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Components and Tools for Nanofluidic Applications

nanoSeminar Dresden, July 4th 2013

Prof. Dr.-Ing. Stephan Klein • Prof. Dr. rer.nat. Bodo Nestler
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Luebeck University of Applied Sciences
Biomedical Sensors- and Devices Lab
www.msgt.fh-luebeck.de

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The Heads of Tandem

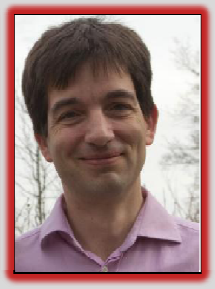
Jürgen Dunst
Strahlentherapie

Ullrich Wenkebach
Elektrotechnik

Christian Hübner
Physik

Ralf Brinkmann
Biomedizinische Optik

Martin Ryschka
Elektronik



Henrik Botterweck
Physik

Hartmut Gehring
Anästhesiologie

Stephan Klein
Maschinenbau

Bodo Nestler
Physik

Gereon Hüttmann
Biomedizinische Optik

Thorsten M. Buzug
Medizintechnik

Achim Schweikard
Mathematik

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Location on the BioMedTec-Campus Luebeck

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Sensors **Actuators**

Drug delivery

Drug multiplexing

Drug release

Pulseoximetry

hardware

application

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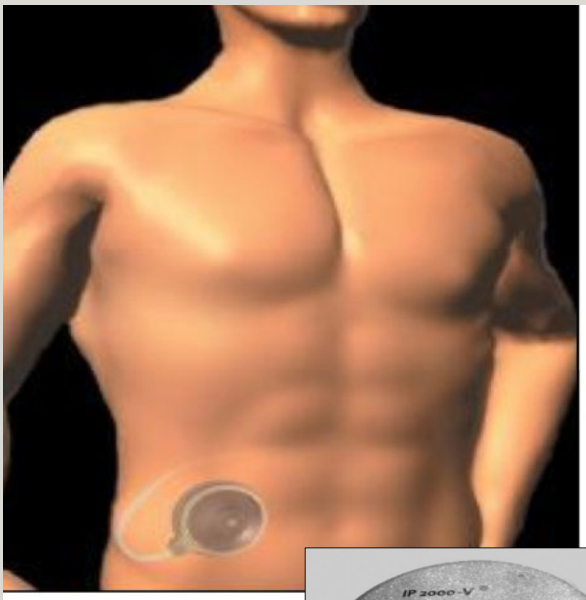
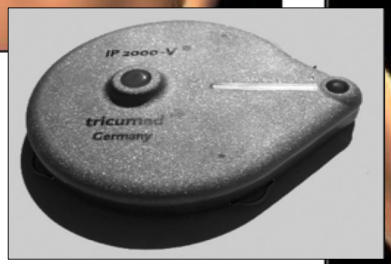
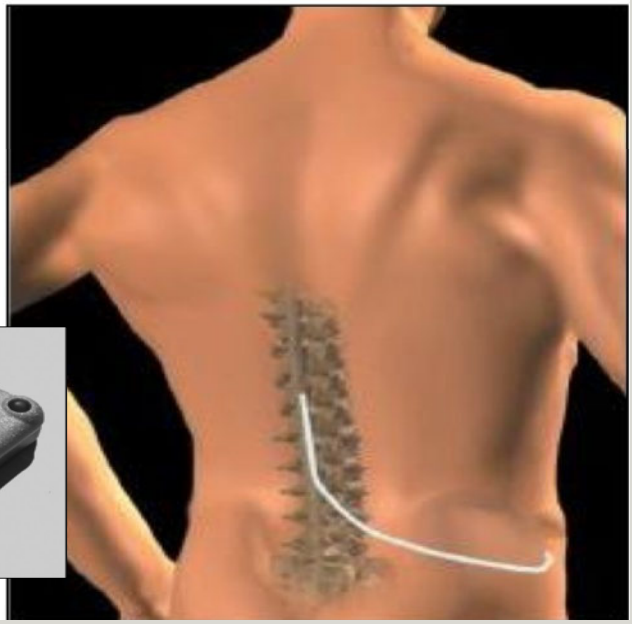
Drug delivery







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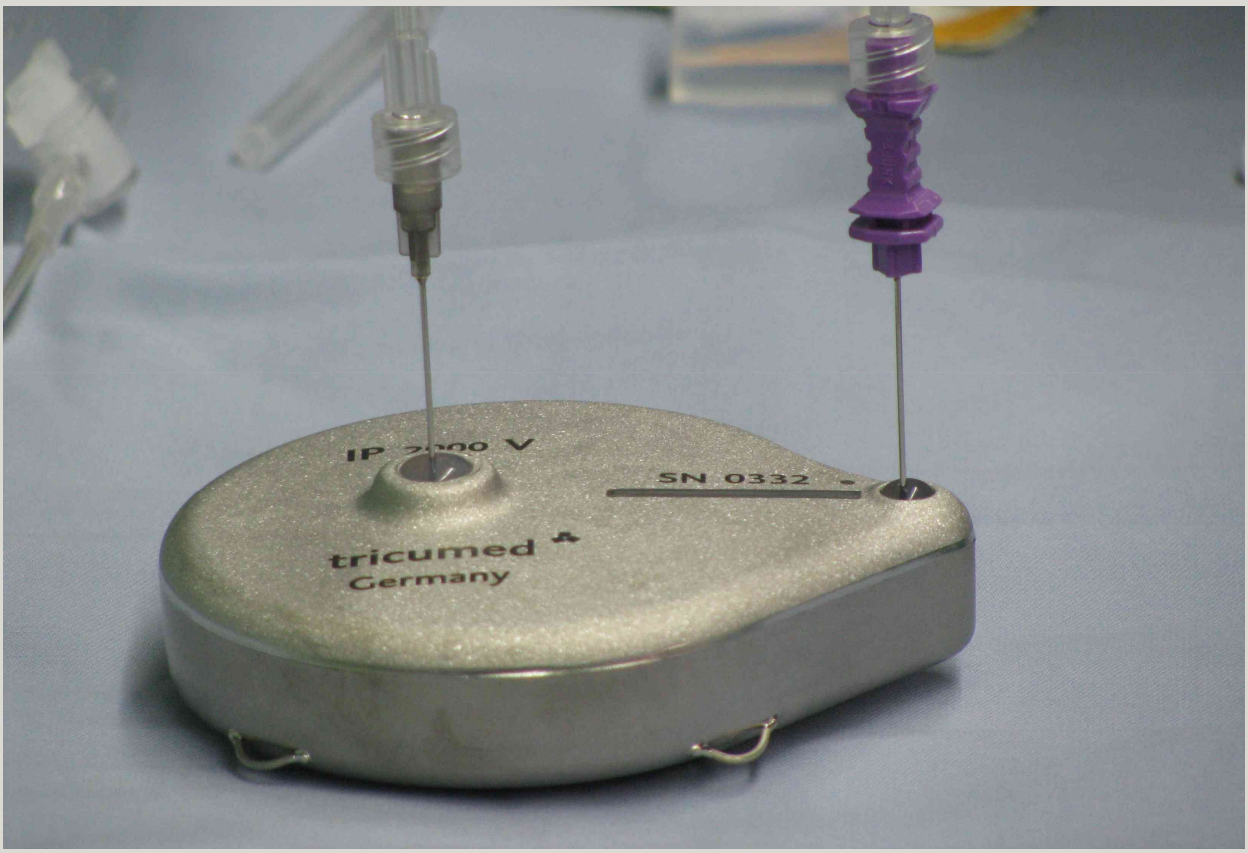

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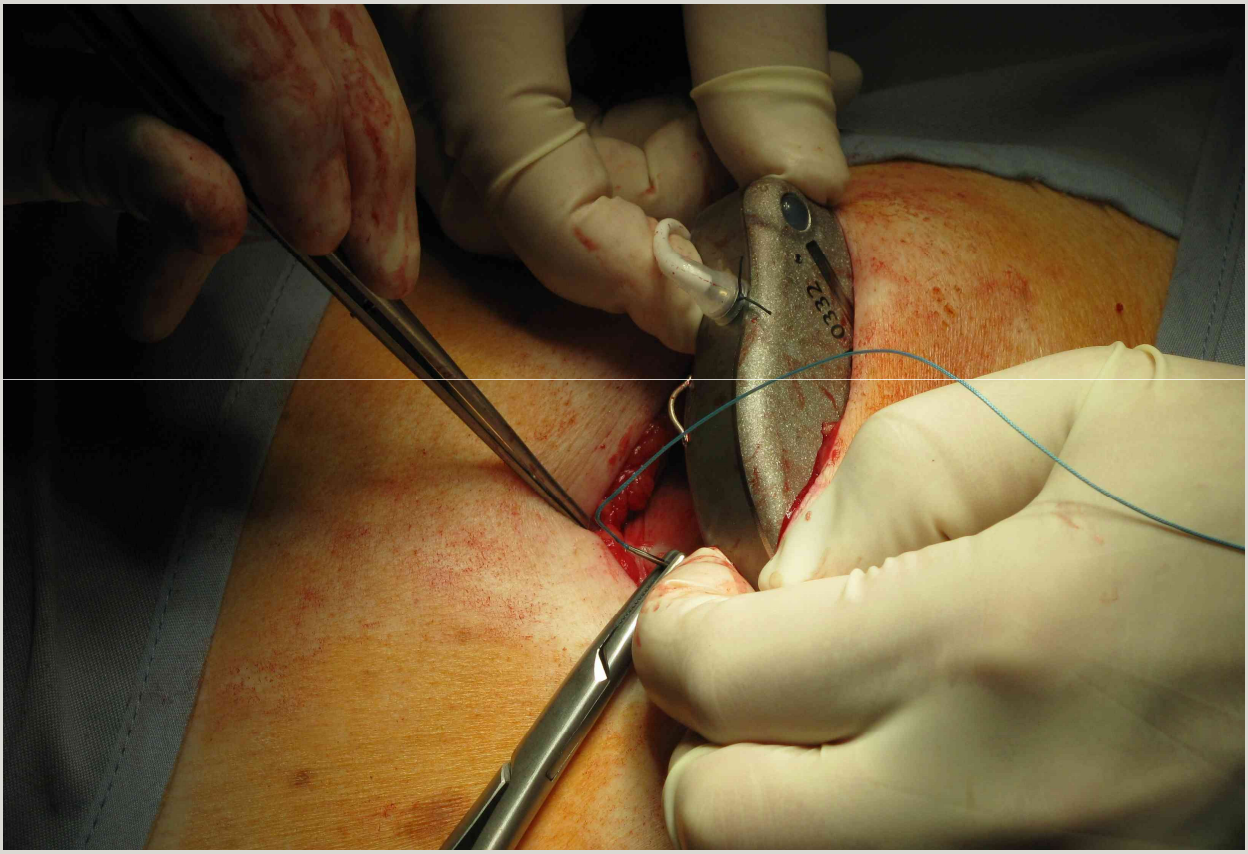

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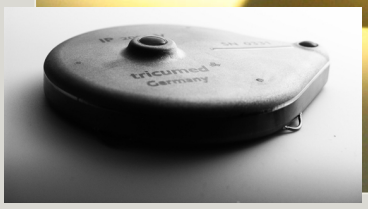
"NaFlowSens"

Testing Nano Flow Sensors in a realistic environment



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Bundesministerium für Bildung und Forschung

Integration of a sensor into the fluidic system of the drug pump

Calibration with another (more exact) measuring method

Simulation of movements inside the abdomen (e.g. heartbeat and breathing)

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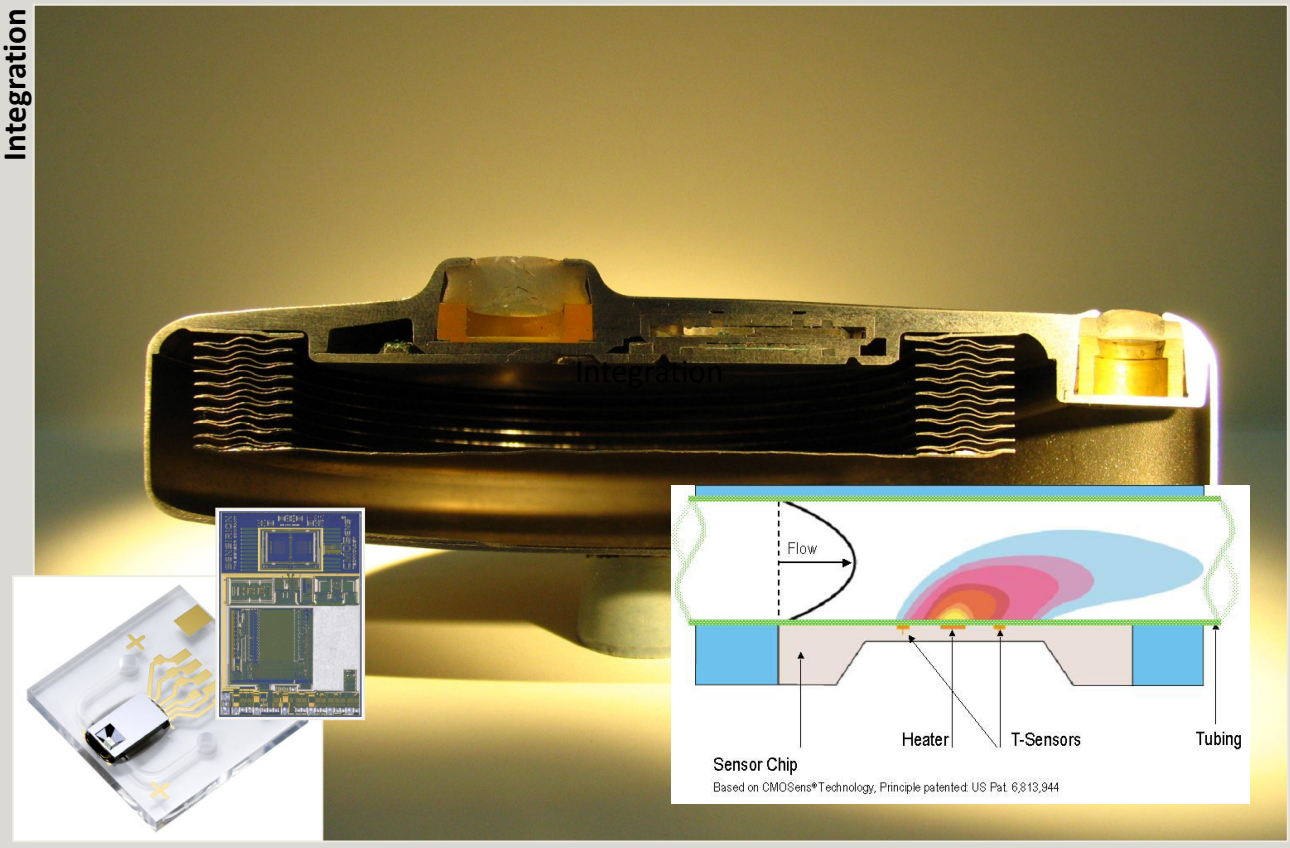
Integration



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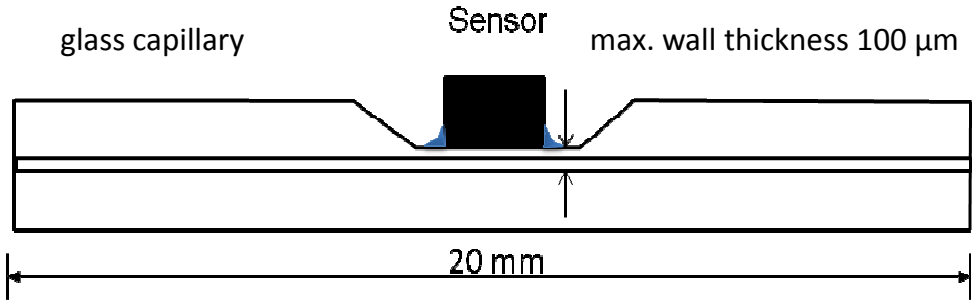
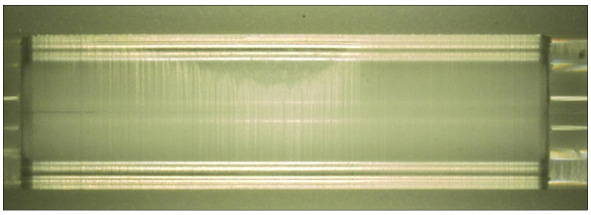
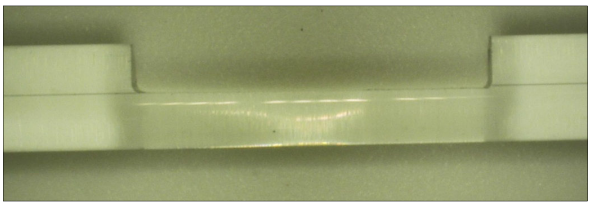
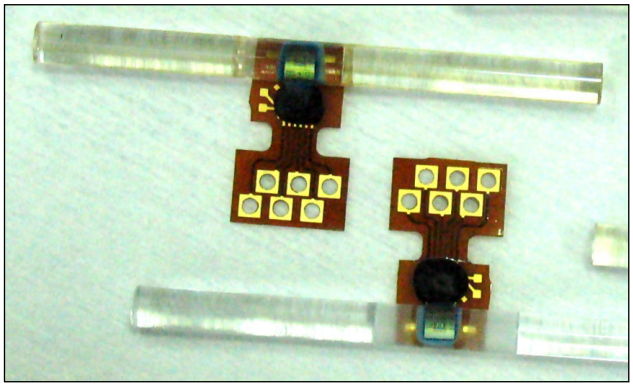
Integration









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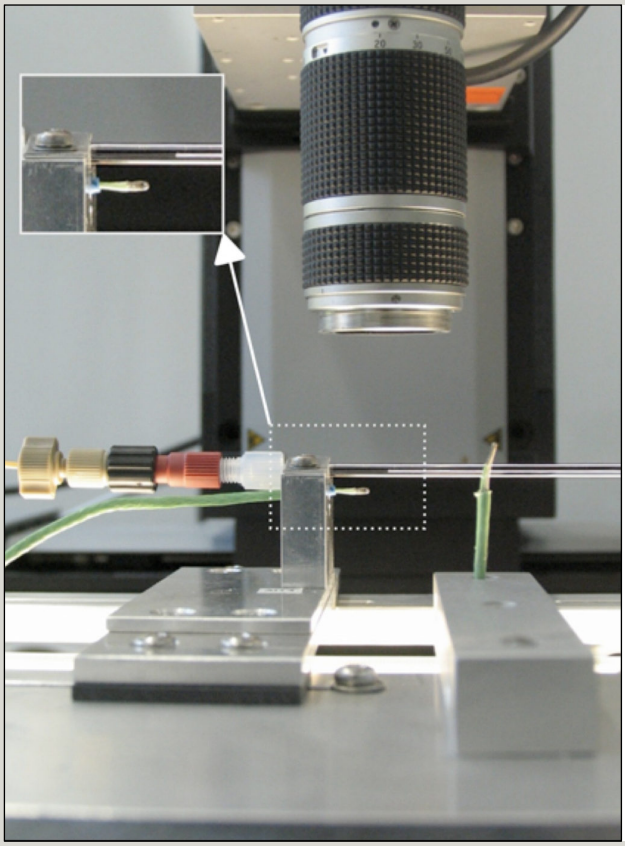
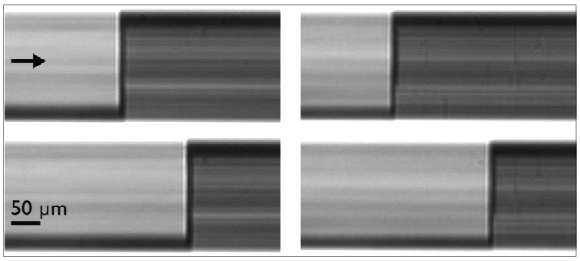
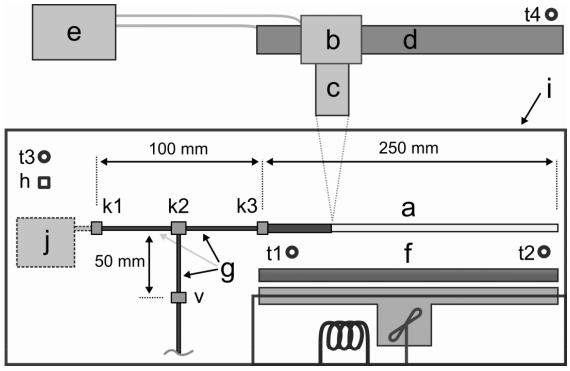
Calibration

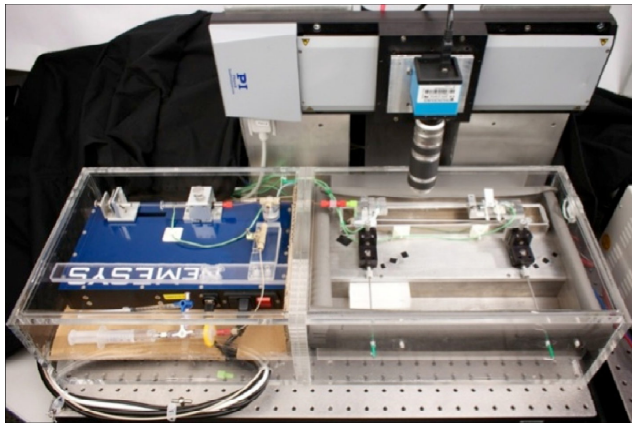




Meniscus appearance at 10 nl/min (left) and 20 nl/min (right).
Time interval between top and bottom frames approx. 7 s.
Motion of the meniscus from left to right.
Water is on the left side.

Calibration





Experimental setup:

(a) glass capillary, (b) CCD camera, (c) 200 x objective lens, (d) linear motion stage, (e) PC, (f) fluorescent tube, (g) PEEKsil tubes, (h) humidity sensor, (i) temperature regulated chamber, (j) **Fluidic system to be verified**, (t1 to t4) thermocouples, (k1 to k3) PEEK fittings, (v) shut-off valve and priming port.

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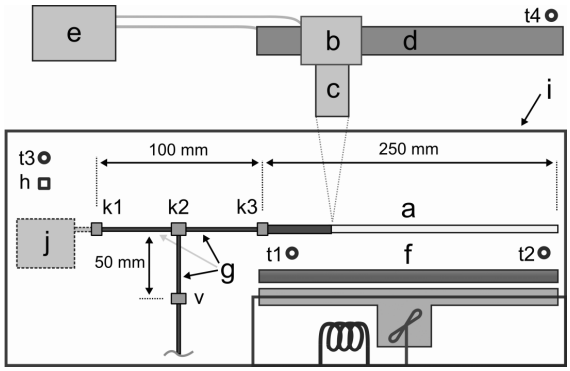
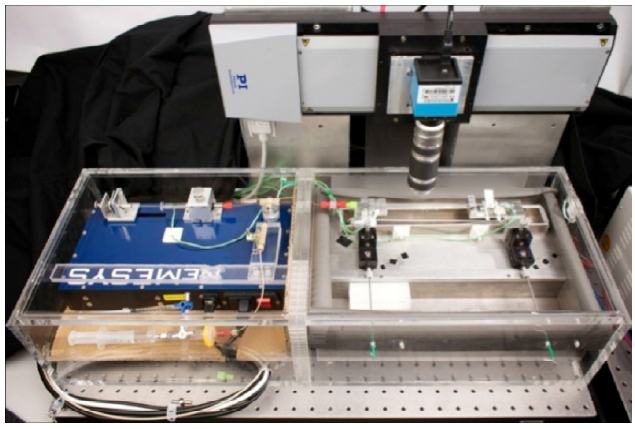
Calibration





Uncertainty analysis

$$\frac{u_{\dot{V}}}{\dot{V}} = \left|\frac{u_{\Delta x}}{\Delta x}\right| + \left|\frac{u_{\Delta t}}{\Delta t}\right| + 2\left|\frac{u_R}{R}\right|$$

$$u_{\Delta x} = u_{\text{drift}} + u_{\text{stage}} + u_{\text{imaging}} + u_{\text{fluctuations}}$$

$$u_{\Delta t} = u_{\text{Daq Latency}} + u_{\text{Clock drift}}$$

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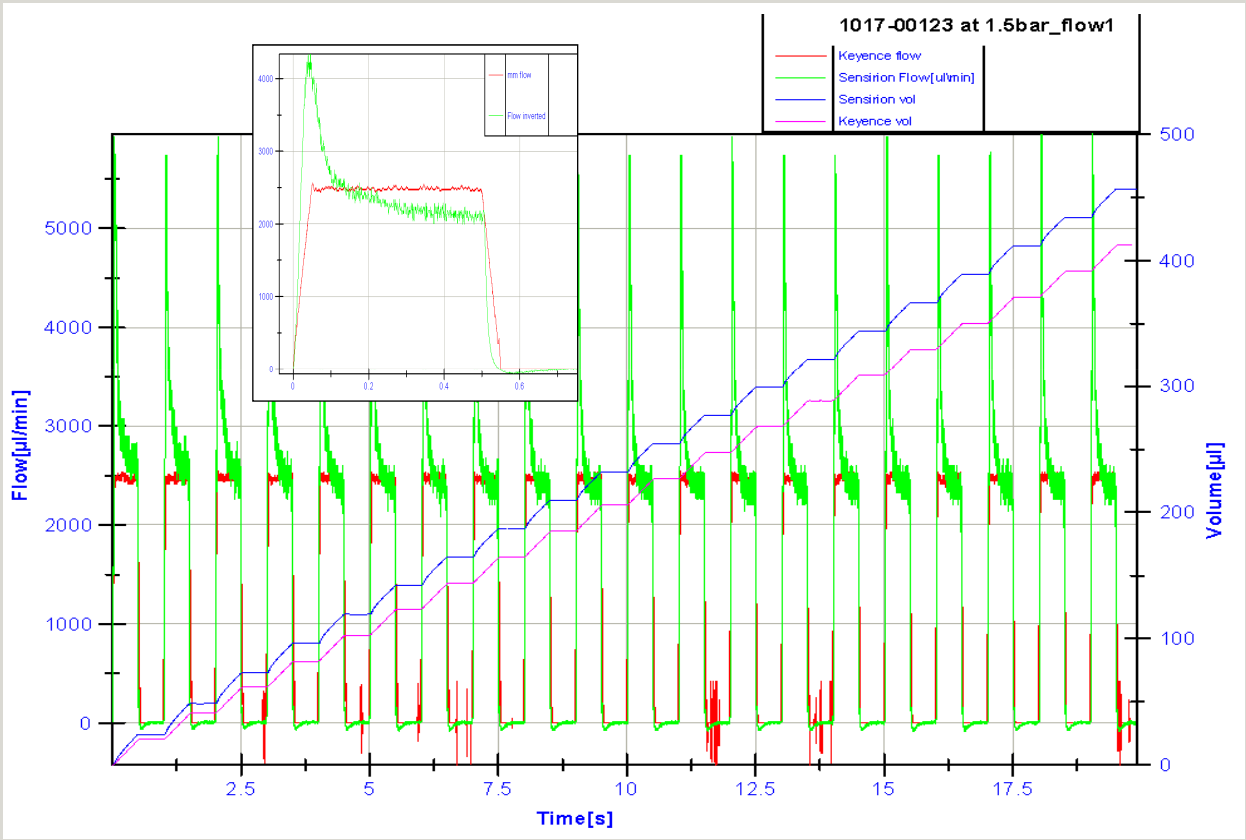
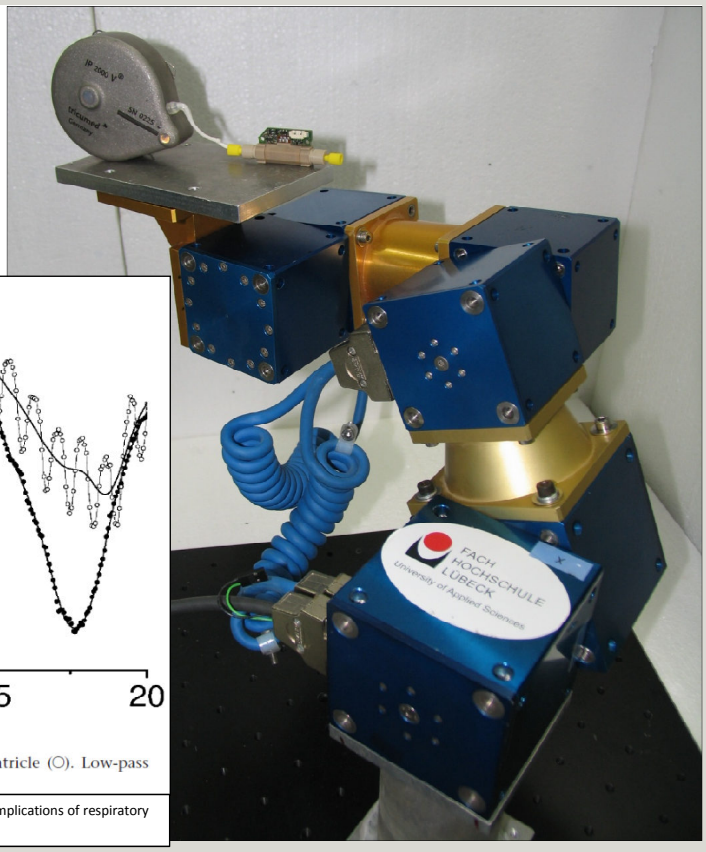
Calibration



Simulation

Investigating the influence of body movements on implanted sensors.



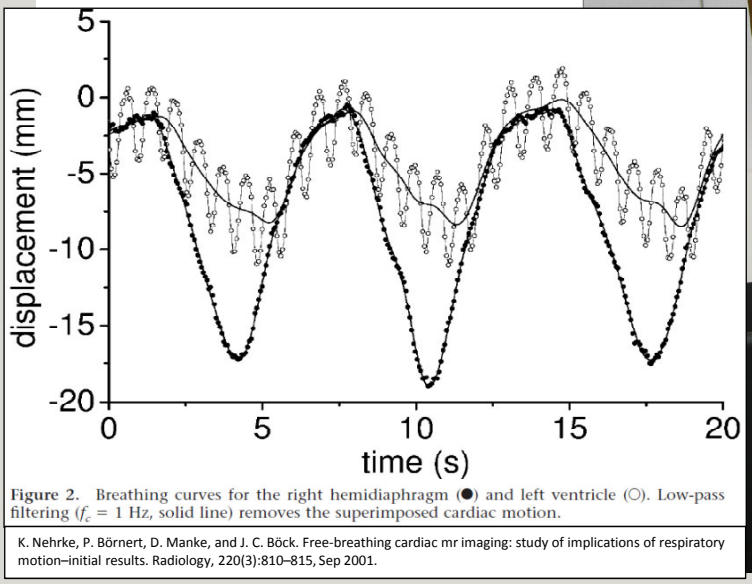


Figure 2. Breathing curves for the right hemidiaphragm (●) and left ventricle (○). Low-pass filtering (f_c = 1 Hz, solid line) removes the superimposed cardiac motion.

K. Nehrke, P. Börnert, D. Manke, and J. C. Böck. Free-breathing cardiac mr imaging: study of implications of respiratory motion–initial results. Radiology, 220(3):810–815, Sep 2001.

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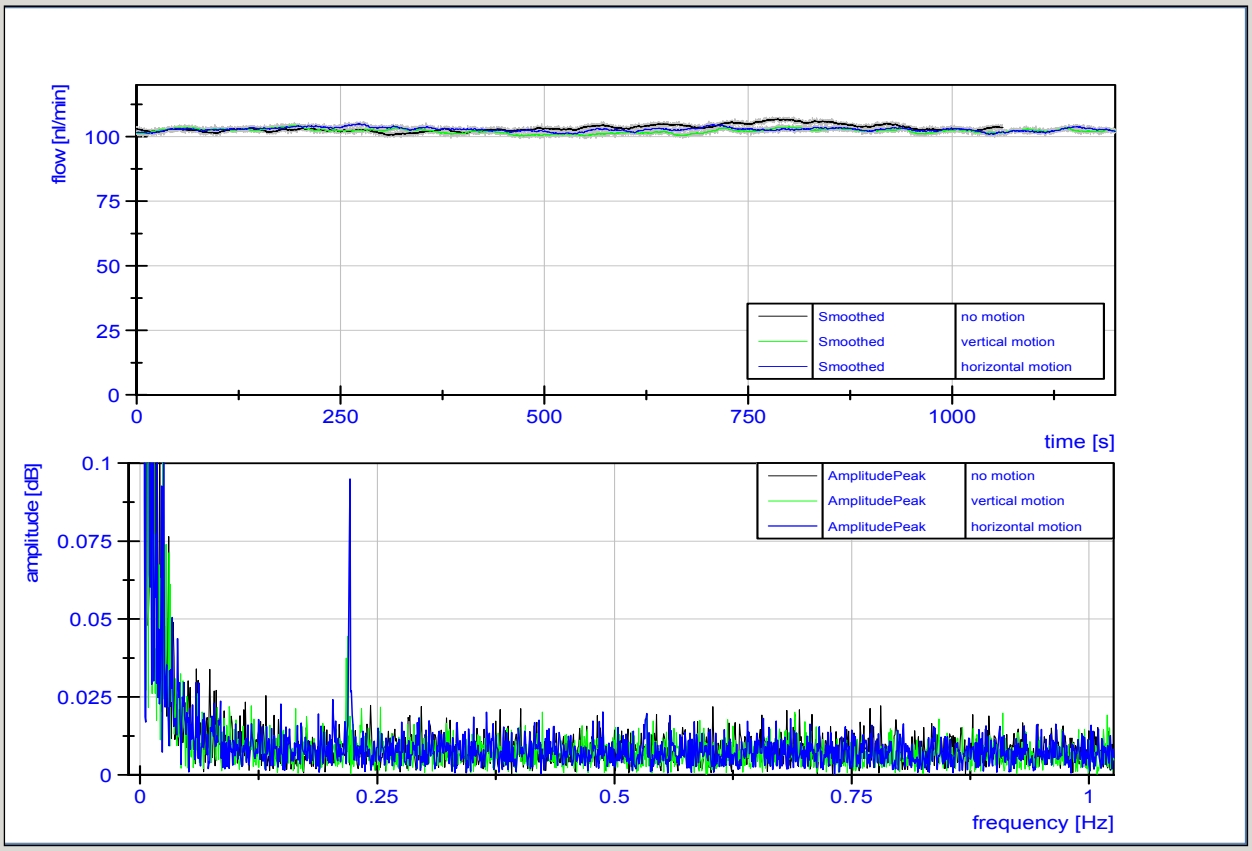
Simulation



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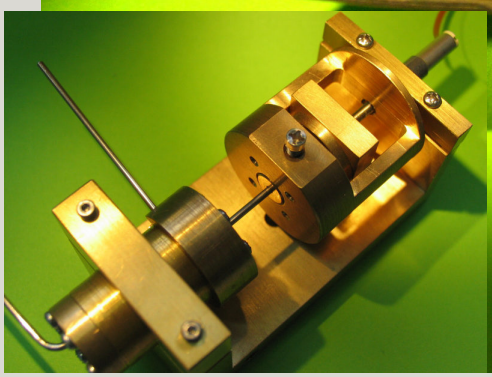
"VarioPump"

Adjustable flow restrictor for an implantable infusion pump



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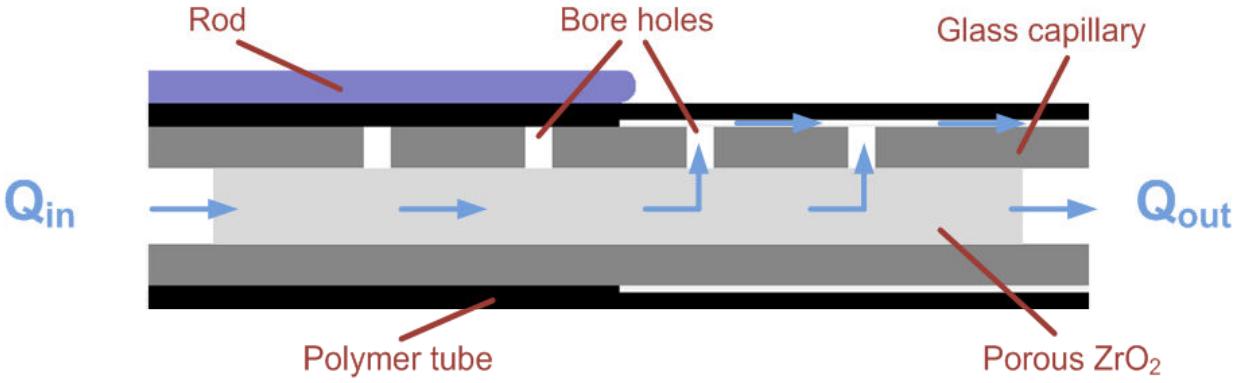
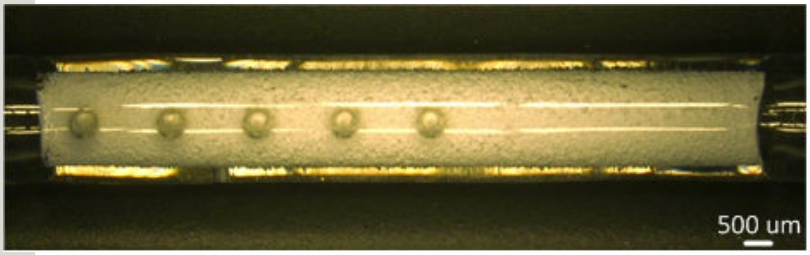
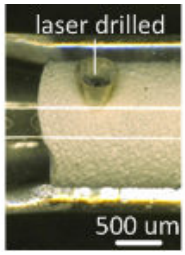
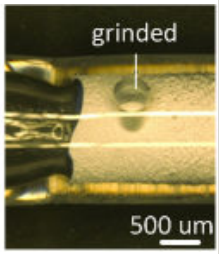
ZrO_2 - Cylinder









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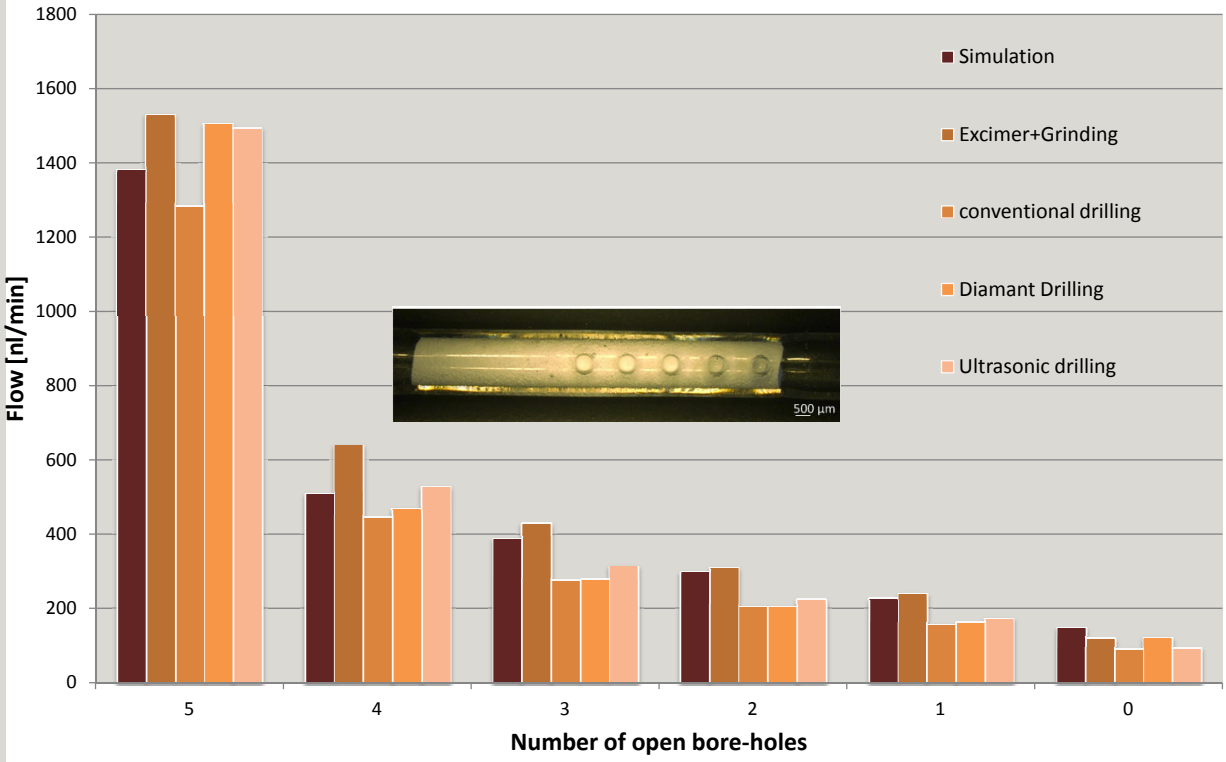
ZrO_2 - Cylinder



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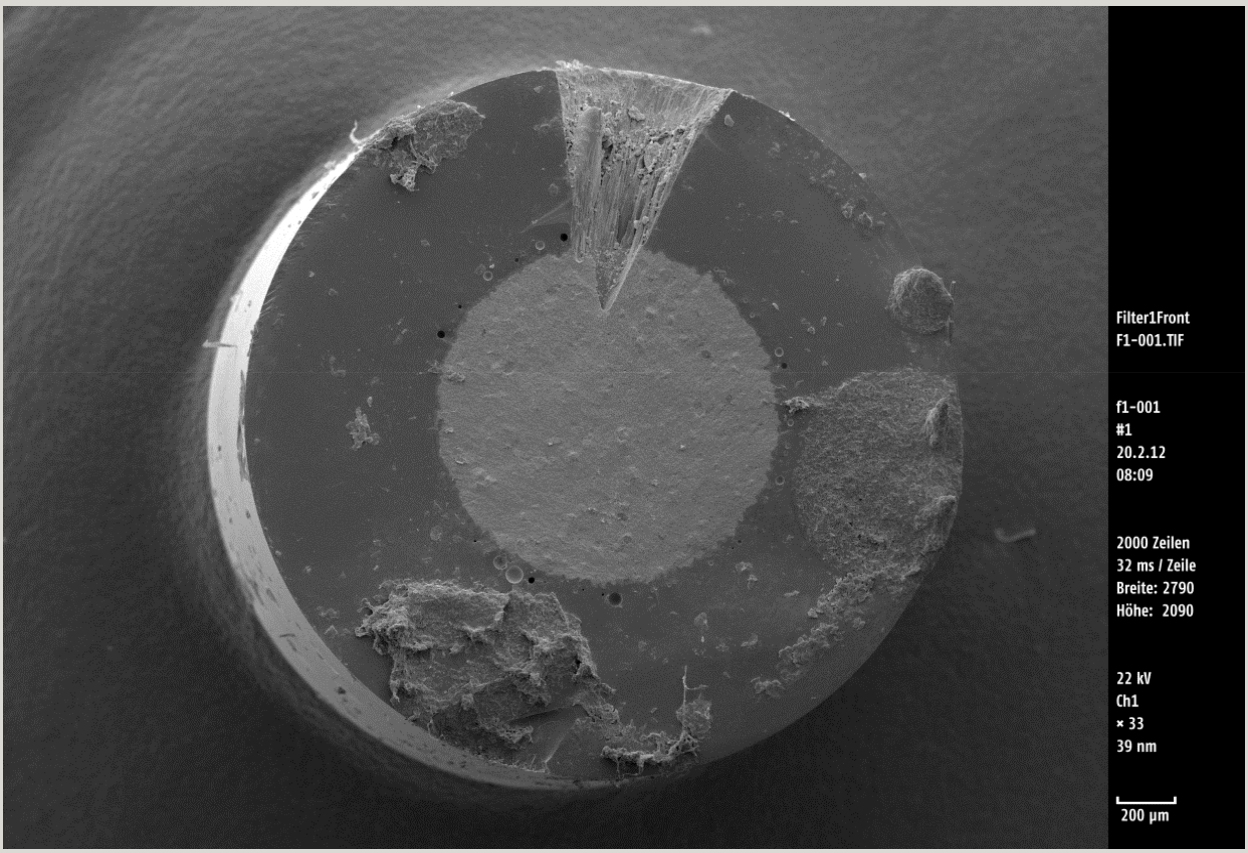
ZrO_2 - Cylinder



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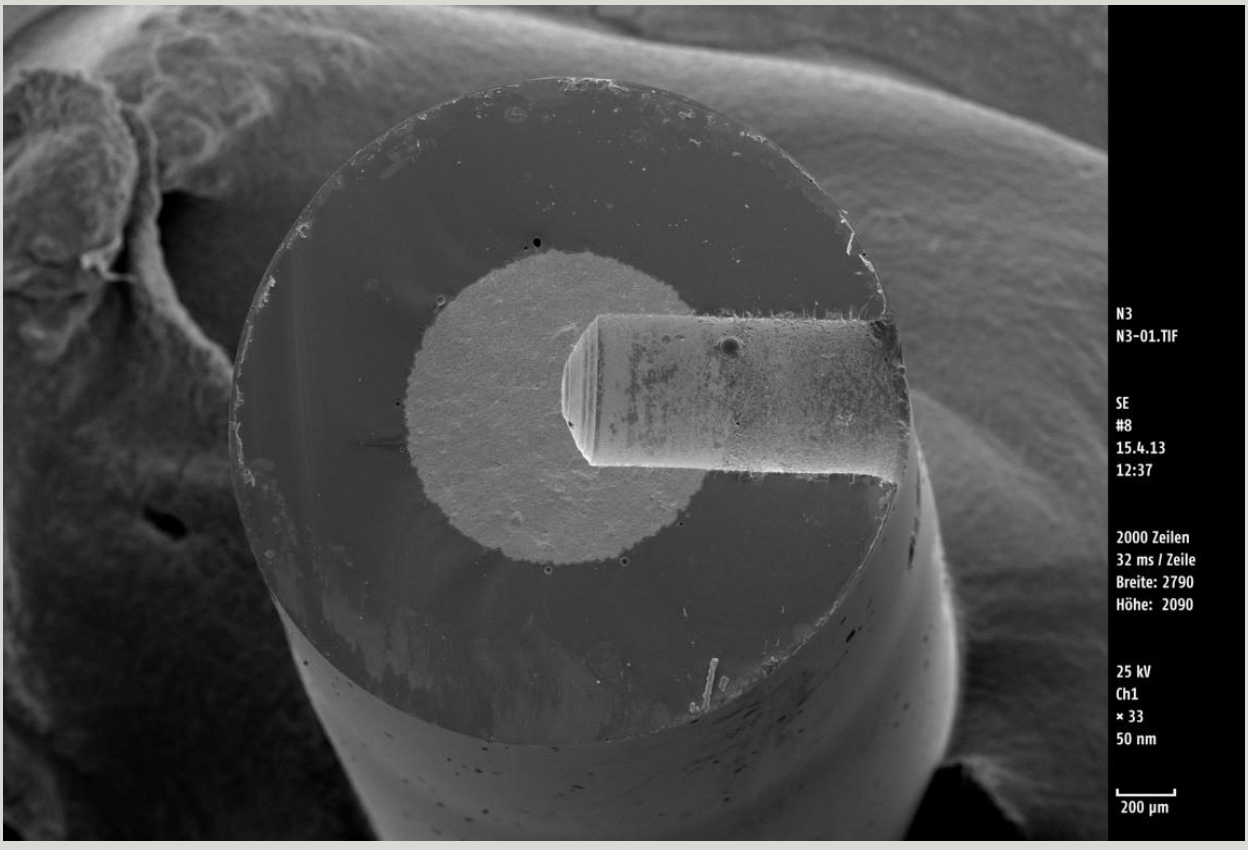

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ZrO_2 - Cylinder

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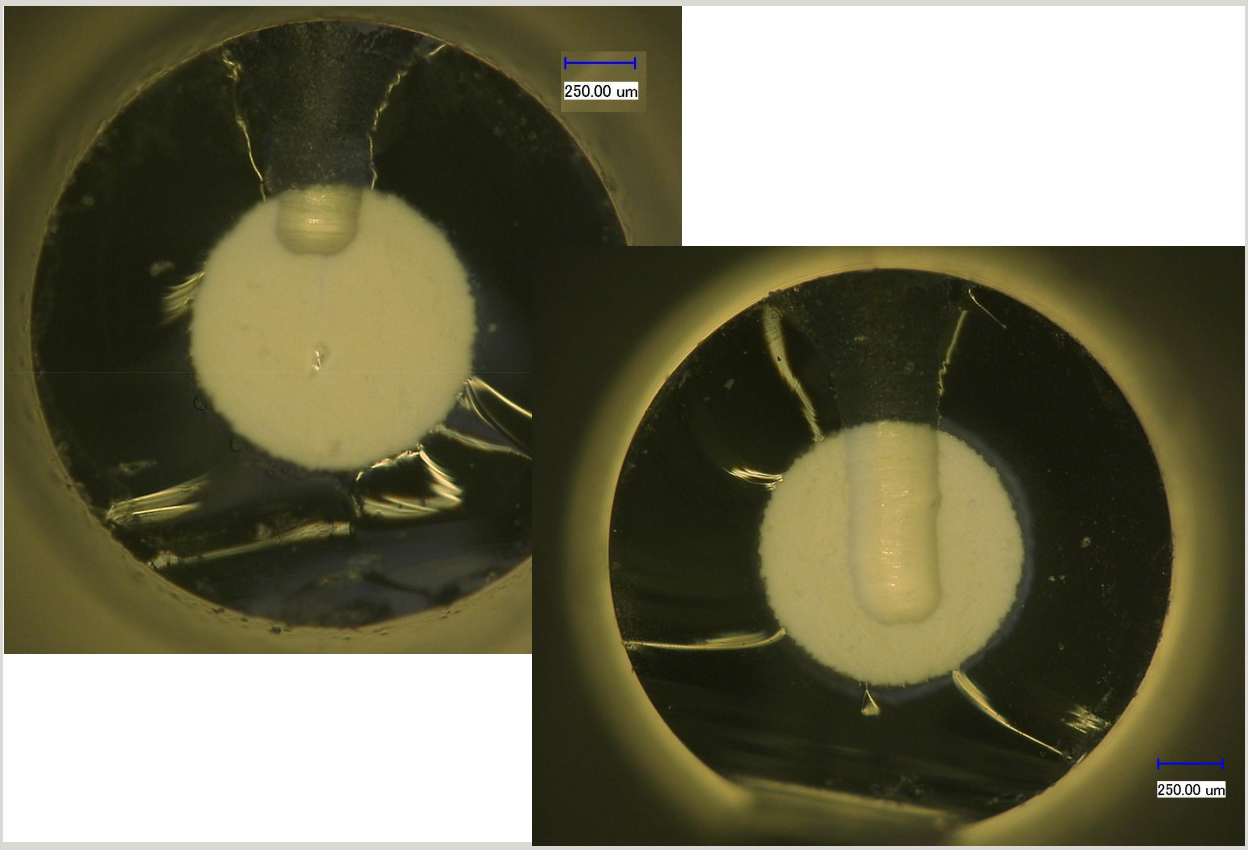
ZrO_2 - Cylinder



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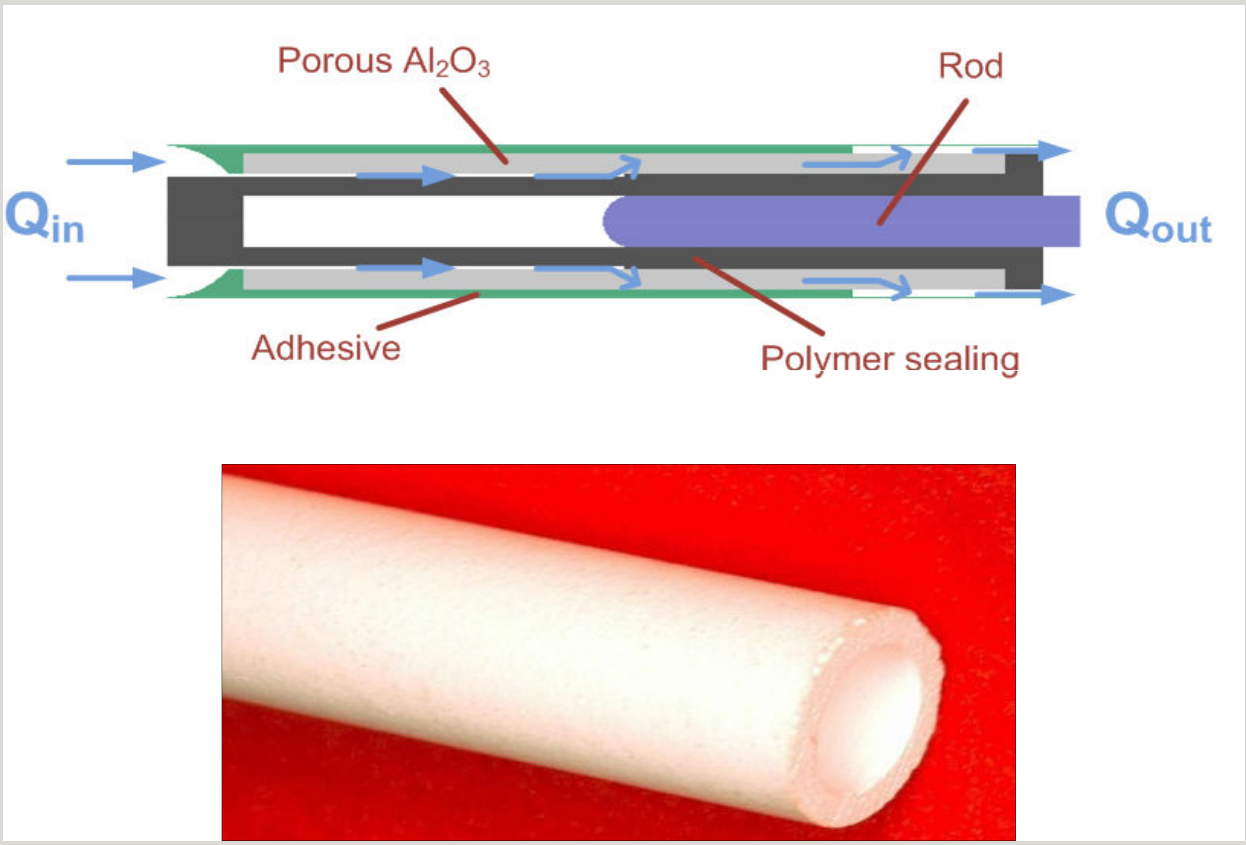
Al_2O_3 - Pipe



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Al_2O_3 - Pipe

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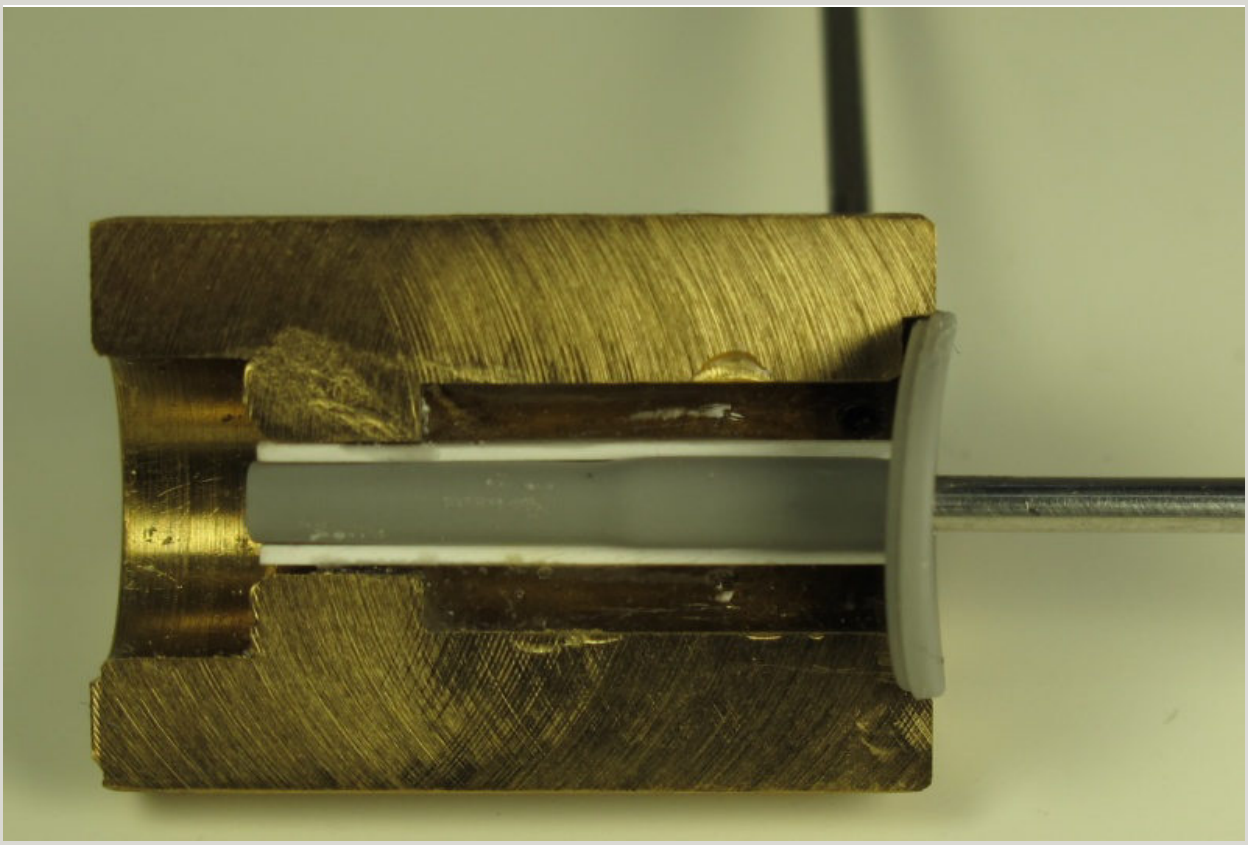
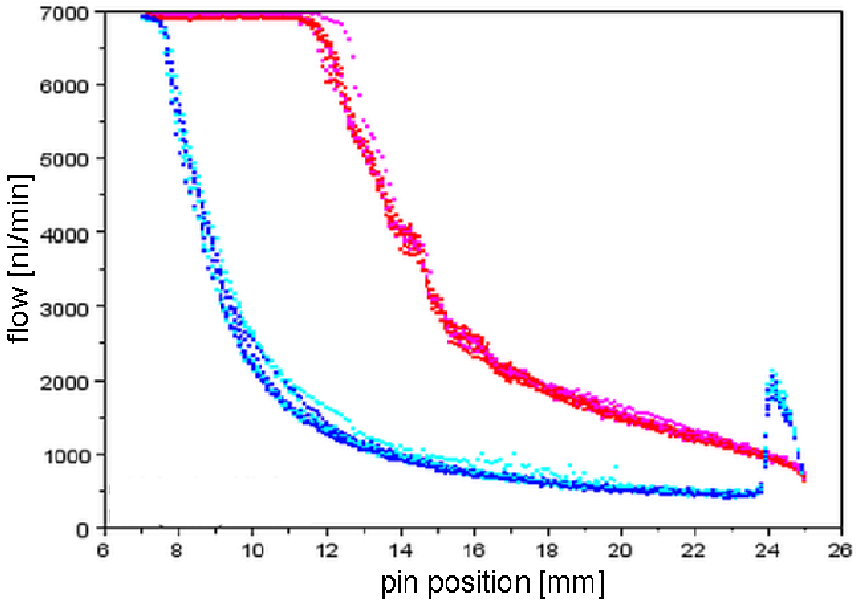
Al_2O_3 - Pipe



Al_2O_3 - Pipe



Unfixed silicon sealing leads to a hysteresis.
Red measuring values belong to the insertion of the bolt, blue ones to the extraction.

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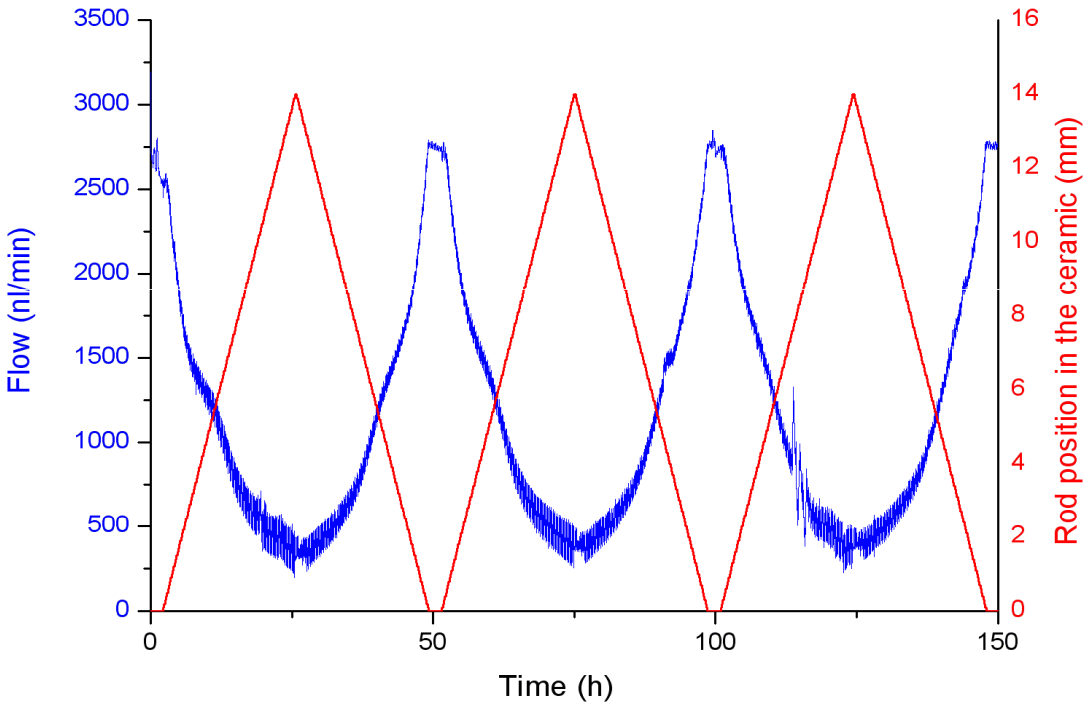
Al_2O_3 - Pipe



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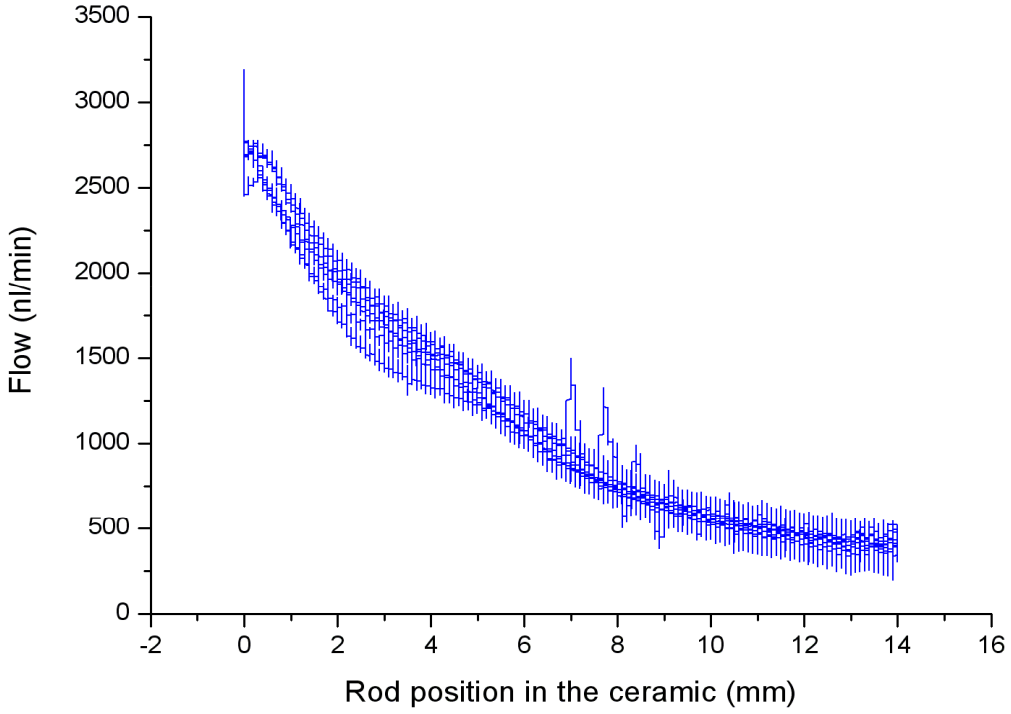
Al_2O_3 - Pipe



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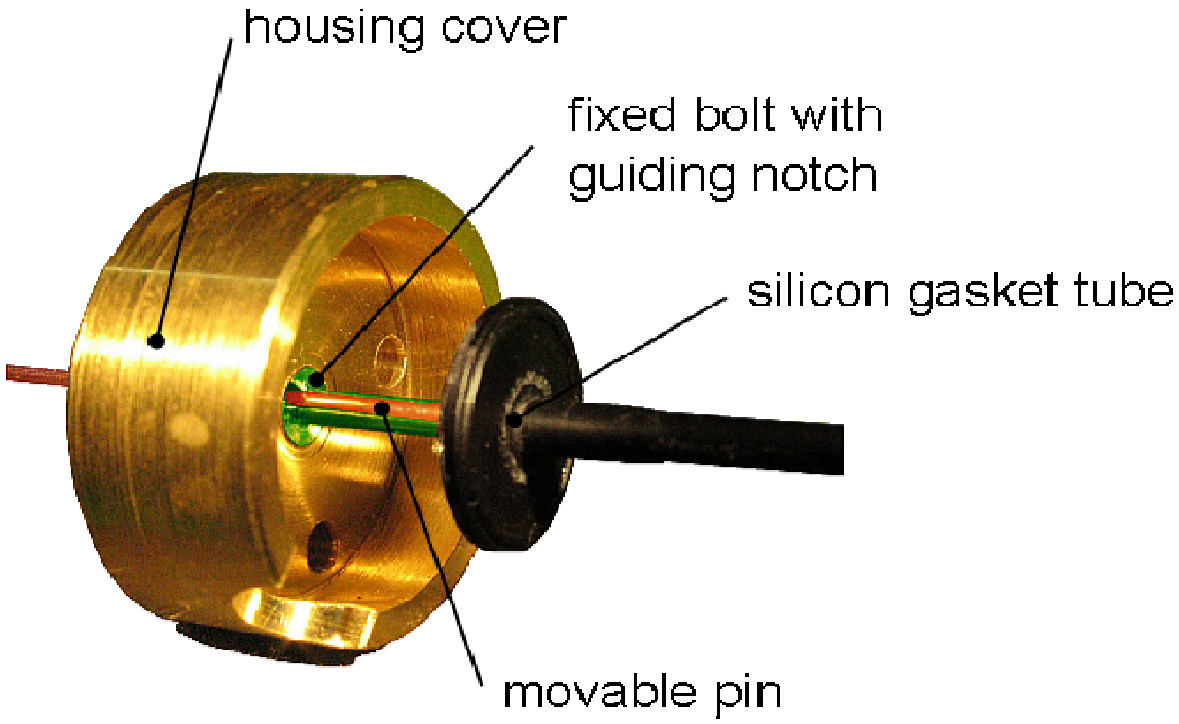
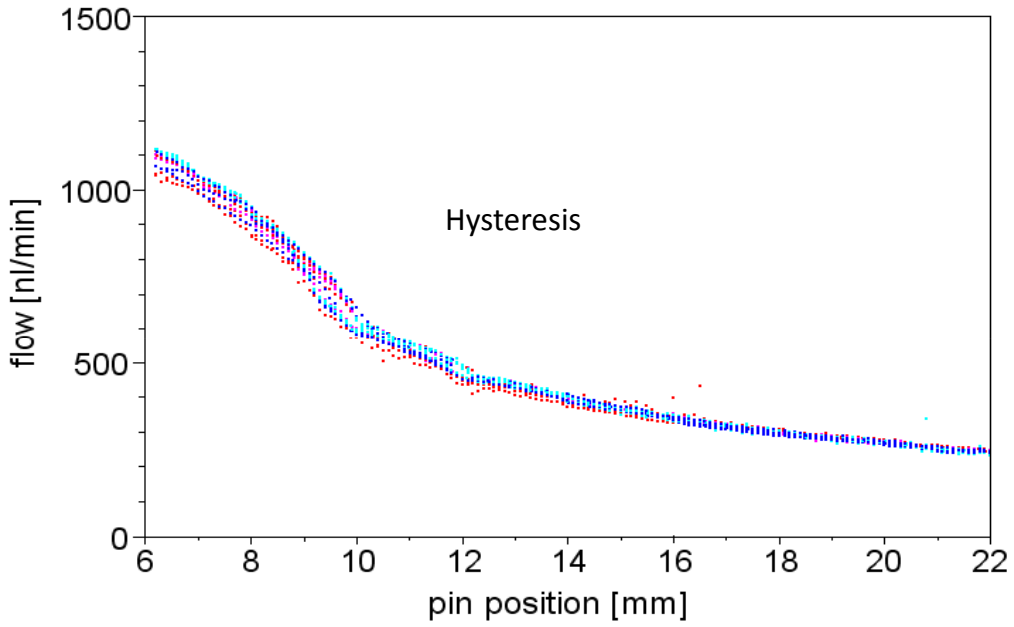
Al_2O_3 – Pipe with movable pin



Al_2O_3 – Pipe with movable pin



Characteristic line of the throttle from ten full insertions and extractions. Red measuring values belong to the insertion of the bolt, blue ones to the extraction.

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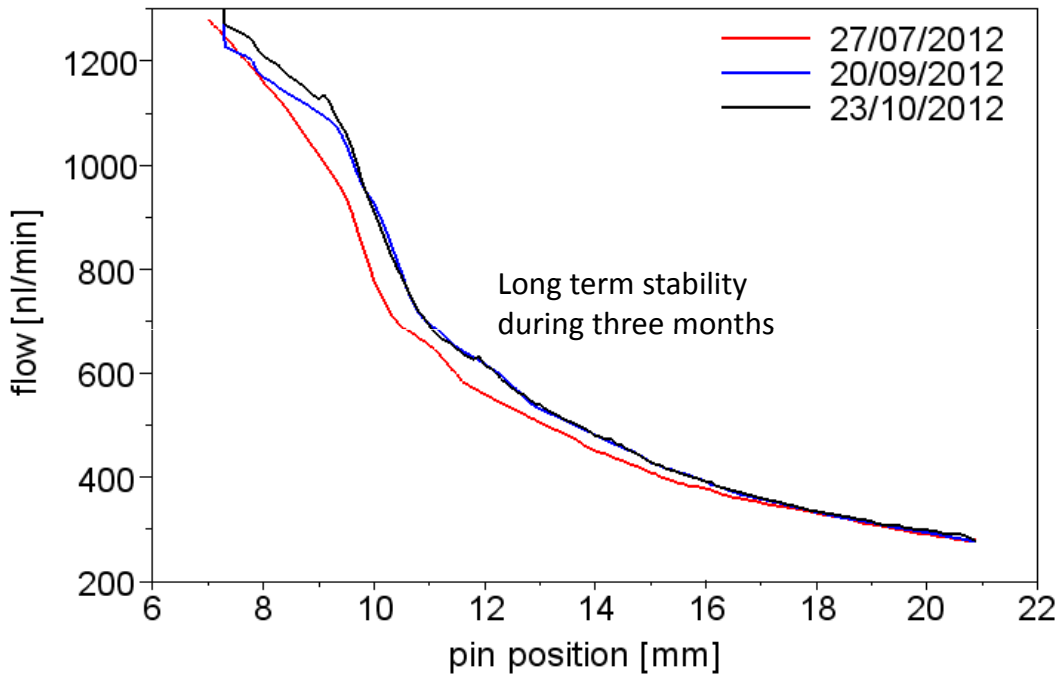
Al_2O_3 – Pipe with movable pin



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Drug multiplexing

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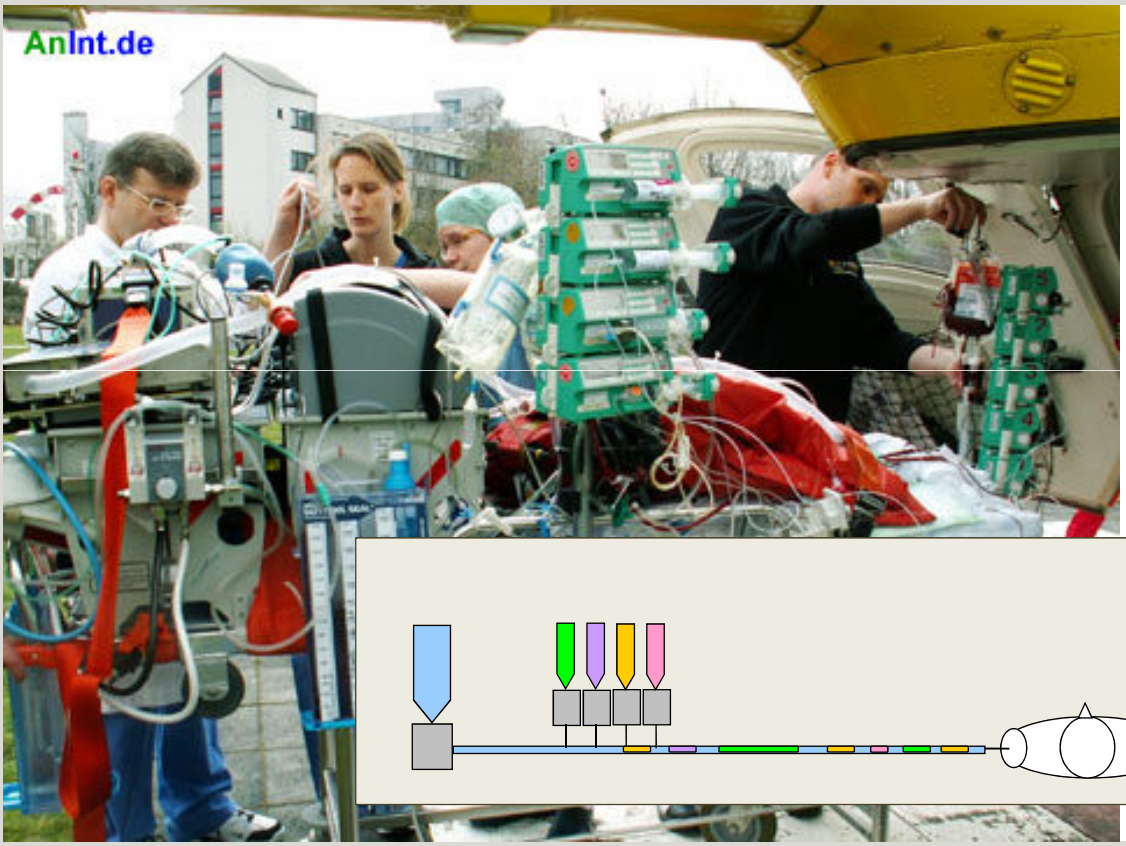
Drug multiplexing



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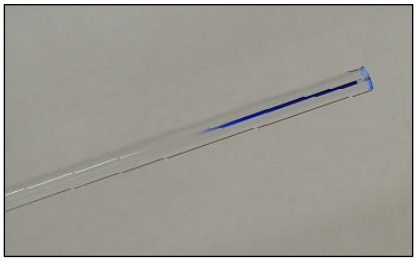
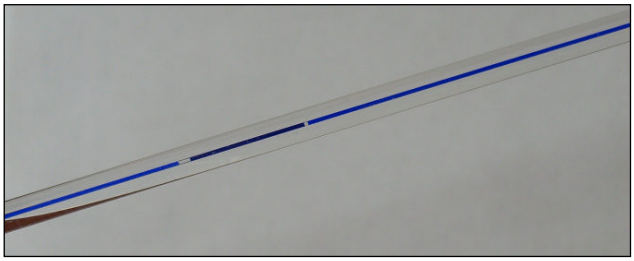
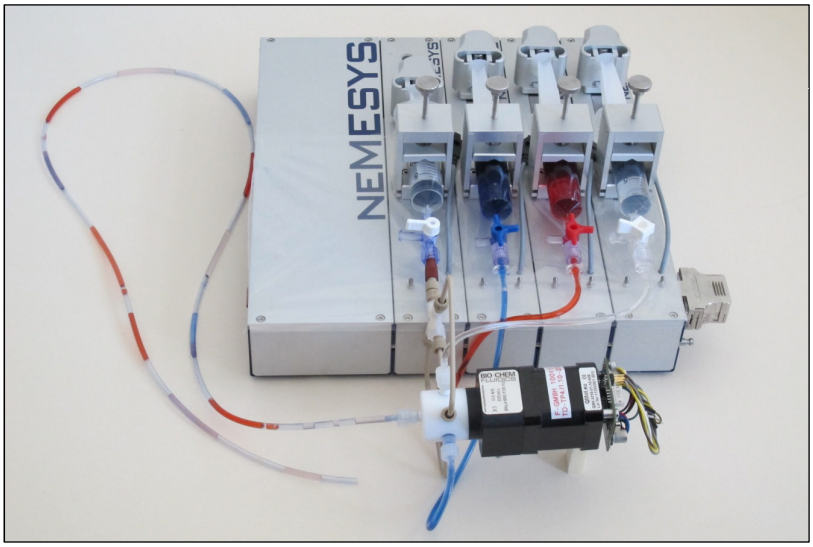
Drug multiplexing







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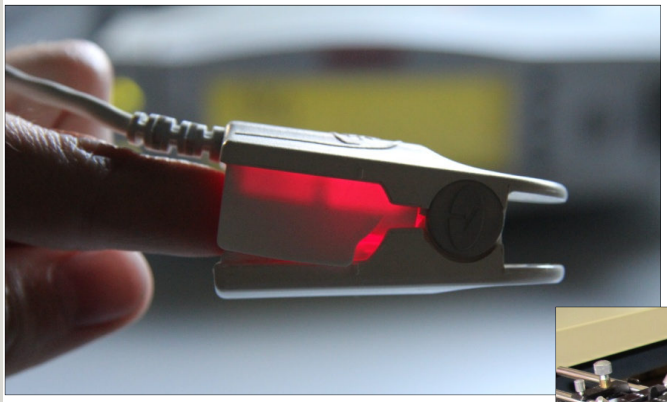
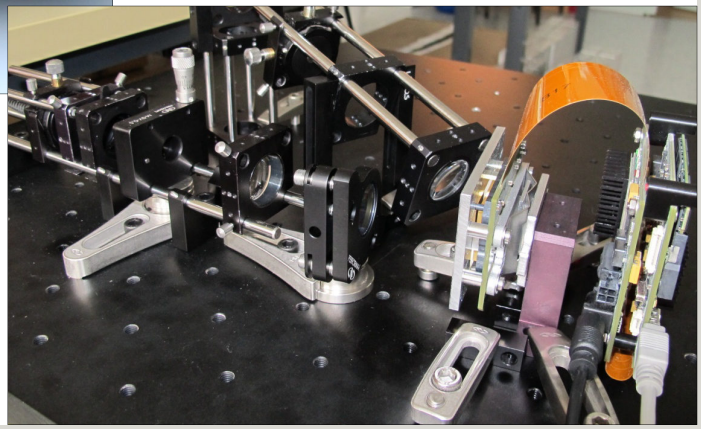
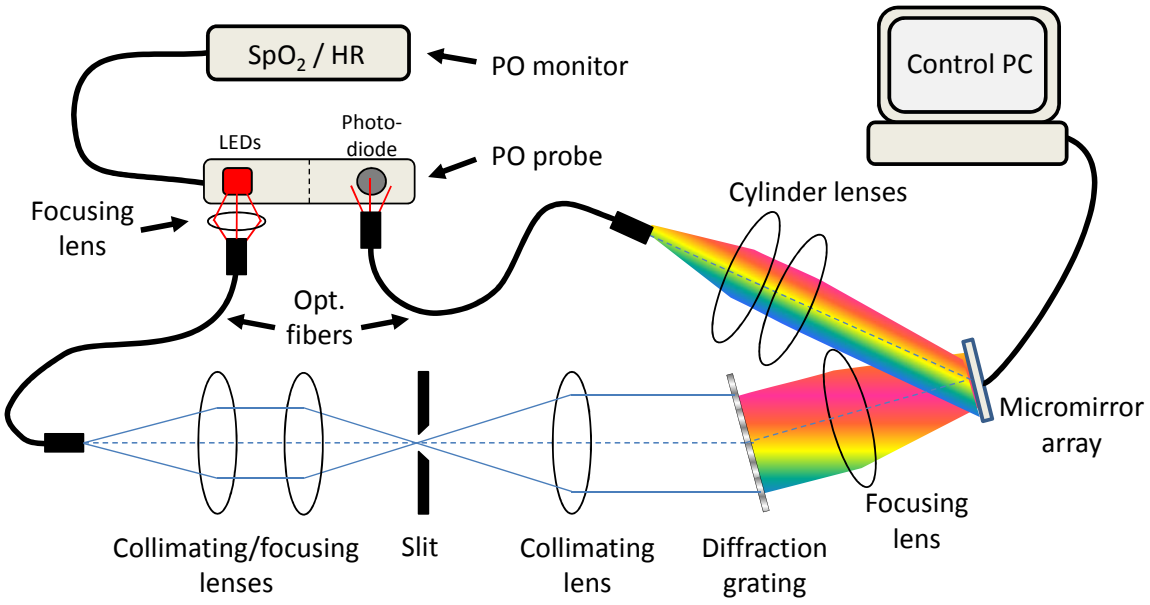
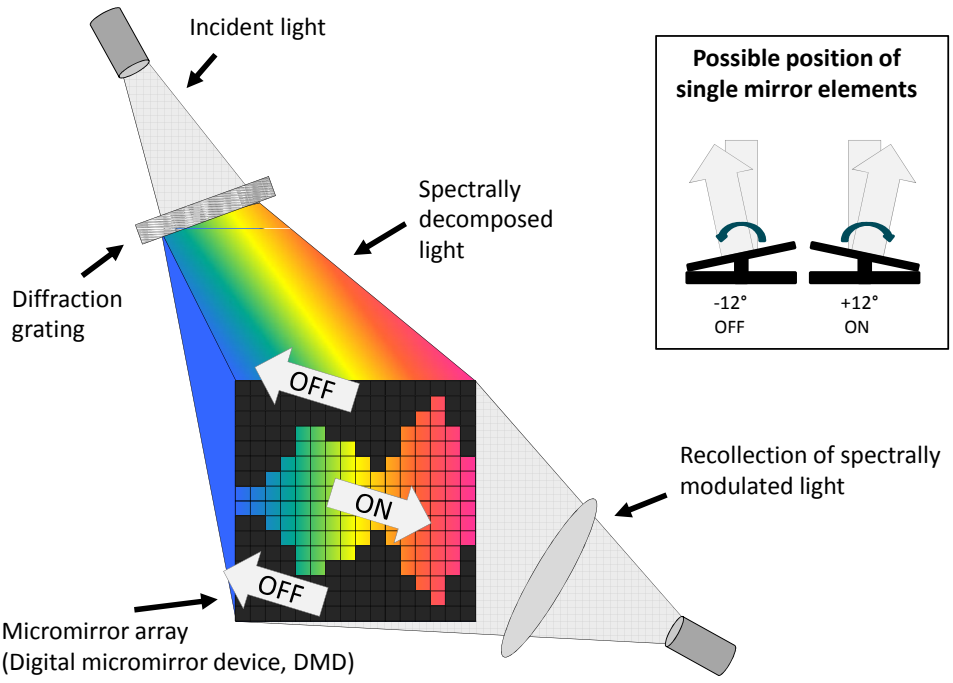
Calibration of Pulse oximeter

UK SH

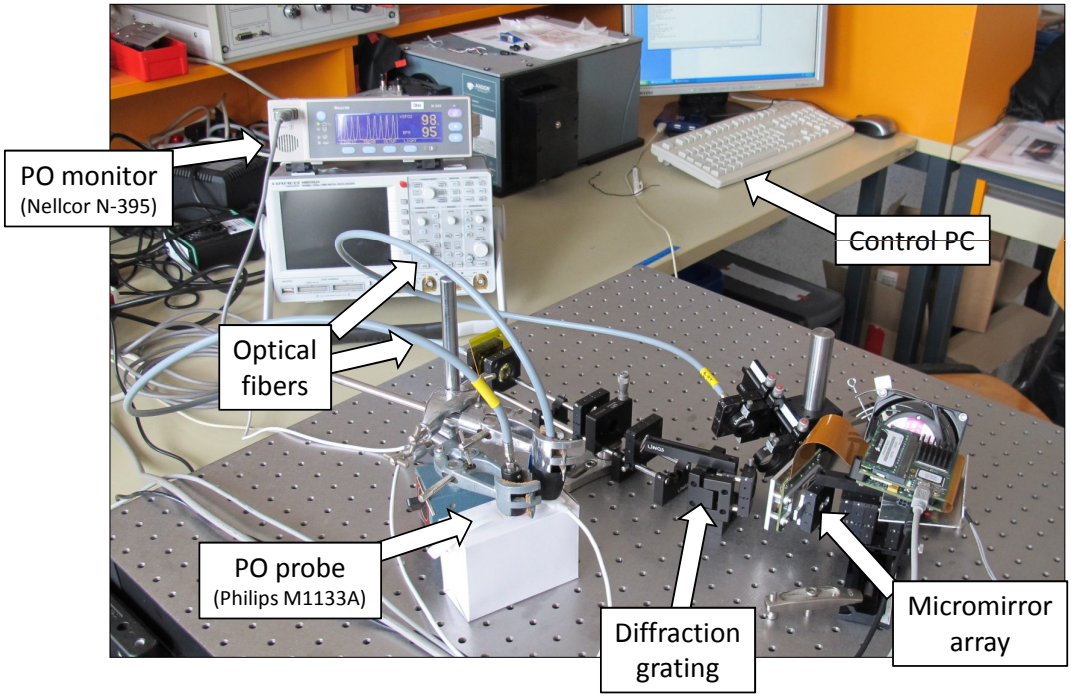





SpO2 / HR
PO monitor
Control PC
LEDs
Photo-diode
PO probe
Focusing lens
Cylinder lenses
Opt. fibers
Micromirror array
Focusing lens
Collimating/focusing lenses
Slit
Collimating lens
Diffraction grating


Incident light
Spectrally decomposed light
Diffraction grating
OFF
ON
OFF
Recollection of spectrally modulated light
Micromirror array
(Digital micromirror device, DMD)
Possible position of single mirror elements
-12°
OFF
+12°
ON

Calibration of Pulse oximeter



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