attocube systems AG
Königinstr.11a
D-80539 Munich

Interferometric Dilatometer For Cryogenic Environments

Dr. Nikolay Tsyrulin

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Outline:

- Quick about us
- Ingredients
- Cooking
- First results
- Conclusions & Outlook

attocube systems

Major ideas for the nano world

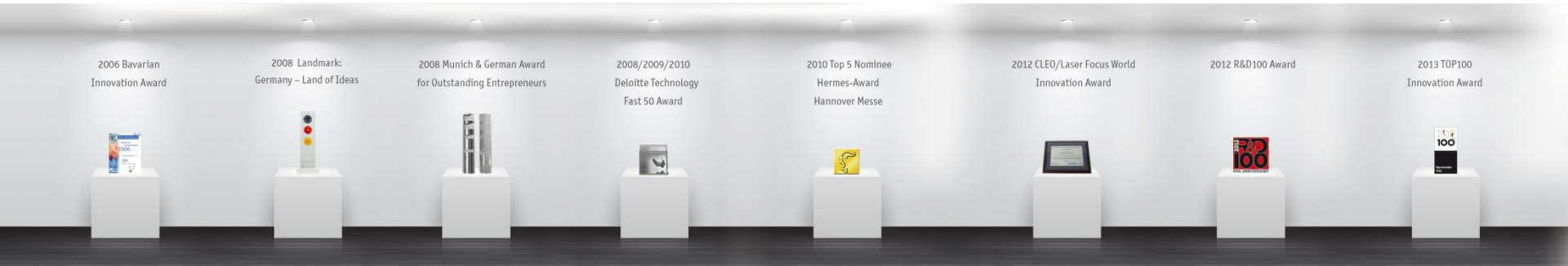
attocube
pioneers of precision

Founded in 2001

70 employees, 30% PhDs
Turnover 2013/14: ~ 15 Mio. €

‘attocube’s central mission is to deliver uniquely precise, elegant, and reliable products, thus solving the emerging challenges in worldwide nanotechnology applications.’

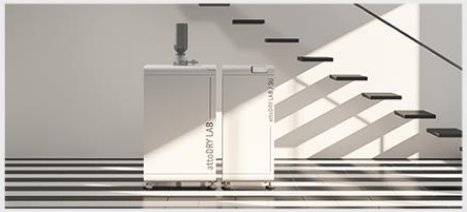
> 800 customers | > 40 countries | > 5000 positioners | > 180 microscope systems



Interferometric Dilatometer For Cryogenic Environments

About us

attoDRY LAB
Dry Measurement Systems



DRY MEASUREMENT SYSTEMS

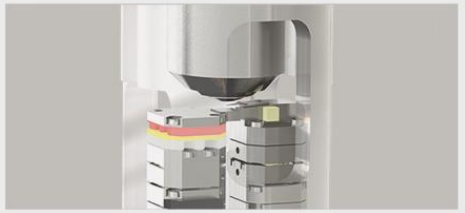
Automated, cryogen-free nanocharacterization platform with a variety of different measurement options.

attoCRYO
Research Cryostats

LOW VIBRATION CRYOSTATS

Dry and liquid cryostats, optimized for most sensitive measurement techniques at variable temperature and high magnetic field.

attoMICROSCOPY
Sophisticated Tools for Science



SCANNING PROBE MICROSCOPES

Measurement inserts for nanocharacterization of surfaces and bulk materials at (ultra-) low temperature and high magnetic field.

attoMOTION
Piezo-based Nanopositioners

NANOPOSITIONERS

Piezo-based nanopositioners for research & industry applications. Suitable for ambient to extreme environments.

attoSENSORICS
Ultra Precision Sensors

INTERFEROMETRIC SENSORS

Ultra precise optical sensors for real-time displacement and vibration measurement with picometer resoultion. For ambient & extreme condtions.

attoCONTROL
Electronic & Software Control Units

CONTROLLER & SOFTWARE

Advanced control electronics and software modules for attocube's nanopositioners and scanning probe microscopes.

pioneers of precision

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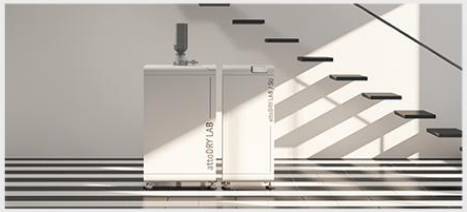

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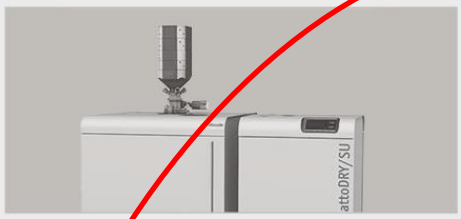

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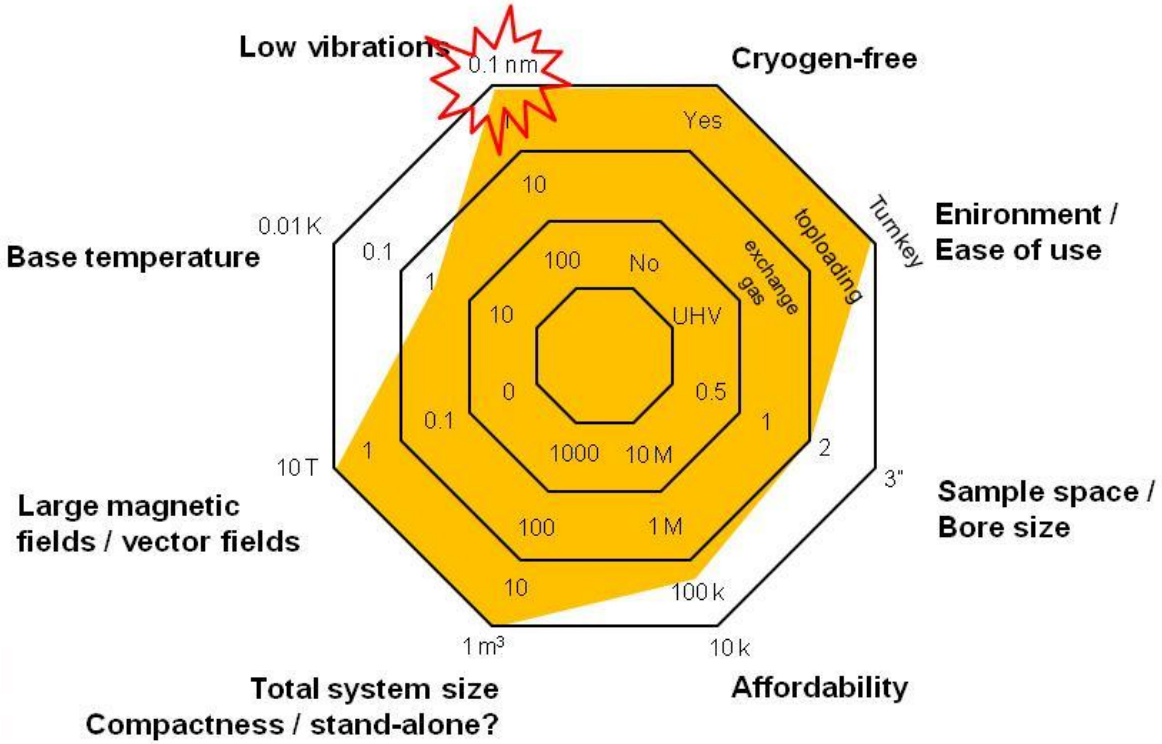
Interferometric Dilatometer For Cryogenic Environments

Ingredients

1: Cryostat

attoDRY2100



Interferometric Dilatometer For Cryogenic Environments

Ingredients

2:
Interferometric sensor

attoFPS

Fabry-Pérot Sensor (FPS)

Sensor heads

- \+ 3 channels: Measurement of erratic pitch and yaw movement
- \+ Easy integration and compactness (sensor heads with only Ø 1.2 mm)
- \+ Position sensing at the sample level with 1pm of internal resolution
- \+ UHV compatibility, non-magnetic, radiation-hard, cryogenic compatibility
- \+ Quick access to the displacement data with the software and USB

Interferometric Dilatometer For Cryogenic Environments

Ingredients

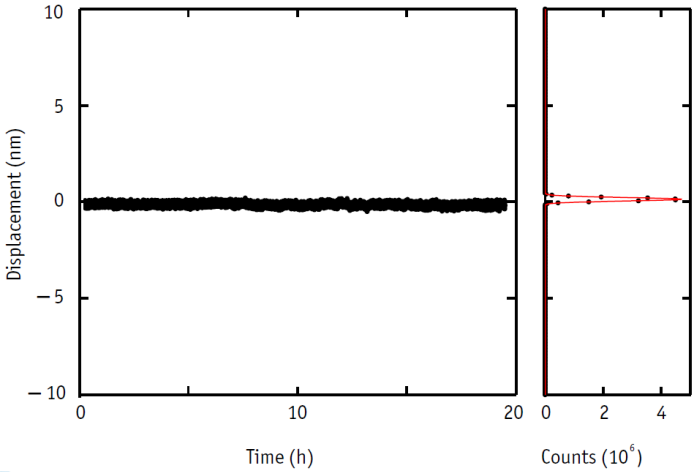
2:
Interferometric sensor

Fabry-Pérot Sensor (FPS)

Sensor heads

attoFPS

A very stable and sensitive system



- 20 hours, sample time 100 Hz
- 77 mm titan cavity @ 3.8 Kelvin
- standard deviation (sigma) **55 pm**

Fiber-based distance sensing interferometry

Klaus Thurner,[1,2,*] Francesca Paola Quacquarelli,[1] Pierre-François Braun,[1] Claudio Dal Savio,[1] and Khaled Karrai[1]

[1]attocube systems AG, Königinstraße 11a RGB, 80539 München, Germany

[2]Institute for Nanoelectronics, Technische Universität München, Theresienstraße 90, 80333 München, Germany

*Corresponding author: klaus.thurner@attocube.com

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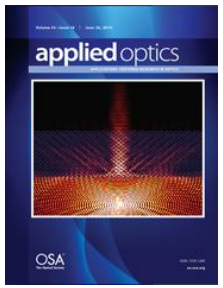
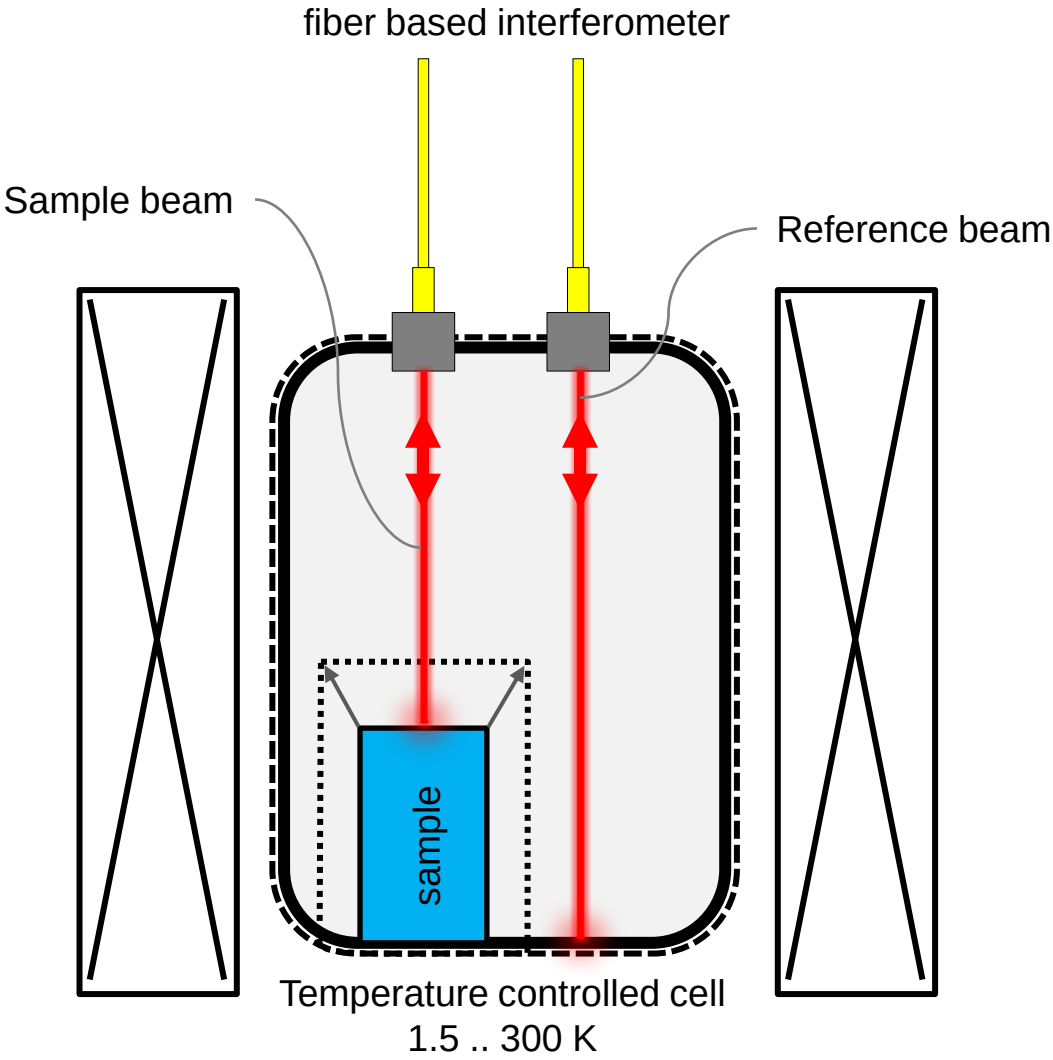


http://dx.doi.org/10.1364/AO.54.003051

Interferometric Dilatometer For Cryogenic Environments

Cooking

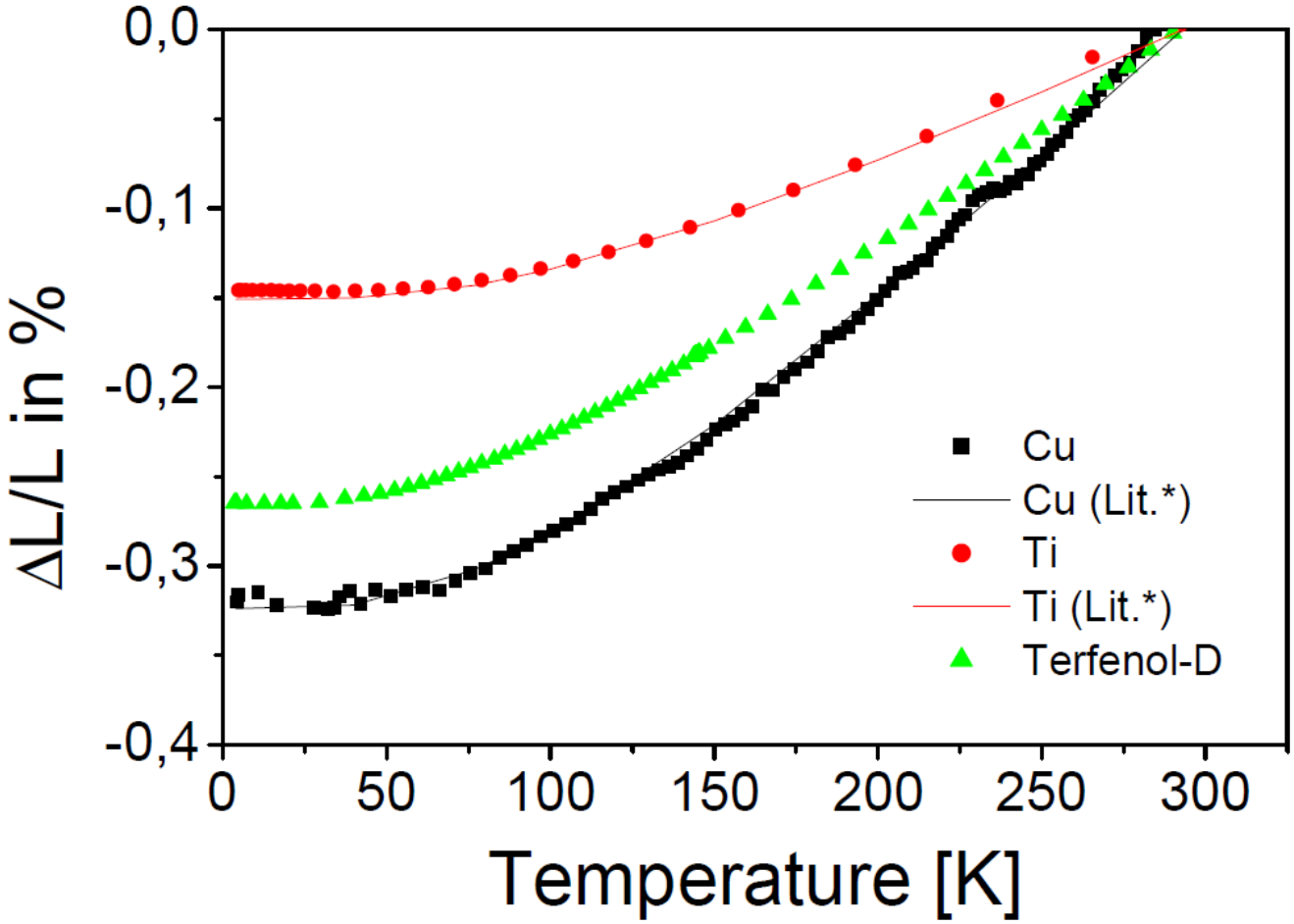


Working principle:

- Sample beam measures expansion or contraction of sample
- Reference beam measures expansion or contraction of cell
- Difference between the two signals yields the absolute change in length ΔL
- Calculate thermal or magnetic strain as ratio between ΔL and the initial length L_0

Interferometric Dilatometer For Cryogenic Environments

First results

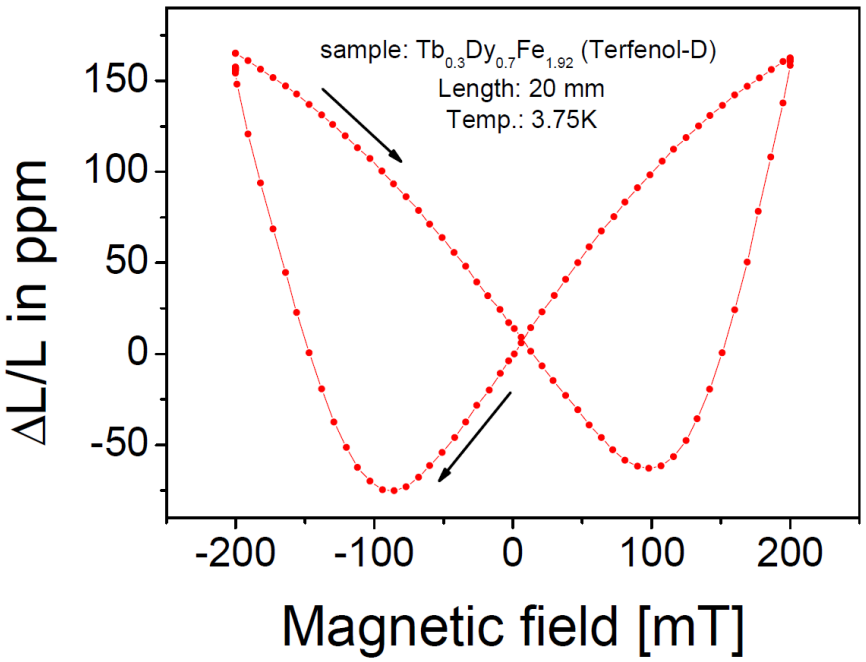


*Clark, A. F. (1983). "Thermal expansion", Chapter. 3 in "Materials at Low Temperatures", eds. R. P. Reed and A. F. Clark, ASM International, Materials Park, Ohio

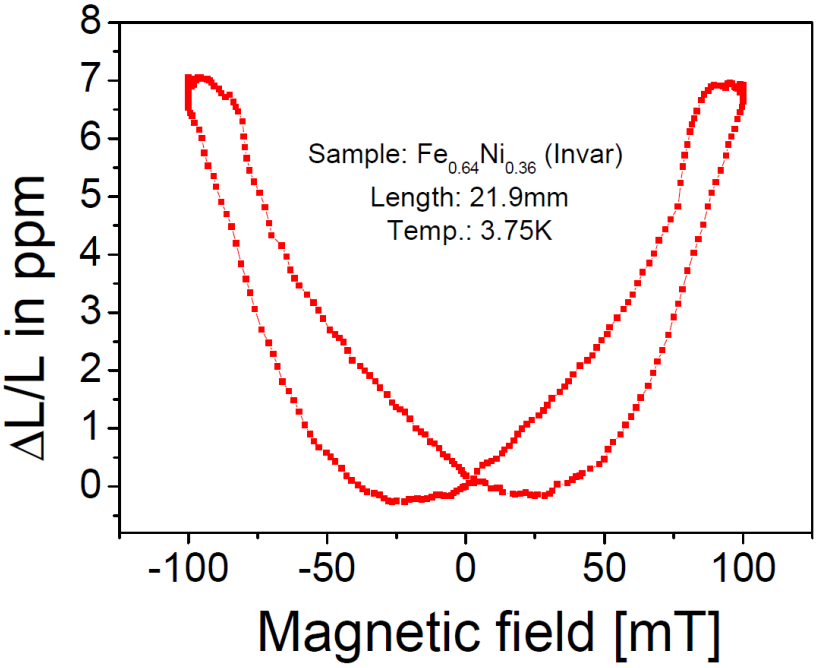
Interferometric Dilatometer For Cryogenic Environments

First results

Terfenol-D



Invar



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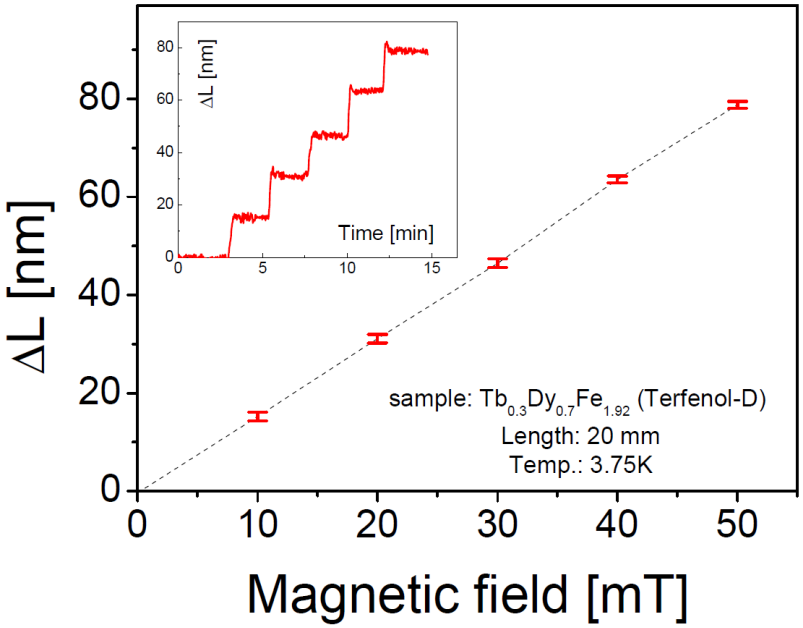
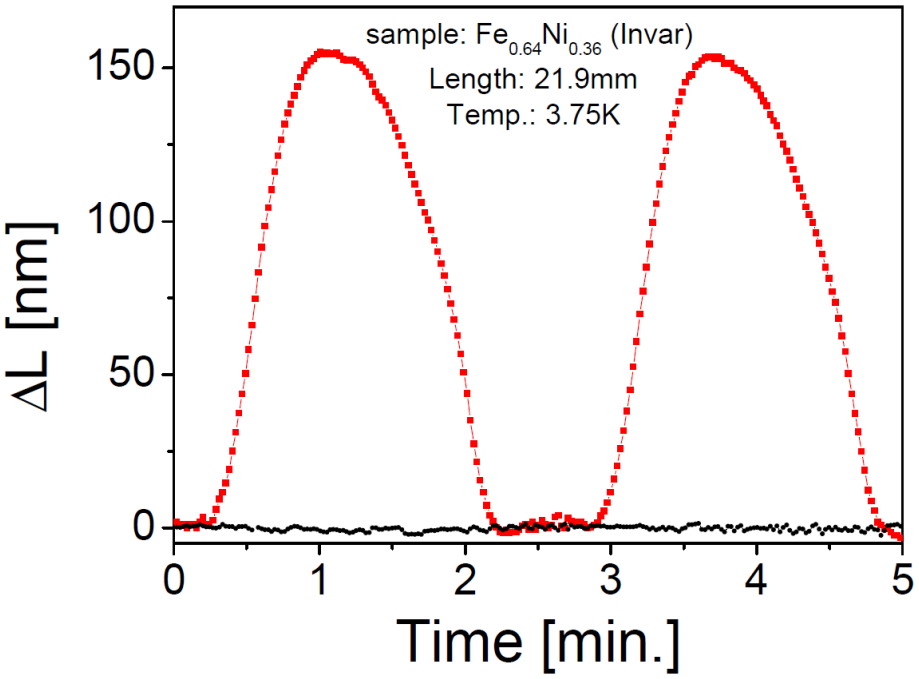
First results





Interferometric Dilatometer For Cryogenic Environments

Conclusions & Outlook

- Proof of concept for miniature interferometric dilatometer compatible with cryogenic environment;

- Demonstrated resolution down to 1nm on mm-sized samples (1 ppm);

- Your feedback

Thank you for your attention!

nikolay.tsyrulin@attocube.com