WP4: Production integrity monitoring
Distributed Temperature Sensing (DTS)

Introduction and overview

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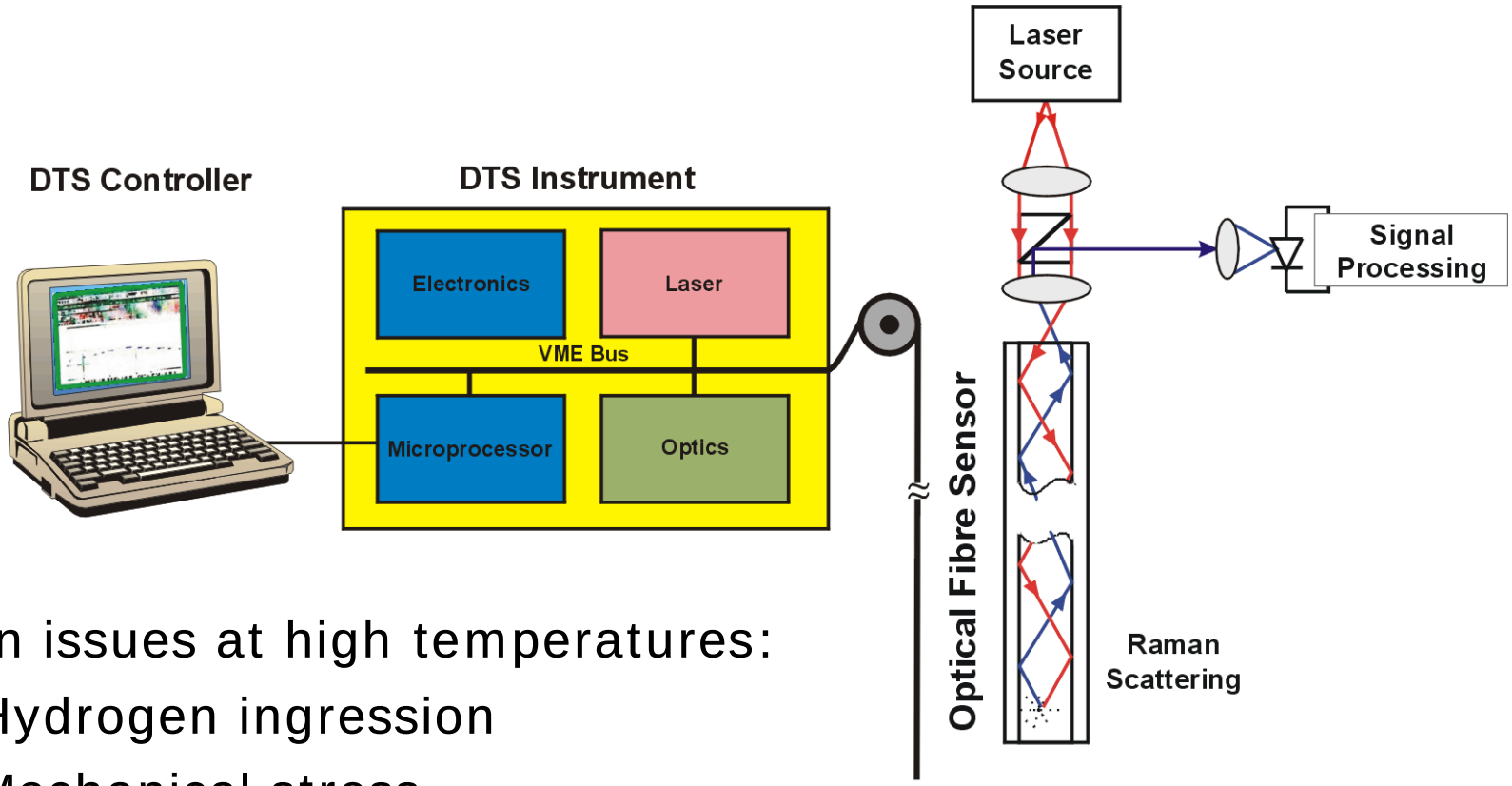
Overview WP 4 and outline of presentation

- WP 4 „Production integrity monitoring“
- ALT: acoustic televiewer (casing survey and cement evaluation)
- GFZ: fiber-optic distributed temperature sensing (DTS), field testing of sensor cable at high temperatures
  - D7: technical concept and results of field experiment
  - D17: new concept for HT-DTS cable (lessons learned)

Outline of presentation:

- DTS method, issues with optical fibers at high temperatures
- Solutions to overcome effects of „differental attenuation“
- Overview of achievements within HiTI, outlook

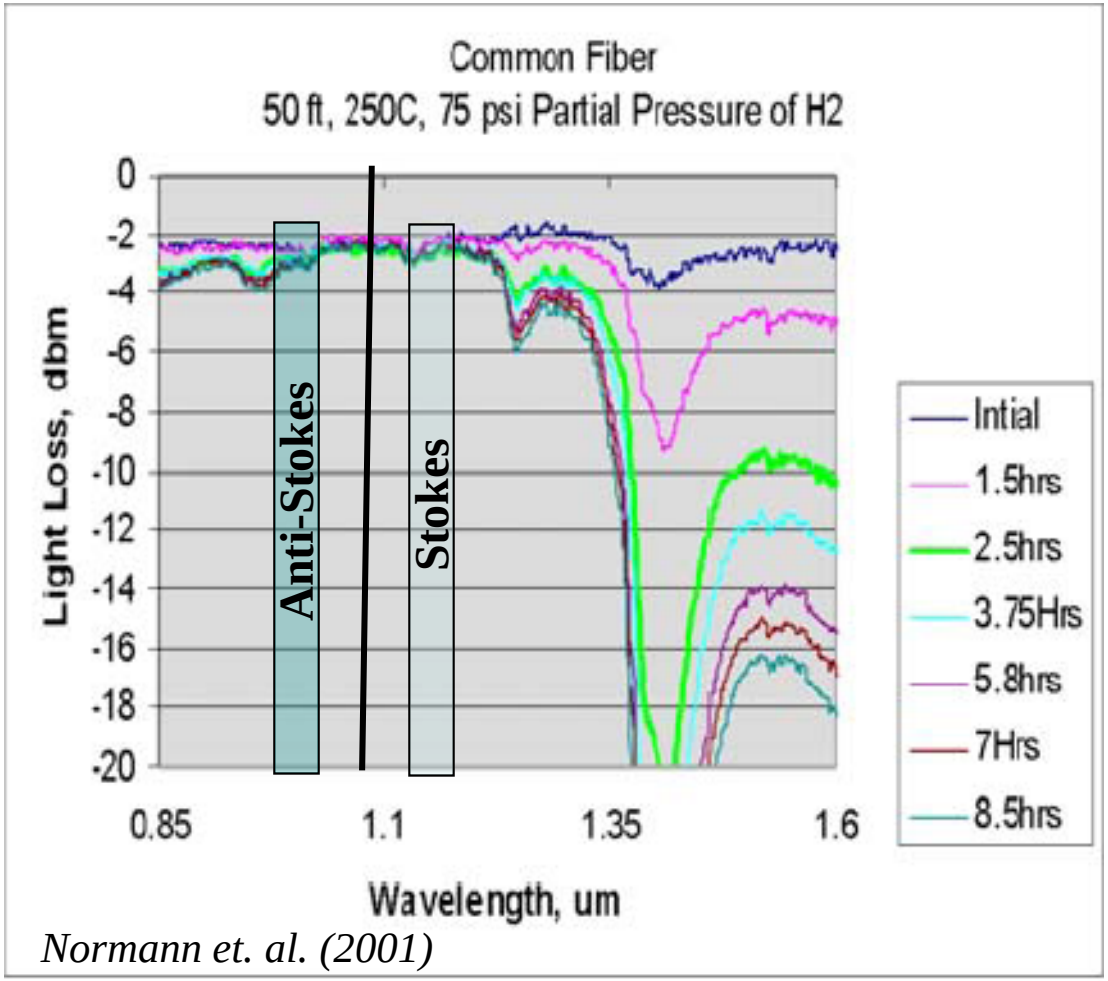
Distributed temperature sensing (DTS)



Main issues at high temperatures:

- Hydrogen ingression
- Mechanical stress

Hydrogen ingression / darkening



Normann et. al. (2001)

Hydrogen (H_2) diffusion into optical fiber

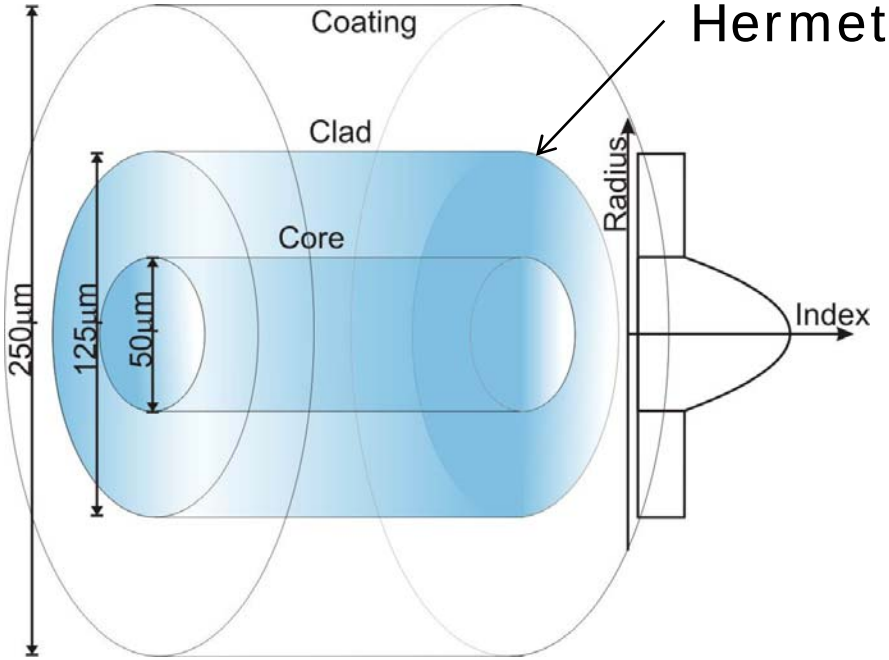
Formation of bound hydroxyl (SiOH) in glass core

Main absorption peaks: 724, 943, and 1383 nm

DTS operating wavelength: 1064 nm

Differential attenuation: ratio of Stokes- and Anti-Stokes wavelength (and calculated temperature) is changed

Fiber coatings: laboratory tests



Hermetic coating: additional carbon layer

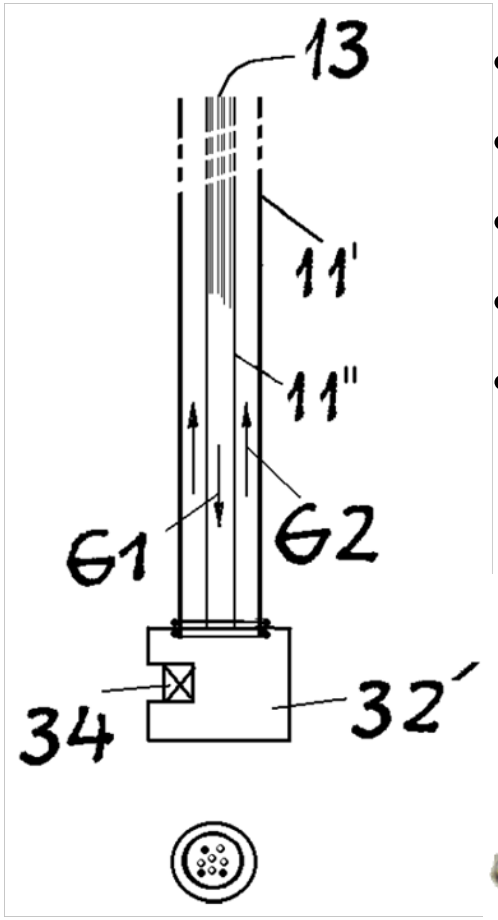
Reinsch (2008)

	Coating	Temp. (°C)
Polymer	HT-Acrylate	-40 - 200
	Polyimide 1	-90 - 385
	Polyimide 2	-90 - 385
	Polyimide 3	-65 - 300
	Polyimide 4	-65 - 300
Metal	Aluminum	-269 - 400
	Gold	-269 - 700

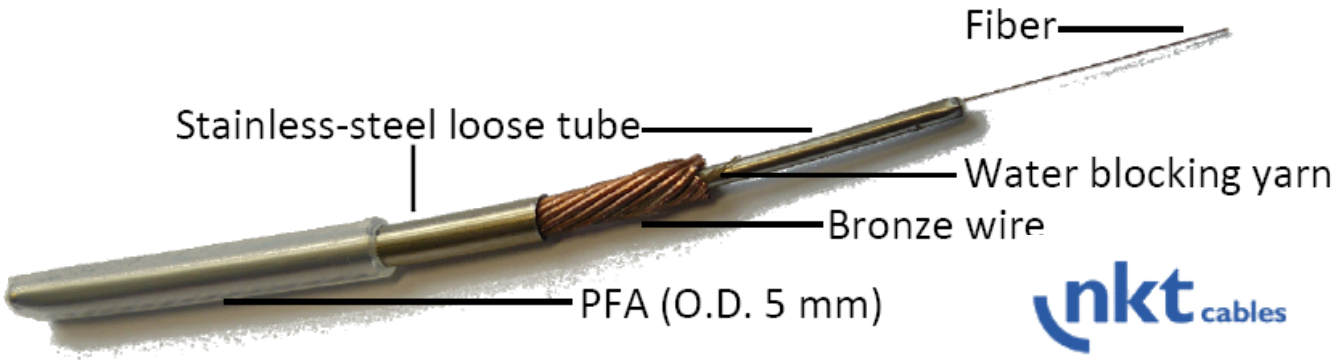
Schematic cross section of optical fiber

Fibers tested at GFZ and manufacturer temperature stability

Fiber-optic borehole sensor cable for high-temperature applications



- Development: GFZ and nkt Cables GmbH
- Borehole sensor cable with gas flushing
- Patent filed, May 2008 (DE 10 2008 026)
- Prototype installed in well HE-53 in Iceland
- Flow test August 2009: successful measurements up to 230 °C, degradation of fiber > 300 °C



H_2-darkening: DTS operation modes

- Double- or dual-ended measurement setup
  - Measurement from both ends of the sensor fiber
  - Standard setup during past GFZ projects (DTS unit from Sensa)
  - Could not be applied for HiTI cable test in HE-53 in Iceland due to cable break
- Dual-laser principle
  - Measurement at two different wavelengths
  - DTS unit (Sensortran): rent for 3-month period
  - Lab test (no H_2): decreased resolution and accuracy
  - Field test: no significant effect on measured data
  - But evaluation is still under way…

Main achievements within HiTI

- 1st period (2007):
  - Fiber tests: behaviour of different coating materials, reversible and irreversible attenuation changes
- 2nd period (2008):
  - Effect of inert atmosphere (polyimide up to 350 °C)
  - Development of HT-DTS sensor cable with nkt cables GmbH
- 3rd period (2009/2010):
  - Installation and test of cable in high-temperature well in Iceland (HE-53, Orkuveita Reykjavikur), DTS monitoring during flow test: >200 °C for two weeks
  - Evaluation of dual-laser measurement principle

GFZ hybrid wireline logging cable

Hybrid cable:

Simultaneous deployment of wireline tools and fiber-optic DTS

- 3 conductors
- 2 SM, 2 MM optical fibers
- GIPS armour
- 10.21 mm dia.

GFZ wireline logging tools: P, T, GR, CCL, flow meter (150 °C)

Thank you for your attention!