Creep of Carbon Fibres

Measurement of mechanical properties and analysis of post-creep structure with X-ray scattering

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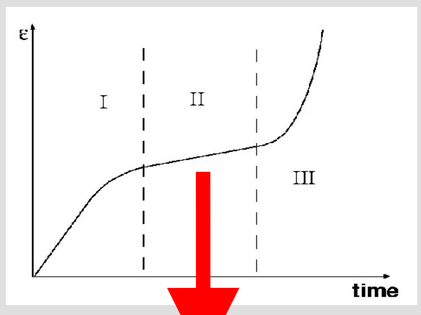
What is creep?



$$\dot{\varepsilon} = A\sigma^{n} \cdot e^{-\frac{Q}{RT}}$$

Elongation of carbon-fibres

under stress at high temperatures

because of structural change:

I... creation of pores

II... growth of pores

III... cracks, coalescence of pores

Measurement

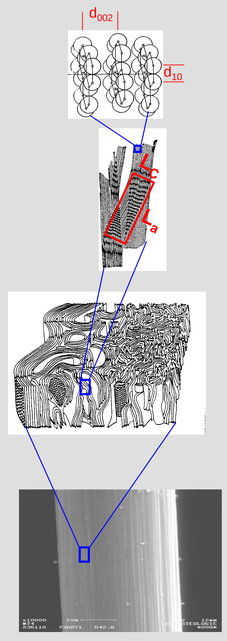
- direct heating (electric current through the bundle of carbon fibres)
- constant load (hydraulic system) in vacuum vessel (pressure < 10^{-3} mbar)
- cooled grips
- (66 +/- 1) mm effective gauge length

measurement at: 173, 217 and 260 MPa

1500, 1600 and 1700°C

Structure

X-ray scattering has been used to investigate the structural change in the carbon fibres caused by creep, dependent on stress and temperature. Information about the pores (small angle X-ray scattering - SAXS) and about the graphite-layers (wide angle X-ray scattering – WAXS) in the fibres is gained.

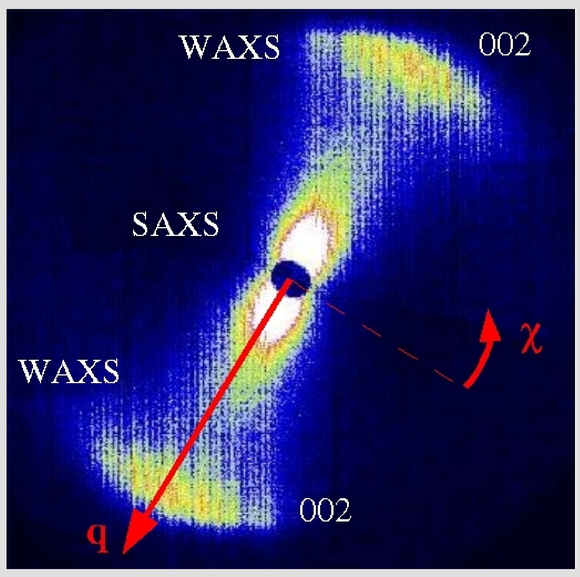


layers

pores

fibre-structure

SEM-image carbon fibre

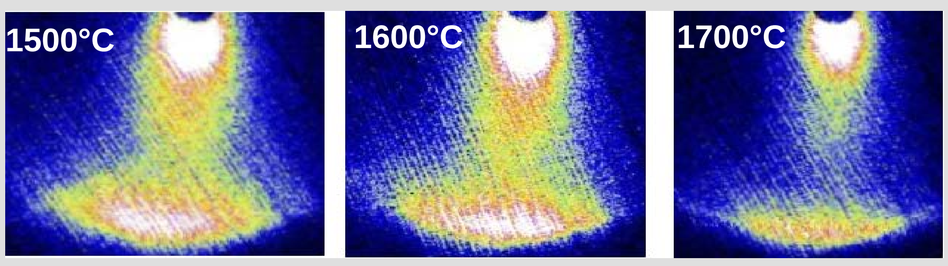


SAXS (information about pores):

- **mean diameter 7 Å growing at T ↑**
- **mean orientation to fibre-axis 18° declining at T ↑**

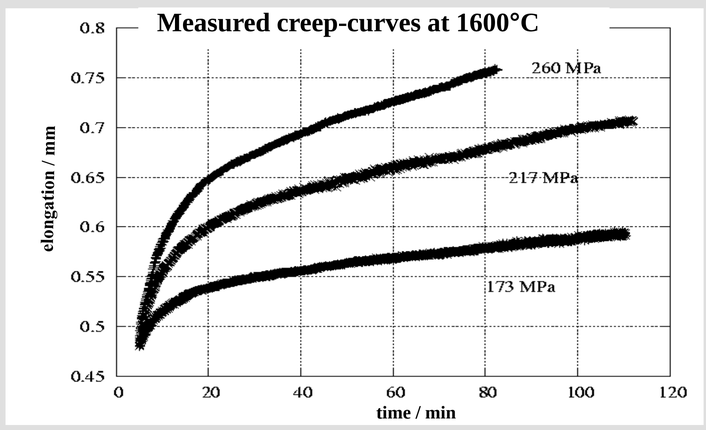
WAXS (information about graphite-layers):

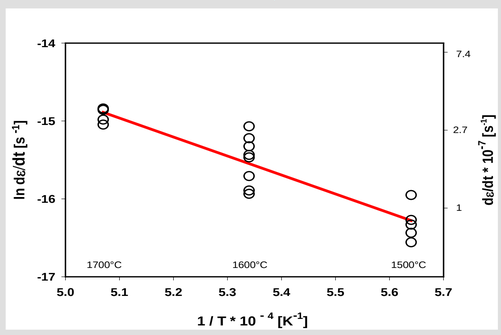
- **mean interlayer-spacing 3.46 Å constant**
- **mean orientation to fibre-axis 18° declining at T ↑**



Scattering-images at 217 MPa: the distribution-width is smaller after creep-experiments at higher temperature.

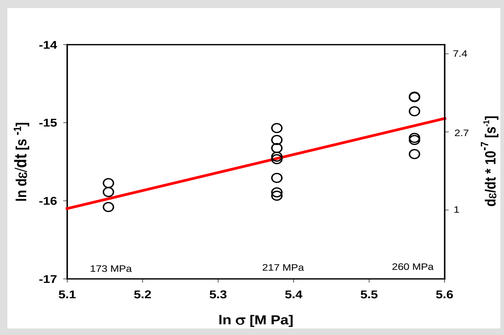
Mechanical Properties





Activation Energy

Q = (167 +/- 26) kJ/Mol



Creep-Exponent

n = 2.3 +/- 0.5

Conclusion

Low Activation Energie Q

↓

No Diffusion of C-Atoms

[Kanter57]

\+ n ≈ 2 [Cannon83, Cannon88]

The creep-mechanism proposed for these experiments is the glide of grain-boundaries:

Rachinger-sliding

Loss of nitrogen during the heating possibly facilitates this process. Further experiments in argon-atmosphere will be perfomed for clarification.

Cannon83: W.R. Cannon, T.G. Langdon, J. Mat. Sci. 1983, 18, 1-50

Cannon88: W.R. Cannon, T.G. Langdon, J. Mat. Sci. 1988, 23, 1-20

Kanter57: A. Kanter, Phys. Rev. Ser. 1957, 107, 655-663