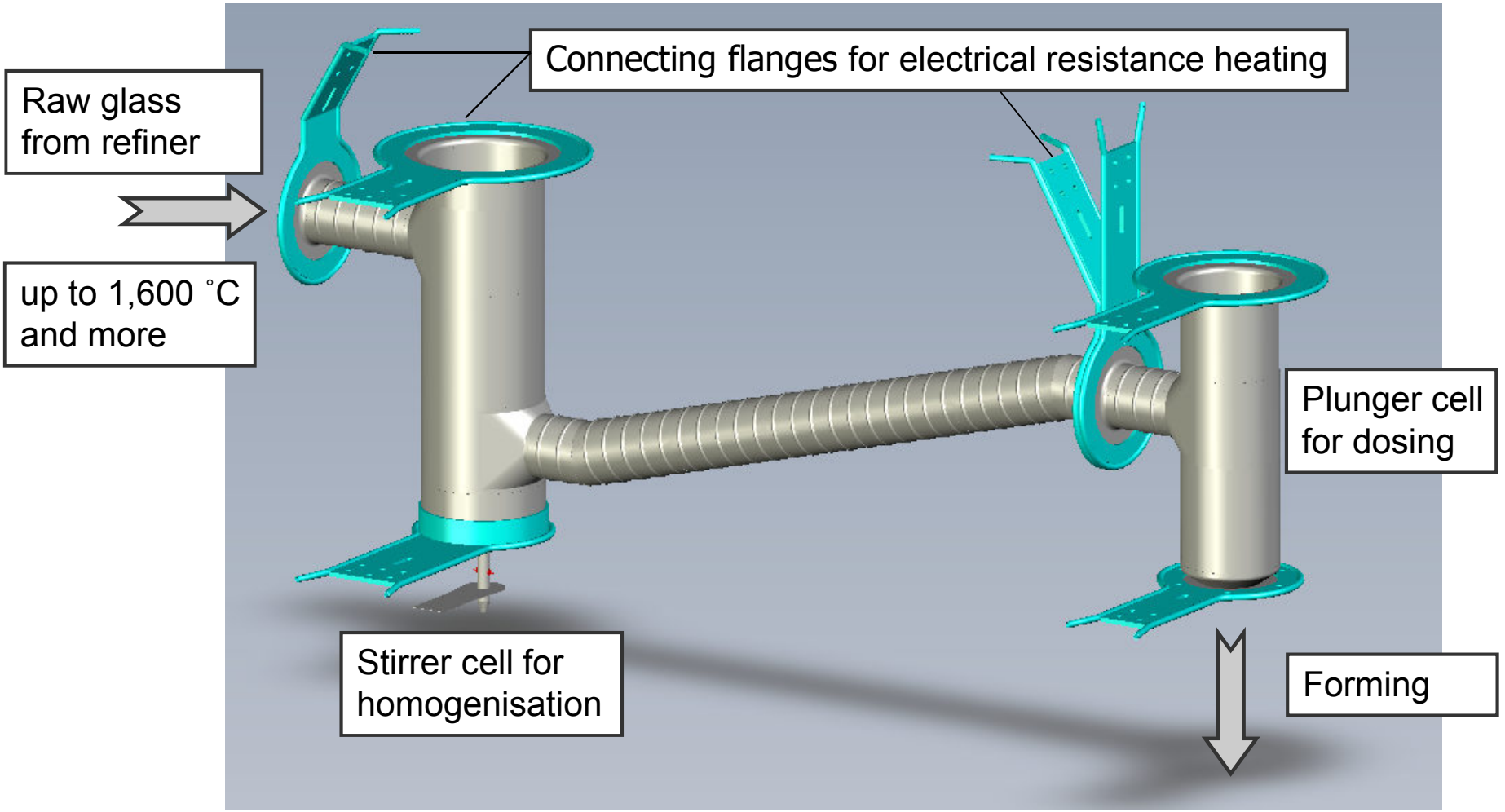
Feeder system: app. 100 kg Pt-Rh alloy, app. 3 m long



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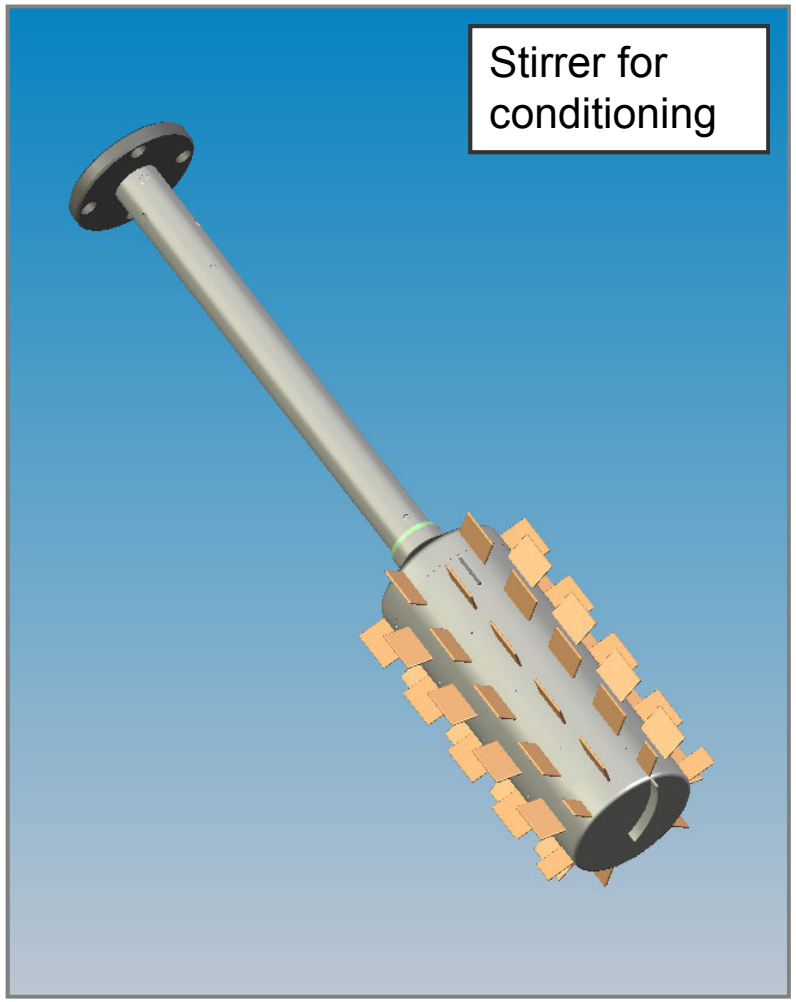
Stirrer and plunger for the feeder system

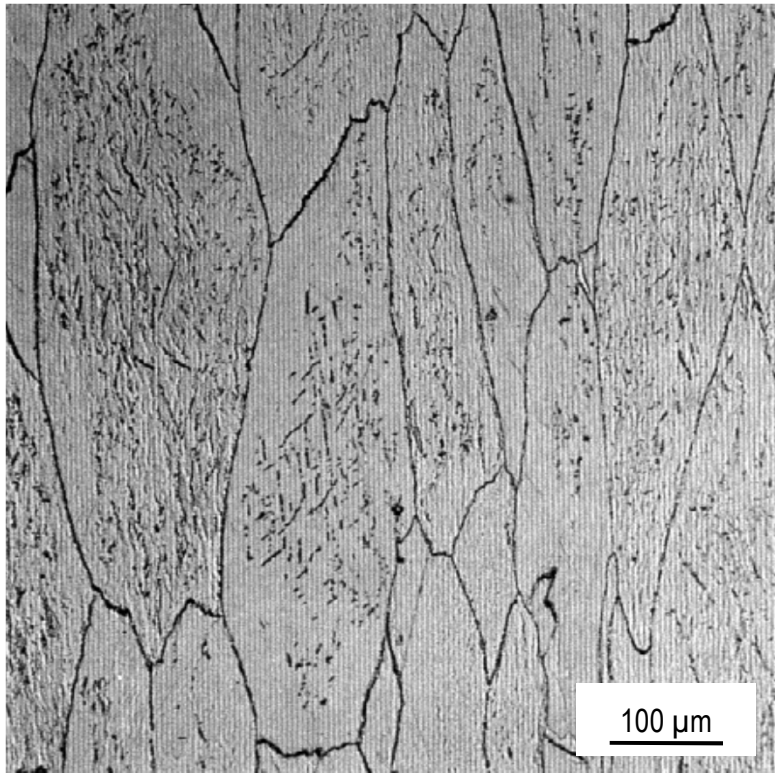


Creep and Fracture of Oxide Dispersion Hardened Platinum with Improved Strength at High Temperatures

Structure:

- Application and properties of platinum structural materials
- **Pt DPH materials**
  - **Pt DPH**
  - **Pt-5%Rh DPH, Pt-10%Rh DPH**
  - **Pt-5%Au DPH**

Optical micrograph showing the structure of Pt DPH:



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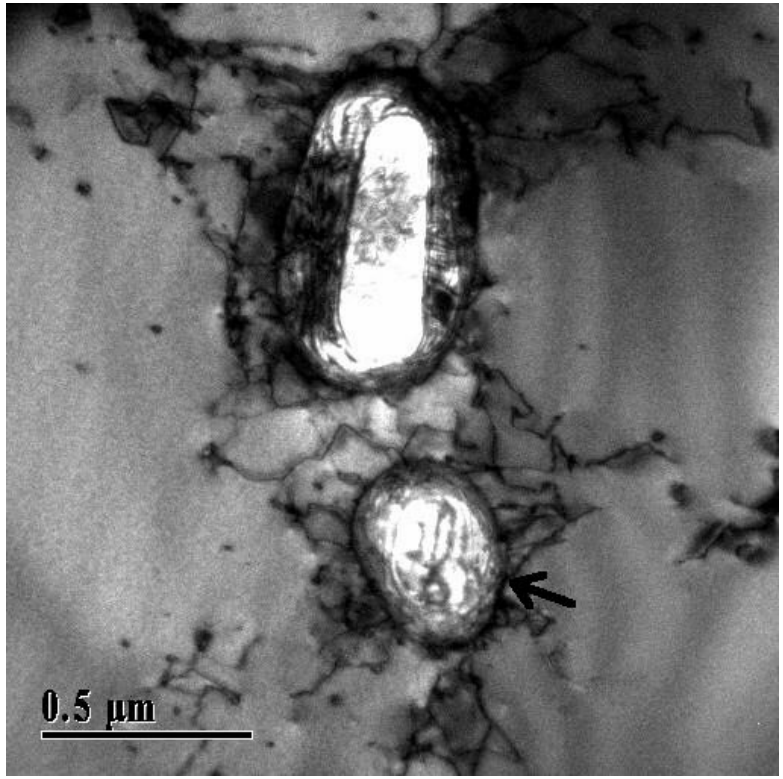
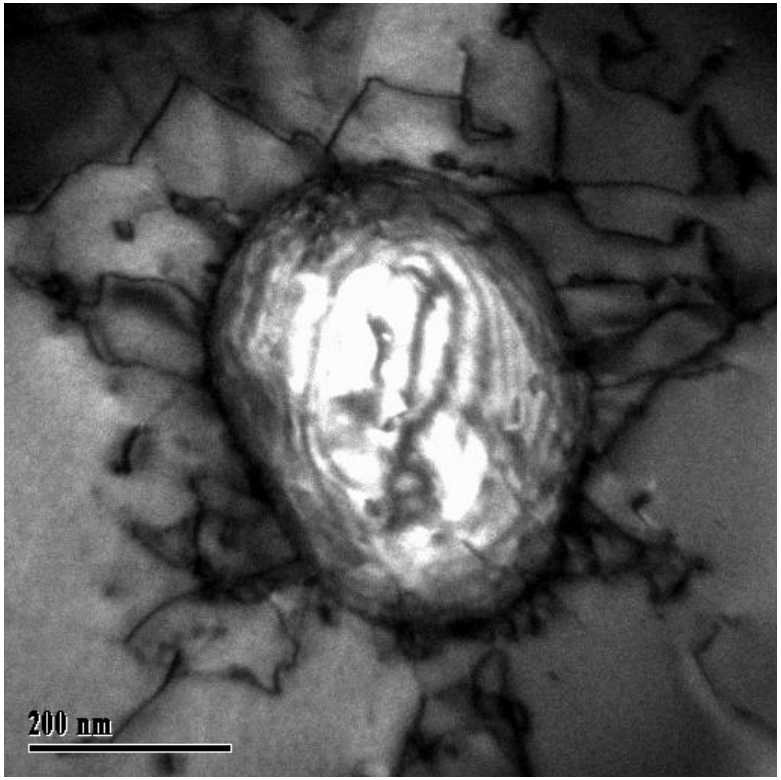
TEM image of Pt DPH (3.5 MPa / 1,600 ºC / 1 h):





Photographer: Dr. Rainer Völkl, University of Bayreuth

Creep and Fracture of Oxide Dispersion Hardened Platinum with Improved Strength at High Temperatures

Structure:

- Application and properties of platinum structural materials
- Pt DPH materials
- **Development of Pt DPH materials with improved strength**

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Creep and Fracture of Oxide Dispersion Hardened Platinum with Improved Strength at High Temperatures

Structure:

- Application and properties of platinum structural materials
- Pt DPH materials
- **Development of Pt DPH materials with improved strength**
  - **Higher contents of oxide dispersoids**

established material	new material
Pt-10%Rh DPH	Pt-10%Rh DPH*hs*
app. 1,800 ppm Zr	app. 4,000 ppm Zr

Both materials are doped with small concentrations of Y and Sc

  - **Modifying process parameters without a higher content of oxide dispersoids**

Pt-10%RhDPH-A

Creep and Fracture of Oxide Dispersion Hardened Platinum with Improved Strength at High Temperatures

Structure:

- Application and properties of platinum structural materials
- Pt DPH materials
- **Development of Pt DPH materials with improved strength**
  - **High temperature mechanical properties**

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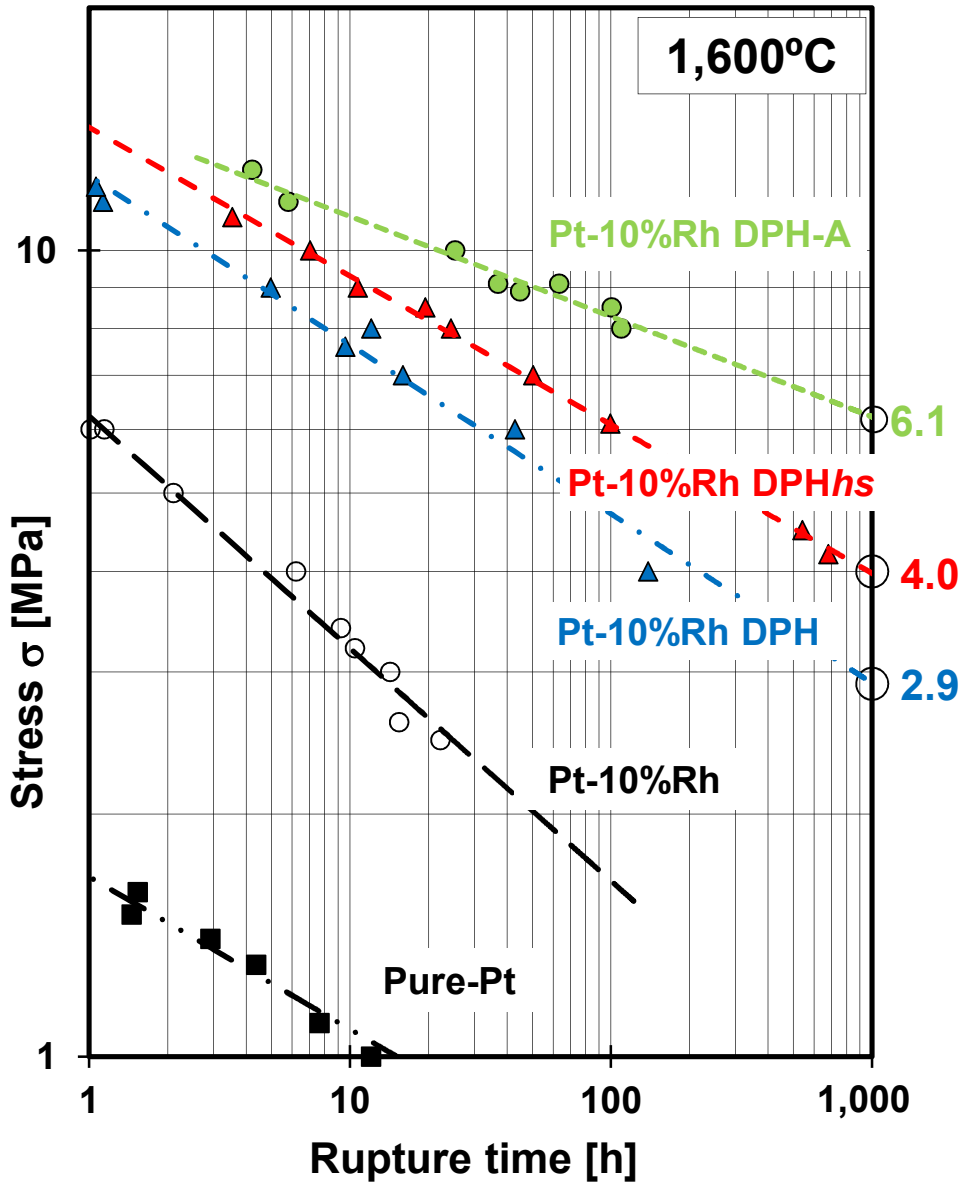

Stress-rupture curves of various platinum materials

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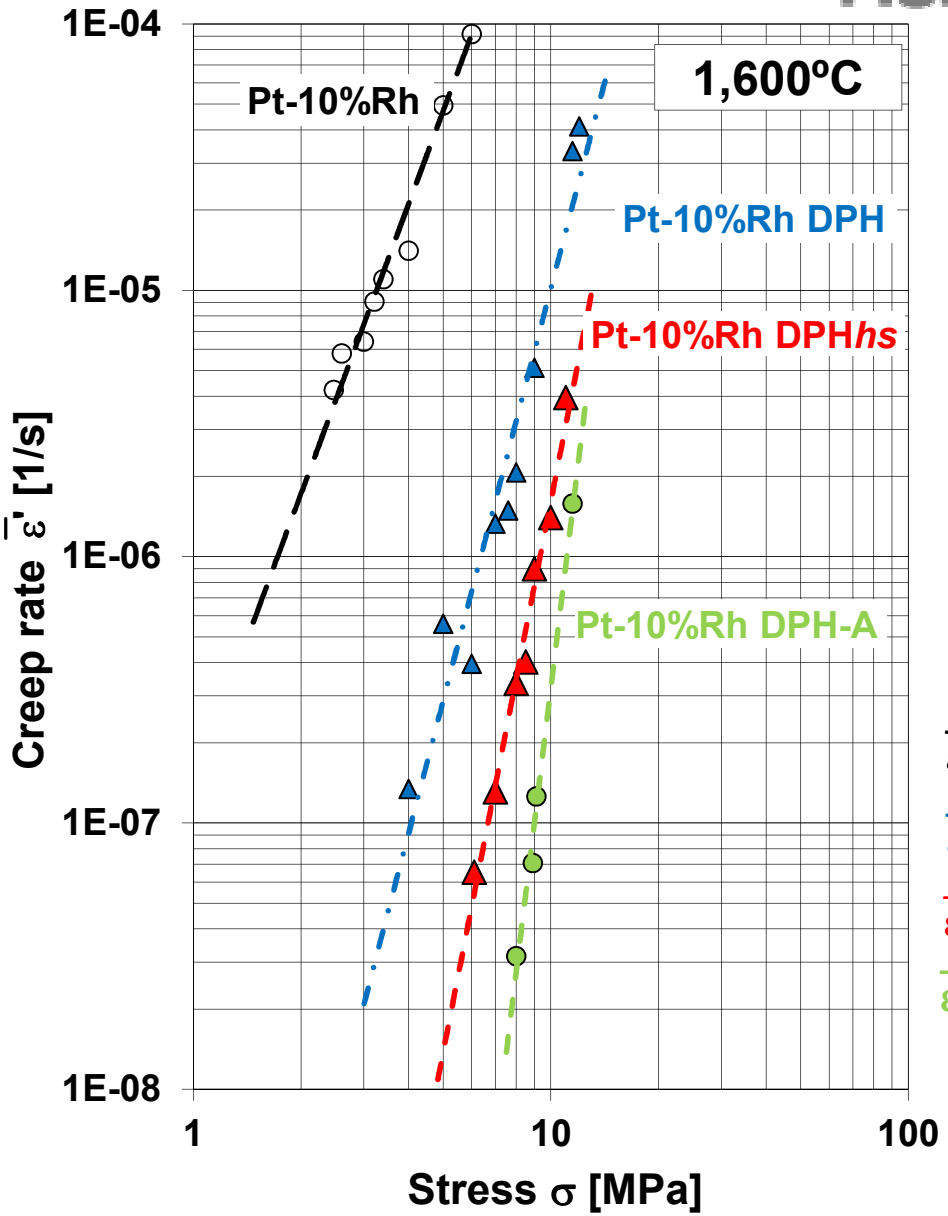

Norton Plot of various platinum materials

$$\bar{\varepsilon}' = A * \sigma^n$$

$\bar{\varepsilon}' = 1E\text{-}07\sigma^{3.61}$ Pt-10%Rh

$\bar{\varepsilon}' = 7E\text{-}11\sigma^{5.14}$ Pt-10%Rh DPH

$\bar{\varepsilon}' = 2E\text{-}13\sigma^{6.87}$ Pt-10%Rh DPH*hs*

$\bar{\varepsilon}' = 3E\text{-}18\sigma^{11.0}$ Pt-10%Rh DPH-A

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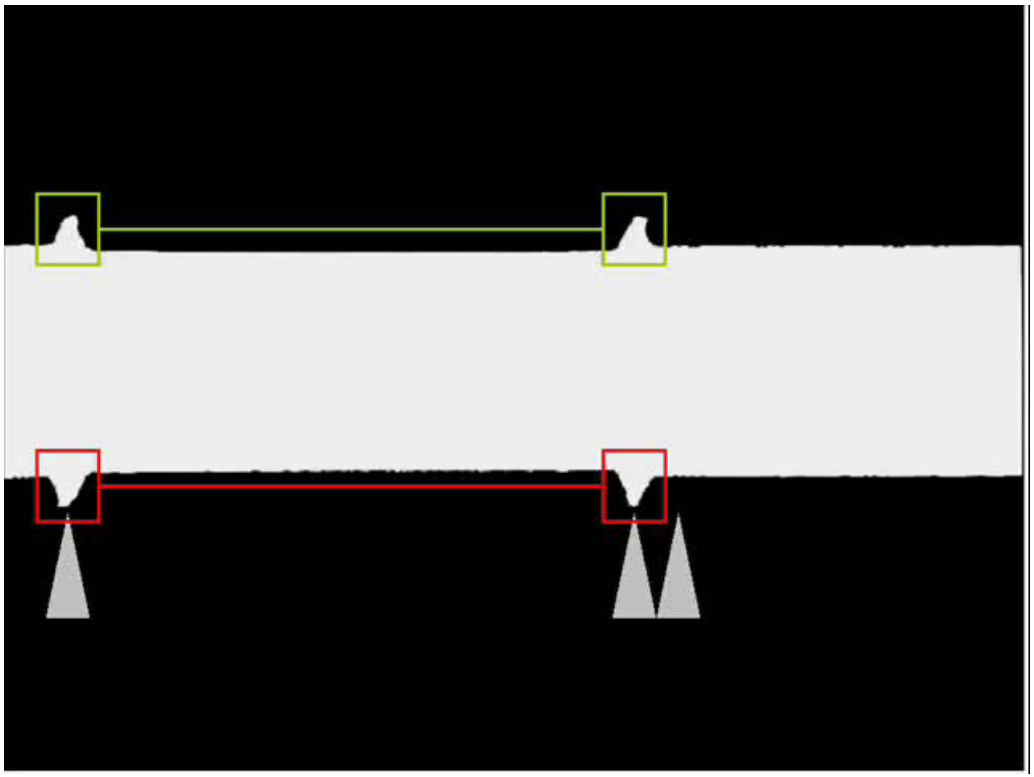
Pt-10%Rh DPH*hs* / 1,400 °C / 15.6 MPa / 5.65 hours



A = 5.8%

$\bar{\varepsilon}$ '= 2.3 E-6 [1/s]

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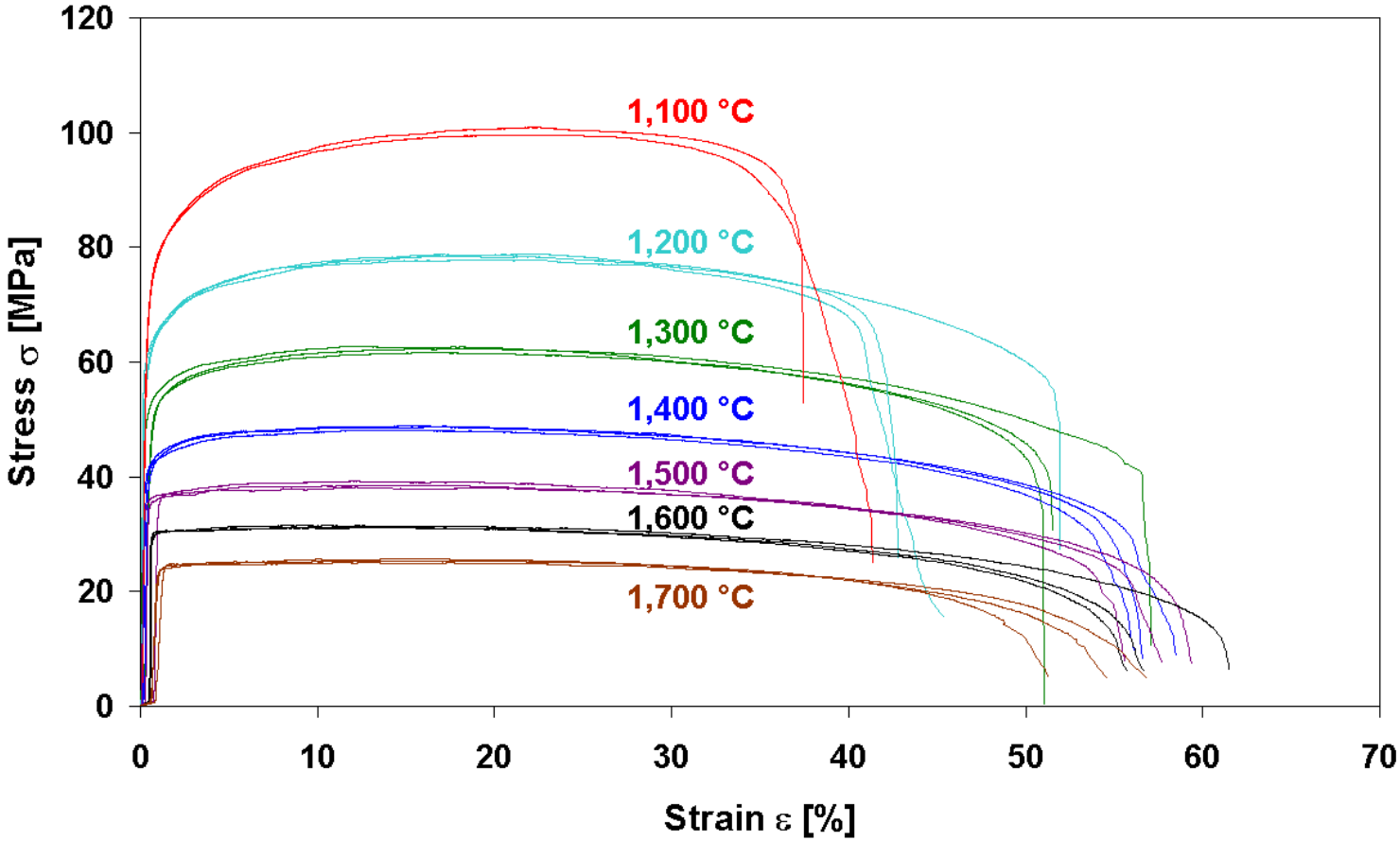
Stress-strain-curves of Pt-10%Rh DPH*hs* at various temperatures



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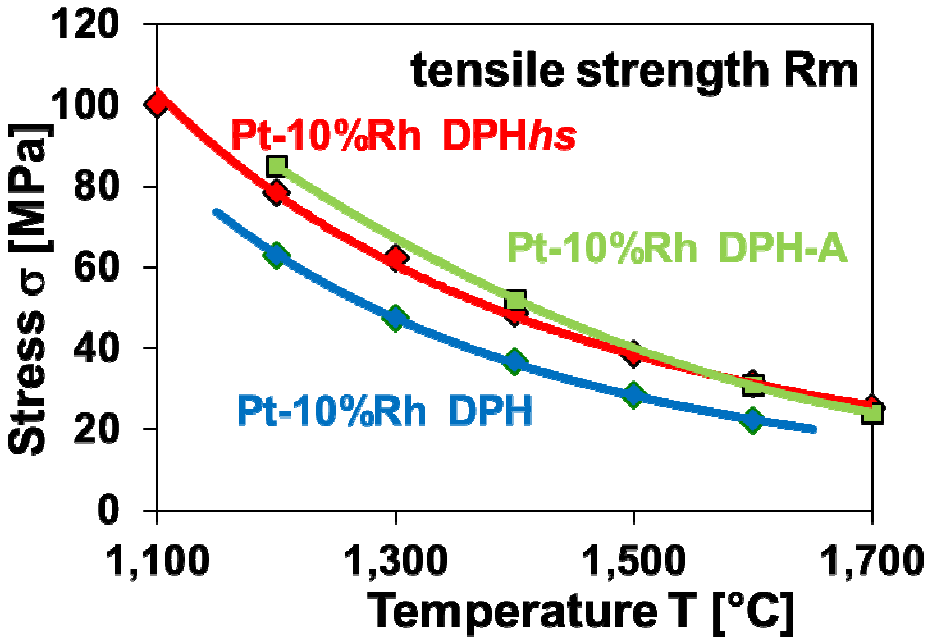
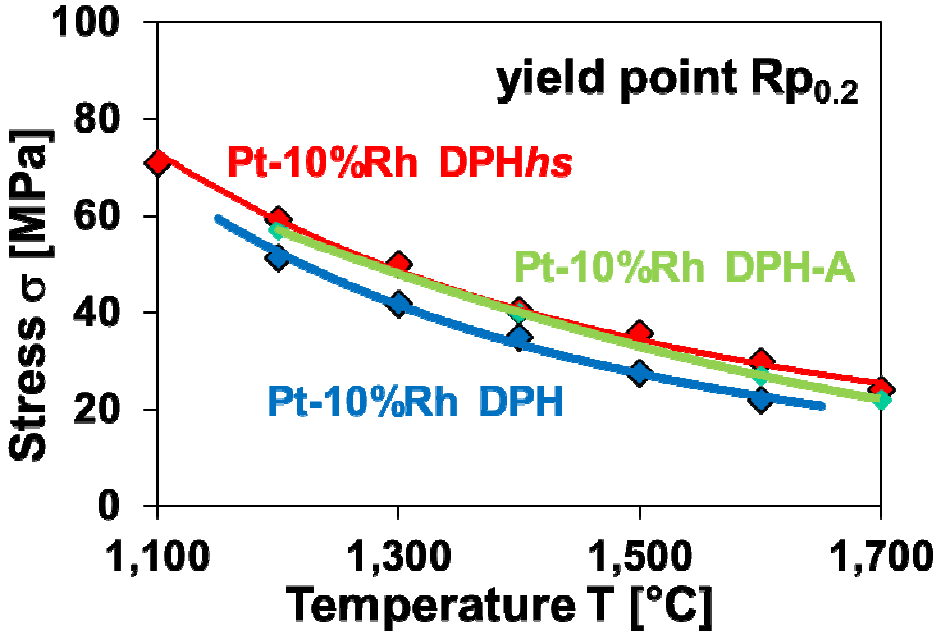
High temperature tensile strength, 0.2% yield point of established Pt-10%Rh DPH, new Pt-10%Rh DPH*hs* and Pt-10%Rh DPH-A at various temperatures





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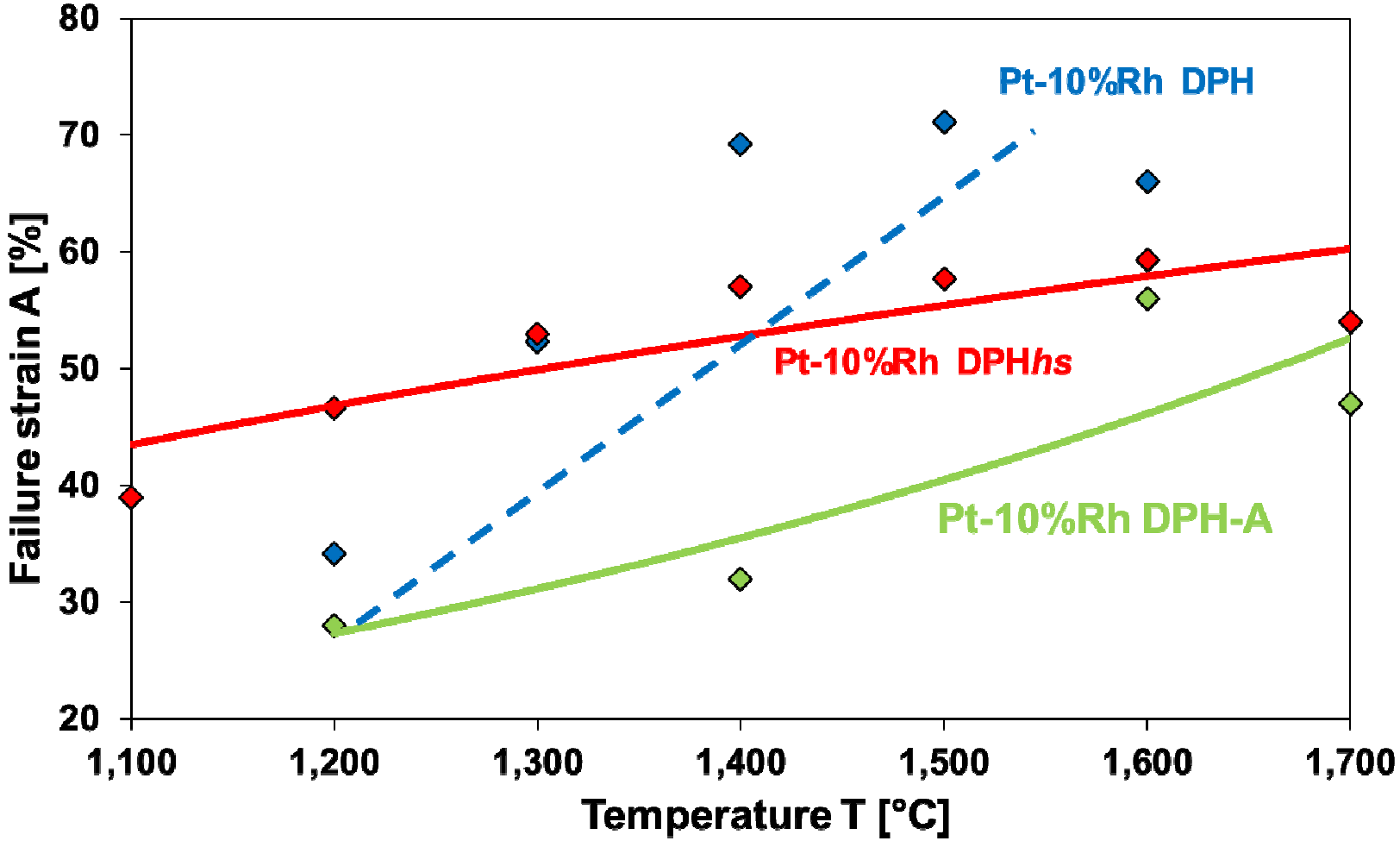
Failure strain of established Pt-10%Rh DPH, new Pt-10%Rh DPH*hs* and Pt-10%Rh DPH-A at various temperatures



Creep and Fracture of Oxide Dispersion Hardened Platinum with Improved Strength at High Temperatures

Structure:

- Application and properties of platinum structural materials
- Pt DPH materials
- **Development of Pt DPH materials with improved strength**
  - High temperature mechanical properties
  - **Metallographic examination**

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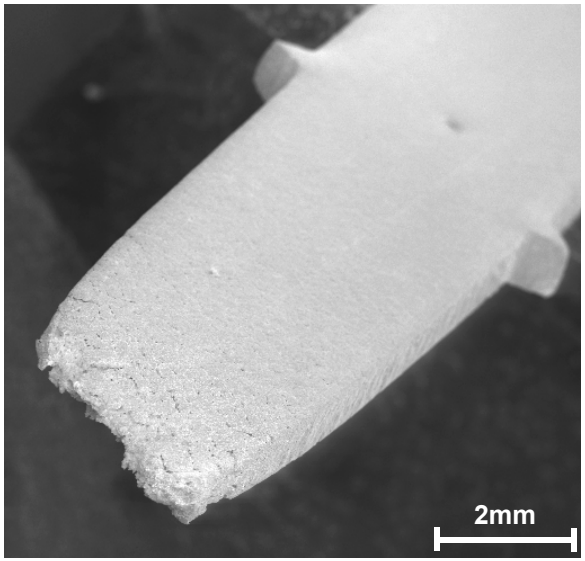

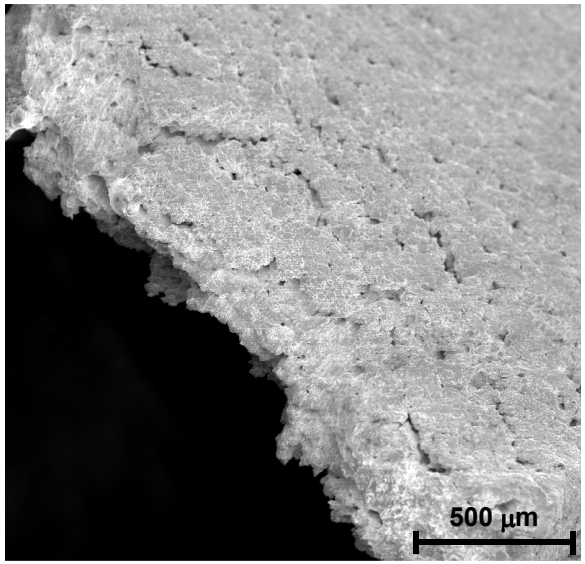

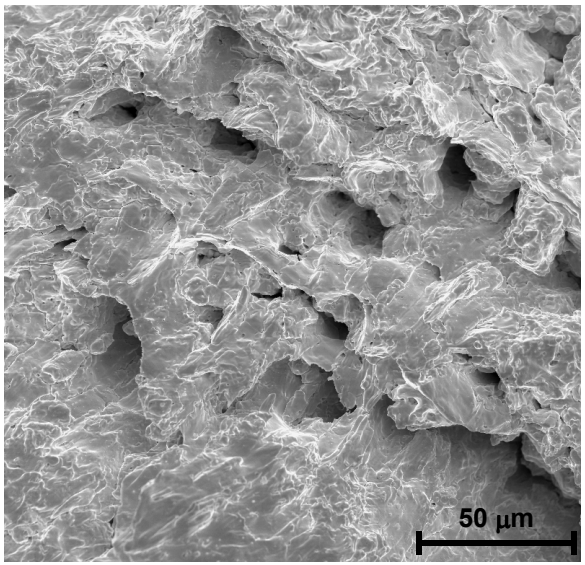

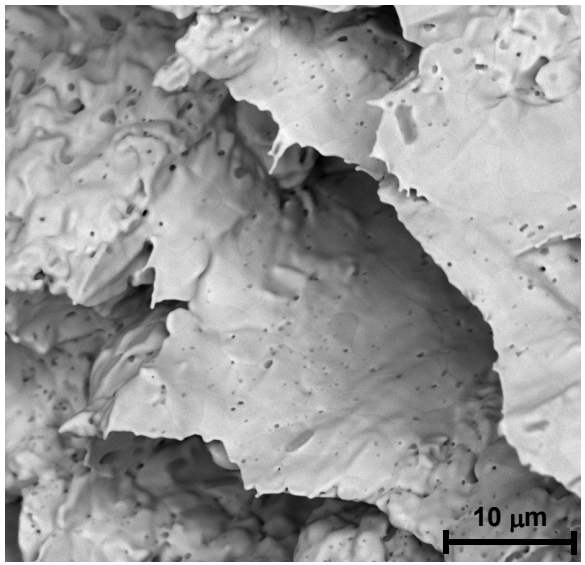

SEM micrographs of the fracture area of Pt-10%Rh DPH*hs* at 1,700 °C after the hot tensile test

A = 59 %

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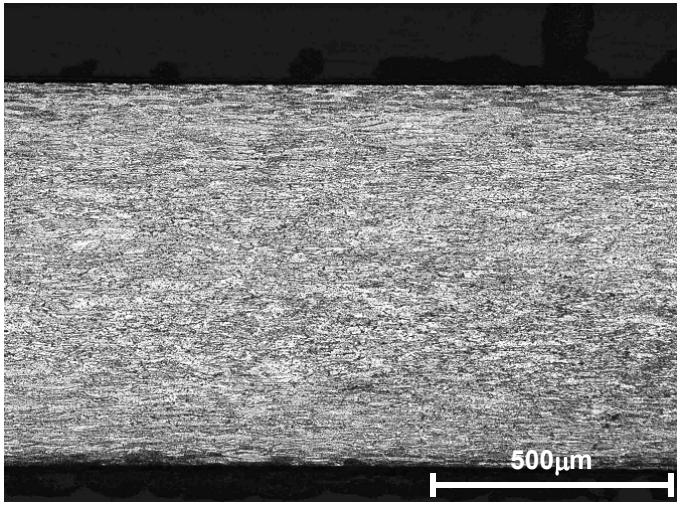
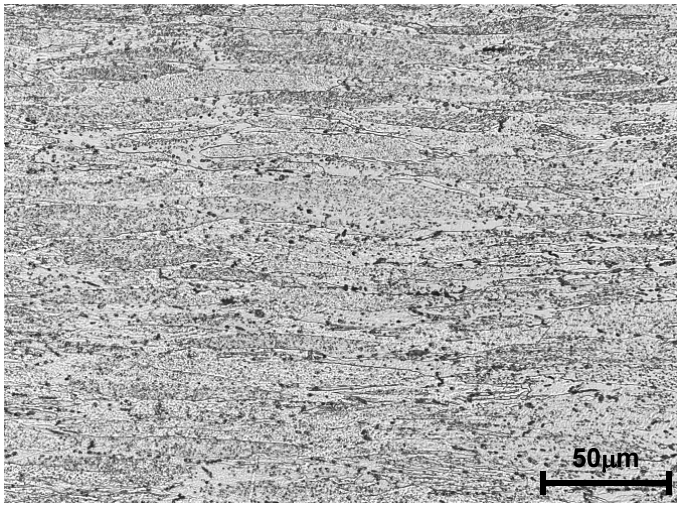
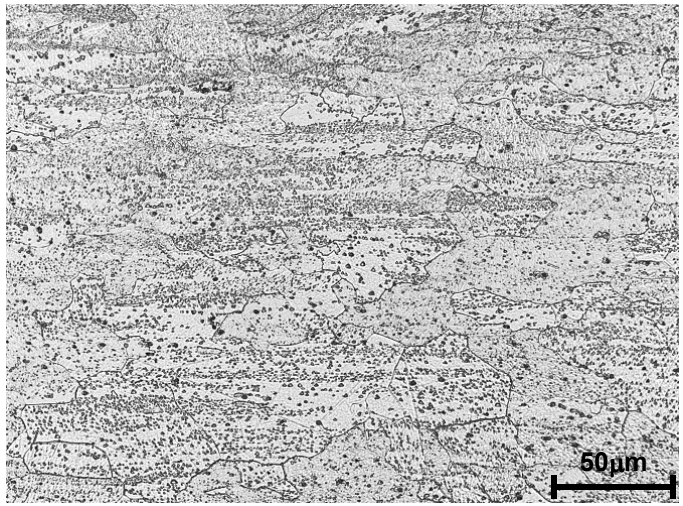
Optical micrographs showing the structure of Pt-10%Rh DPH*hs* in longitudinal sections



initial state



initial state



after creep test

1,400 ºC
6.5 MPa
750 hours

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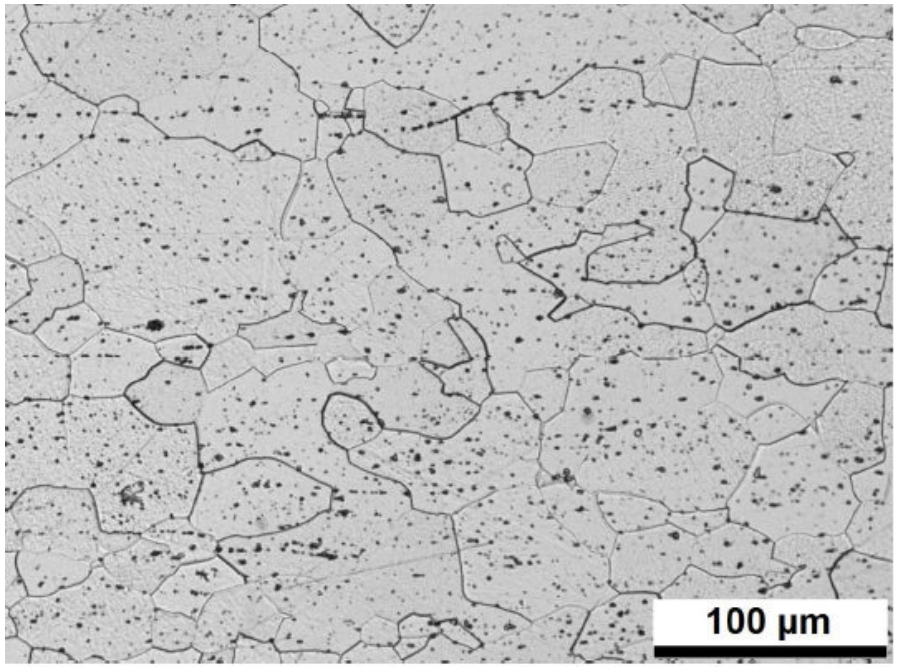
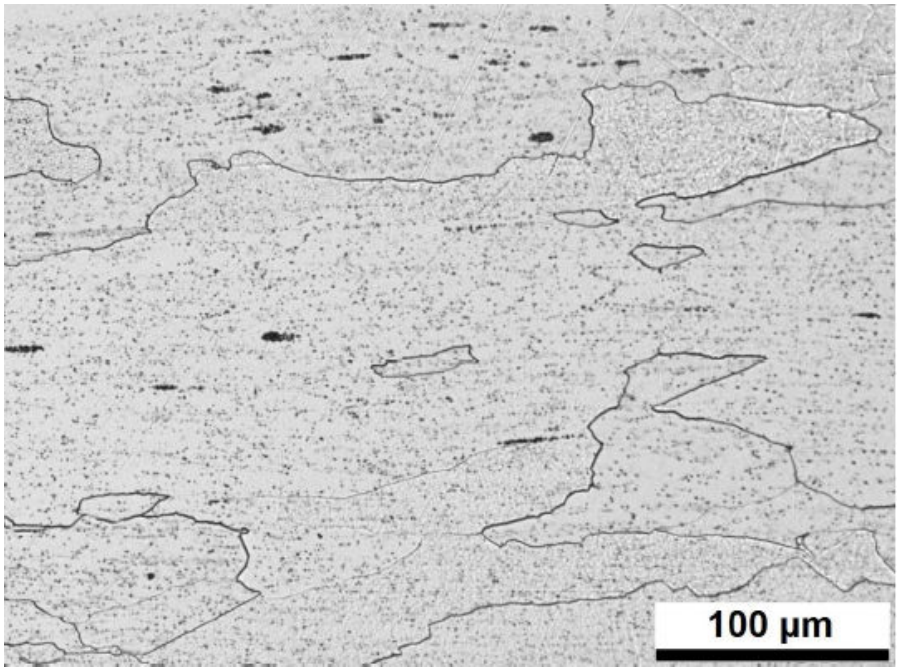
Optical micrographs showing the structure of Pt-10%Rh DPH and Pt-10%Rh DPH-A



Pt-10%Rh DPH



Pt-10%Rh DPH-A

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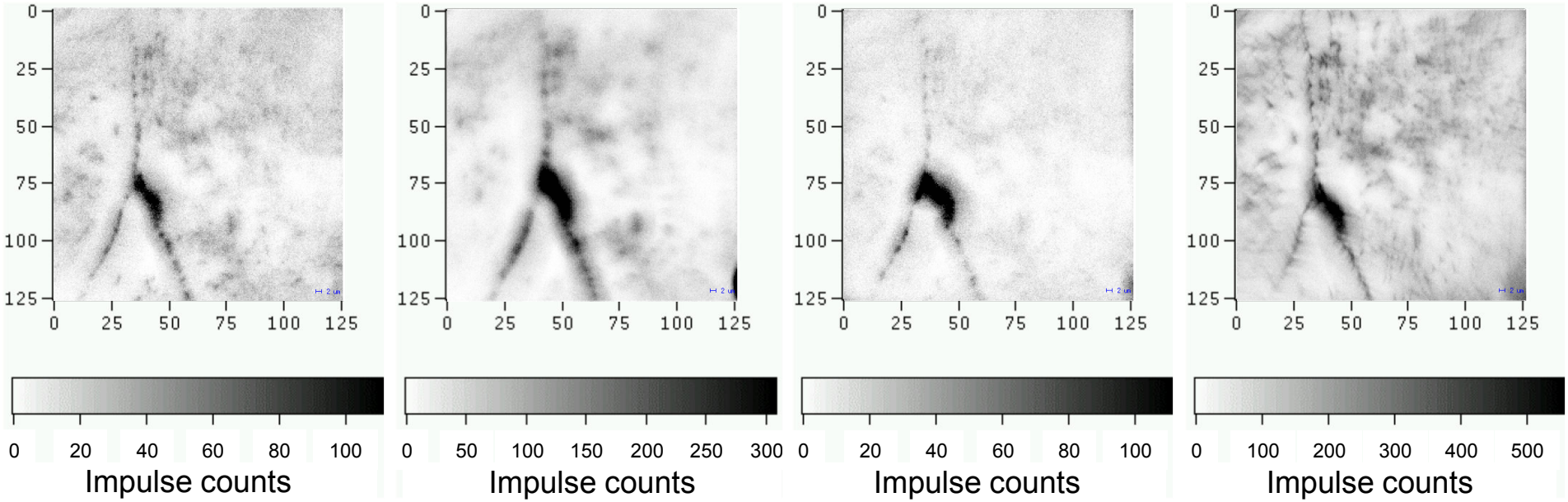
Scanning SIMS micrographs showing the distribution of various elements in Pt-10%Rh DPH*hs*:



Zr Distribution **Y** Distribution **Sc** Distribution **O** Distribution

Summary:

- The new Pt DPH materials Pt-10%Rh DPH*hs* and Pt-10%Rh DPH-A have an increased stress-rupture strength and higher form stability than the established materials.
- The quality Pt-10%Rh DPH-A has the highest creep strength and the best weldability.
- The newly developed materials (Pt-10%Rh DPH*hs* and Pt-10%Rh DPH-A) can be readily rolled to thin sheets and processed to seamless tubes.
- They have already been implemented into the production.
- First components have been proved in the glass industry at high mechanical load.

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- University of Applied Sciences Jena
  Carl-Zeiss-Promenade 2, D-07745 Jena, Germany

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Thank you very much for your attention.

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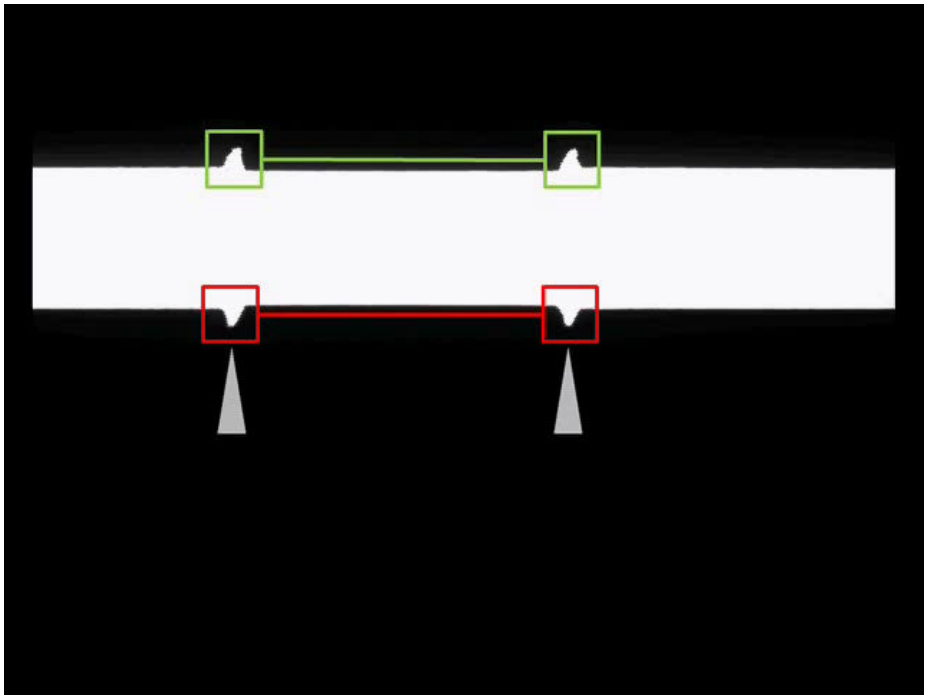
Reference:

This presentation includes parts of the paper „Oxide Dispersion Hardened Platinum Alloys with Improved Strength at High Temperatures", B. Fischer, U. Jantsch, M. Koch, 36th International Precious Metals Conference, June 9-12, 2012, Las Vegas, USA, proceedings, 32 pages, edited by IPMI – International Precious Metals Institute, Pensacola, Florida, USA

Pt-5%Rh / 1,600 °C / 3.0 MPa / 4.87 hours



A = 47 %

$\bar{\varepsilon}$ '= 1.4 E-5 [1/s]

(Pt-10%Rh DPH*hs*: A = 5.8 %)

$\bar{\varepsilon}$ '= 2.3 E-6 [1/s]

Strength, Deformation and Fracture of Oxide Hardened Platinum Alloys at High Temperatures

Structure:

- Application and properties of platinum structural materials
- Pt DPH materials
- **Equipment for creep and tensile tests at high temperatures up to 3,000 °C**

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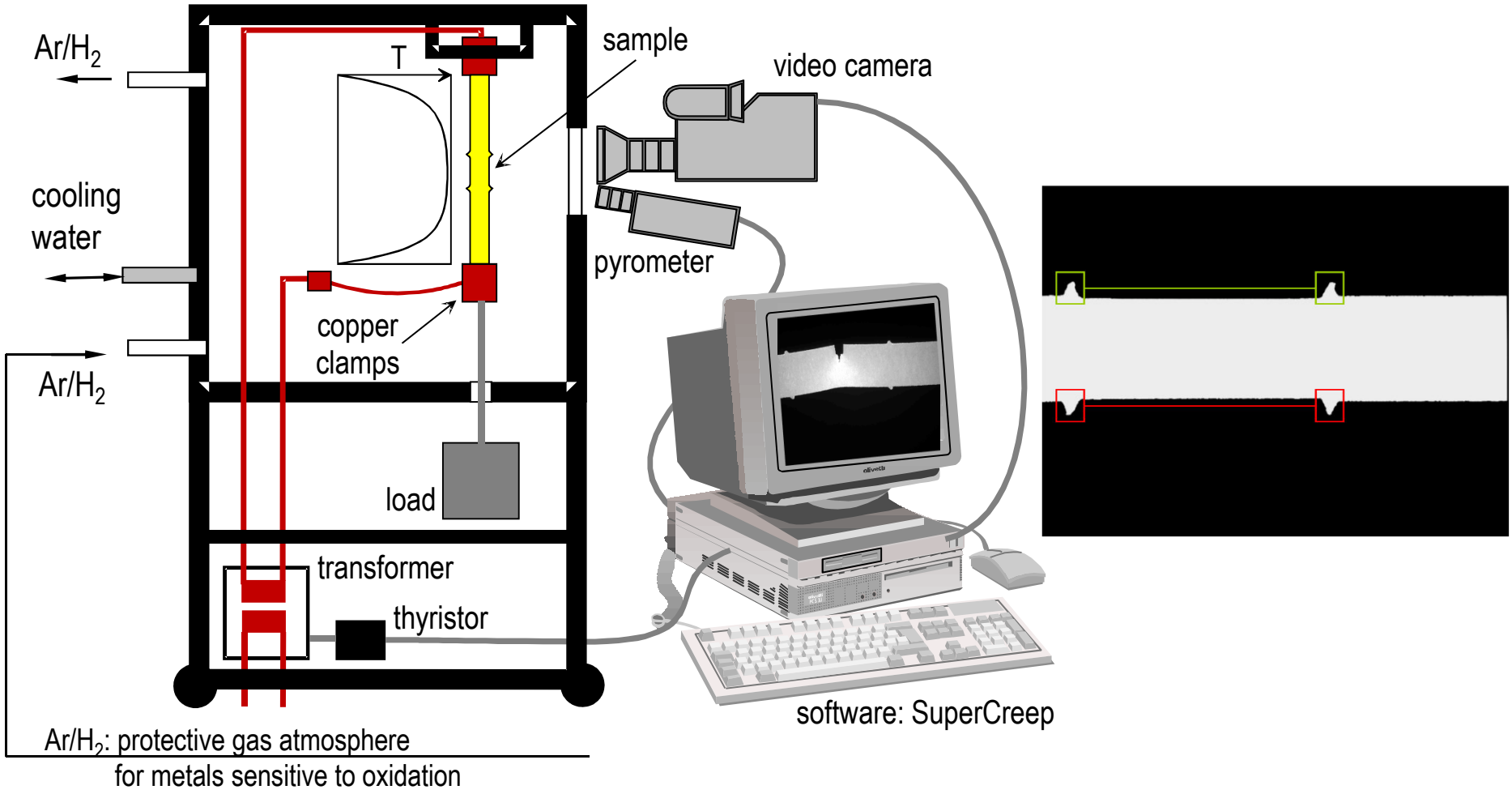
Equipment for creep tests up to 3,000 °C, schematic



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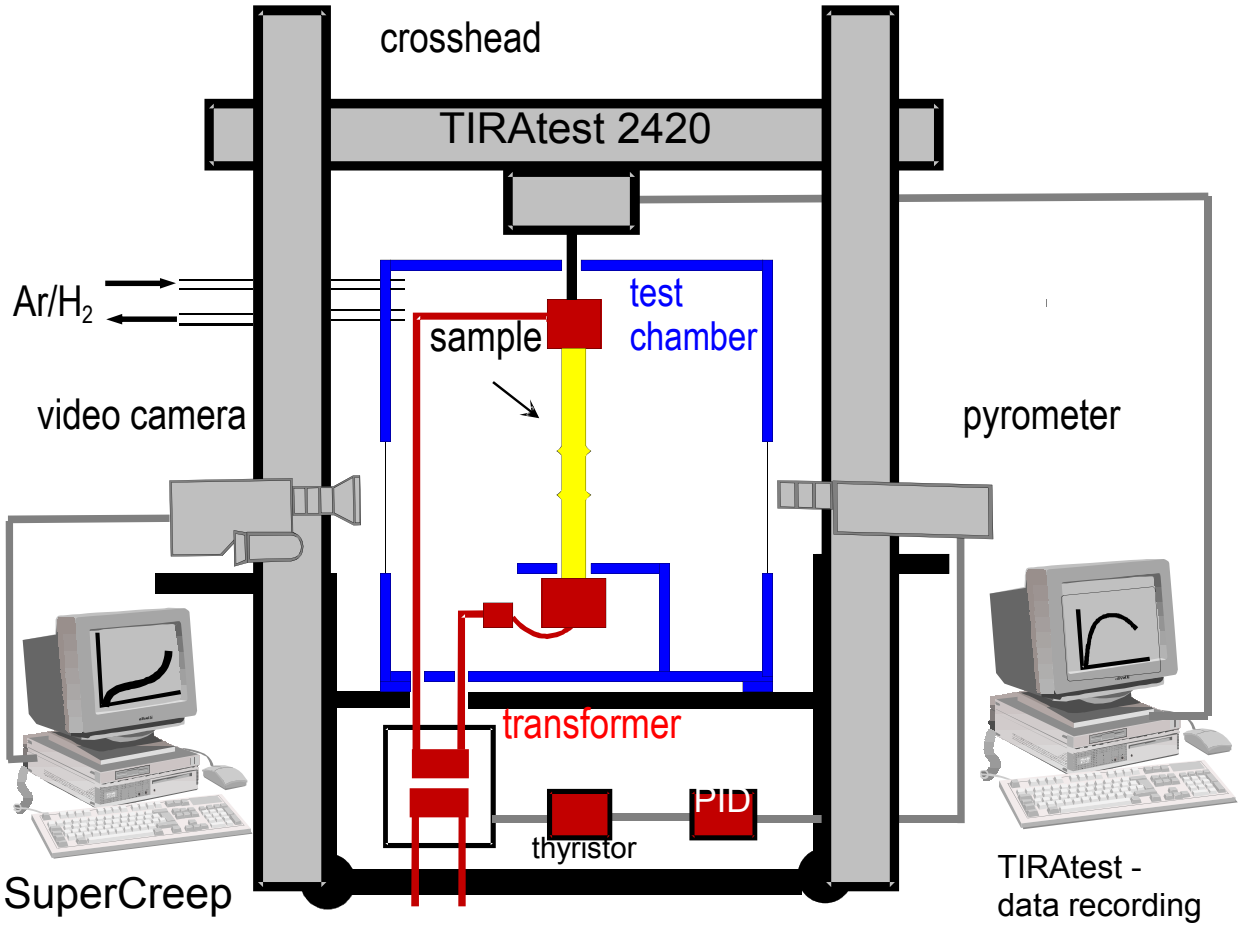
Equipment for high temperature tensile tests up to 3,000 °C, schematic



Experimental – test facility stress-rupture tests:

Stress-rupture tests:

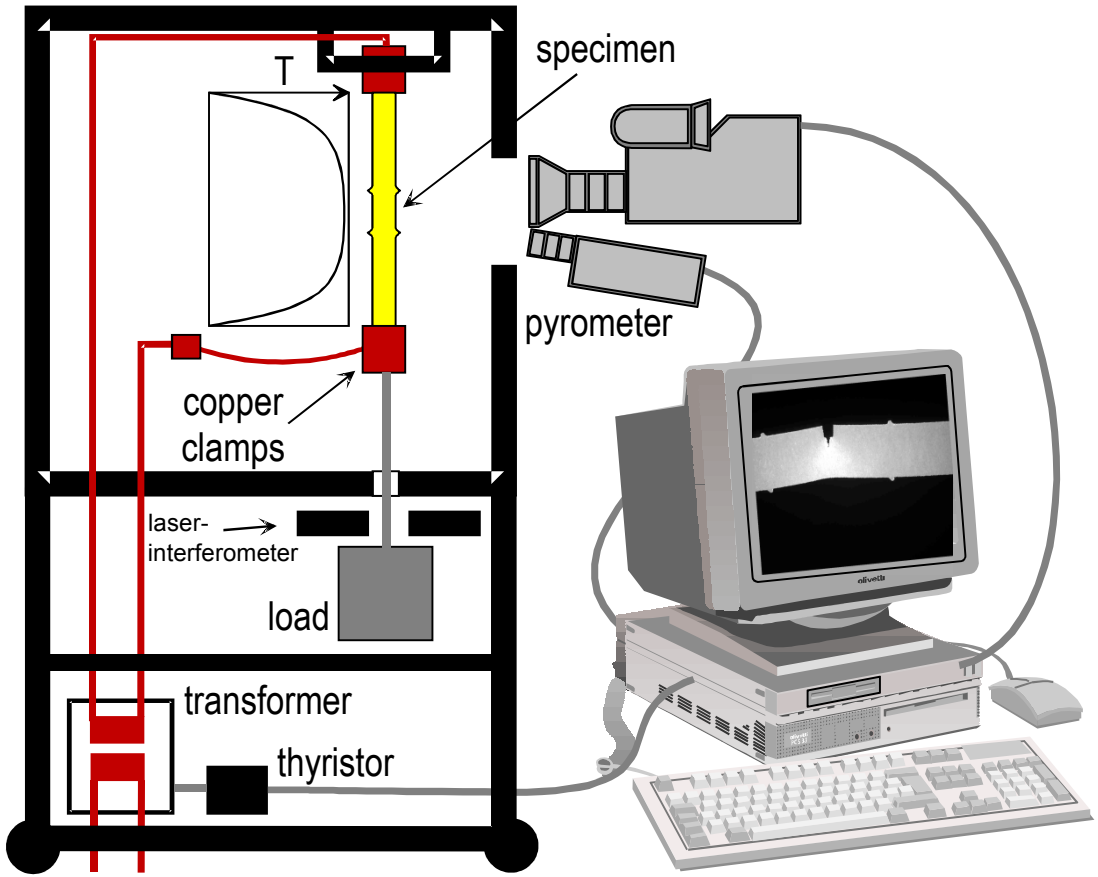
- Direct electric current heating
- IR-pyrometer
- Computer controlled temperature
- Temperature range: 750 to 3,000 °C

Creep tests:

- Determination of creep curves by means of laser interferometer or high resolution camera and the software *SuperCreep*

Sample dimensions (laser-machined from sheet):

- Length: 120 mm
- Width: 4 mm
- Thickness: 0.8 mm



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Experimental – test facility tensile tests:

Test chamber for tensile tests:

- Same principle
- Integrated in a conventional tensile testing machine
- Samples with shoulders

Strain measurement by using a high resolution camera and the software SuperCreep