KUECHLER
Innovative Measurement Technology

Manufacturer of high-precision miniature capacitance **dilatometers**

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High Performance since 2002

TRADITION

INNOVATION

2002

More than 15 years of experience as Scientist in the Max-Planck-Institute for Chemical Physics of Solids, Germany

One of the world's leading experts in the field of thermal expansion and magnetostriction measurements

2007

Start to develop different types of dilatometers

2012

Own company to manufacture high-precision miniature dilatometers

The new scientific instruments are fabricated using a patent pending technology

2014

Start of an extensive cooperation with the High Field Magnet Laboratory in Nijmegen, Netherland

Continued optimization of design and manufacturing method using latest production technology

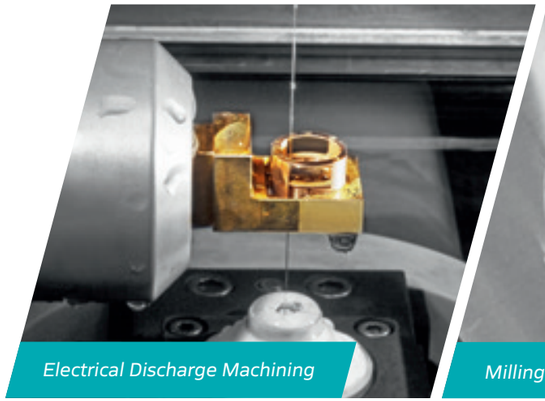
2015

Development of the uniaxial stress dilatometer

2017

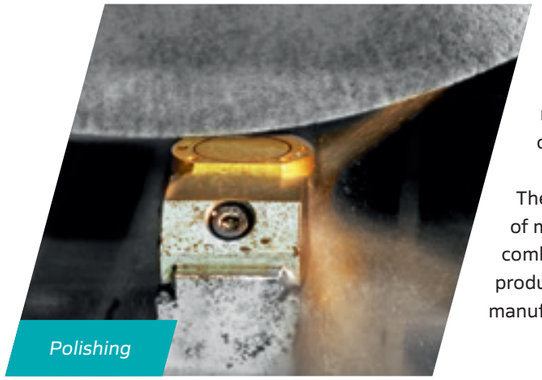
Release of the world's smallest high-precision dilatometer

Manufacturing



Electrical Discharge Machining

Milling



Polishing

Innovative patent-pending production method allows for an unprecedented resolution in a dilatometer of this compact size.

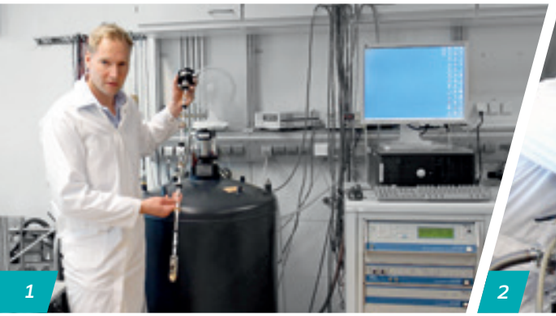
The great advantage of the new type of measuring cells is based on a unique combination of powerful design, production technology and high level of manufacturing quality.

Key features and advantages

- Very Small dimensions
- Extremely high-resolution (ΔL = 0.01 Å, $\Delta L/L=10^{-10}$)
- Very small weight and excellent thermalisation
- Compact and stable
- Simple sample mounting
- Suitable for a large temperature range (10 mK < T < 320 K) and for very high magnetic field (currently max. tested field: 37.5 T)

Applications

The dilatometers can be used in a wide temperature range (from room temperature down to less than 10 mK) and in magnetic fields up to at least 40 T and with several cryogenic systems.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Selected Applications

1 *PPMS® (Physical Property Measurement System by Quantum Design)*

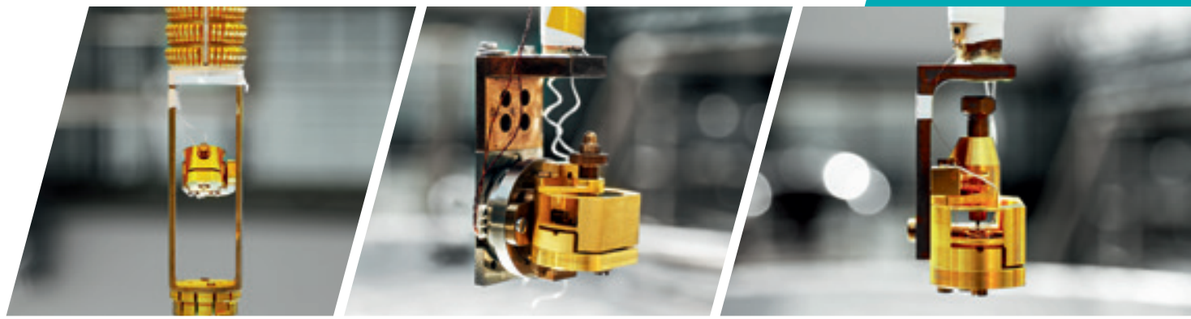
2 *Kelvinox™ Dilution Refrigerator by Oxford Instruments*

3 *Resistive Bitter Magnets (High Field Magnet Laboratory)*

4 *Exchange Gas cryostat*

Working environment

Our dilatometers can be used in a wide range of temperature. They were tested and operated down to extremely low temperature (10 mK). The maximal operation temperature is determined by the thermal capability of the insulating pieces of vespel and the used coaxial cables. So far, dilatometers were only tested at temperatures just above room temperature. To achieve the best possible results the dilatometers have to be operated in a steady flowing inert gas atmosphere, where the dielectric constant of the medium does not change with temperature (e.g. helium, nitrogen, clean and dry air, vacuum). The operation in flow cryostats or directly in cryogenic liquids (helium) is not recommended. Our dilatometers have been successfully operated in most commonly measurement systems, e.g. in the Quantum Design PPMS under helium atmosphere or in an Oxford Instruments Kelvinox dilution refrigerator under vacuum. For all these systems, we offer the matching accessories for suitable mounting.

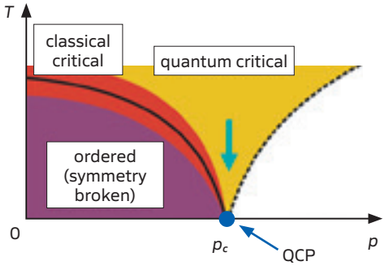


PPMS-dilatometry probe includes all necessary cables and software

Selected Measurements

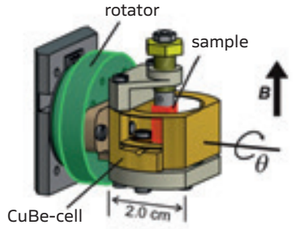
Thermal expansion: Smoking gun experiment to determine Quantum Critical Points (QCPs):

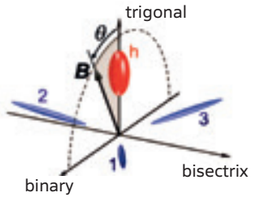
For materials near a QCP, the volume thermal expansion coefficient β diverges much more strongly than the specific heat C as T → 0.
⇒ $\Gamma = \beta/C$ has to diverge at any pressure tuned QCP.
The exponent x of Γ^x even allows to determine the nature of the QCP.
Moreover, the sign of Γ must to change by entering the ordered phase close to a QCP.
Dilatometry enables to obtain directional dependent information.



Phase diagram of bismuth in the quantum limit studied with high-resolution magnetostriction

Tiny changes in length for various orientations of the magnetic field could be resolved with our extremely sensitive dilatometer. From the sample's change in length one can deduce the changes in the electronic distribution in the respective direction of the magnetic field. Physicists refer to this as determining the energy distribution or energy structure of the electrons as a function of the magnetic field. With our dilatometer, this relief map for bismuth, which shows how the electronic structure changes as a function of the magnetic field, was measured more precisely than has been possible to date using other methods.

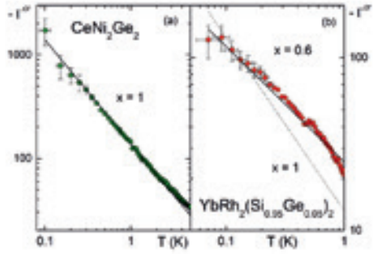


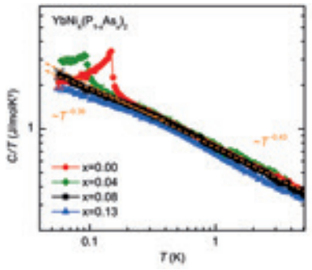


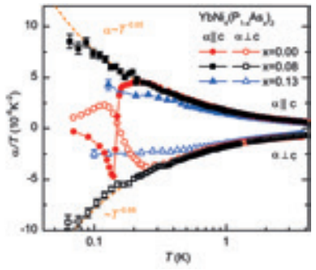
Article | Nature Physics 4, 186 - 197 (2008)
Quantum criticality in heavy-fermion metals

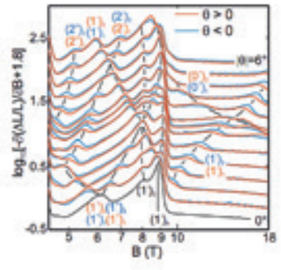
Article | Science 339, 933 (2013)
Ferromagnetic Quantum Critical Point in the Heavy-Fermion Metal $YbNi_4(P_{1-x}As_x)_2$

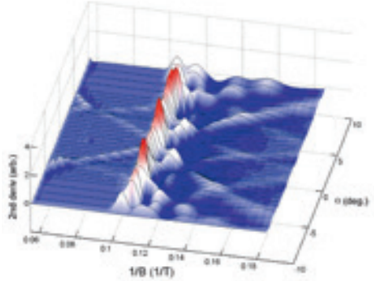
Article | Nature Materials 13, 461-465 (2014)
Thermodynamic evidence for valley-dependent density of states in bulk bismuth

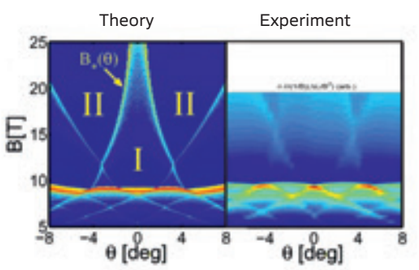










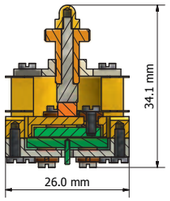


Standard-Dilatometer

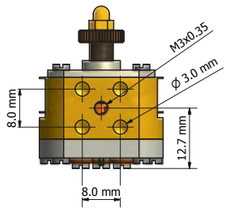
Compact and miniaturized high resolution capacitance dilatometer

Side cut-away view

Front cut-away view



Back view



Size and Dimensions	
footprint; height	20 mm × 26 mm; 34 mm
weight	45g

Absolute resolution	
@ low Temperature (Kelvinox-Systems (0.01 K up to 6 K))	ΔL = 0.02 Å
@ PPMS	ΔL = 0.1 Å

Range of operation	
Temperature range	10 mK < T < 320 K
Magnetic field range	At least up to 30 T (max. tested field)

Measurable sample size	
footprint (max.)	(3.5 mm × 10 mm) or Ø = 5 mm
height	Less than 1 mm up to 5 mm

Materials	
Dilatometer-parts	copper beryllium
Insulating pieces; washers	vespel; sapphire

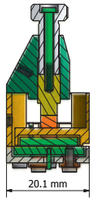
Options	
Varity of Cryostats	Dilatometer + attachments
PPMS	Dilatometer complete with PPMS-probe and cables + software

Article | Rev. Sci. Instrum. 83, 095102 (2012)
A compact and miniaturized high resolution capacitance dilatometer for measuring thermal expansion and magnetostriction

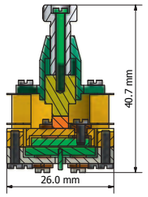
Stress-Dilatometer

Uniaxial stress capacitance dilatometer for high-resolution thermal expansion and magnetostriction

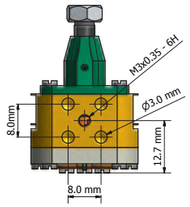
Side cut-away view



Front cut-away view



Back view



Size and Dimensions	
footprint; height	20 mm × 26 mm; 41 mm
weight	52g

Absolute resolution	
@ low Temperature (Kelvinox-Systems (0.01 K up to 6 K))	ΔL = 0.02 Å
@ PPMS	ΔL = 0.1 Å

Range of operation	
Temperature range	10 mK < T < 320 K
Magnetic field range	At least up to 30 T (max. tested field)

Range of operation	
Applied force	from 40 up to 75 N
max. uniaxial stress	3 kbar for cuboid sample of $(0.5\ mm)^2$ cross section

Measurable sample size	
footprint (max.)	(3.5 mm × 10 mm) or Ø = 5 mm
height	Less than 1 mm up to 5 mm mm

Materials	
Dilatometer-parts	copper beryllium
Insulating pieces; washers	vespel; sapphire

Options	
Varity of Cryostats	Stess-dilatometer + attachments
PPMS	Dilatometer complete with PPMS-probe and cables + software

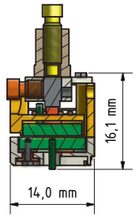
Article | Rev. Sci. Instrum. 87, 073903 (2016)

A uniaxial stress capacitive dilatometer for high-resolution thermal expansion and magnetostriction under multiextreme conditions

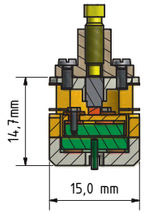
Mini-Dilatometer

Super compact high-resolution capacitance dilatometer

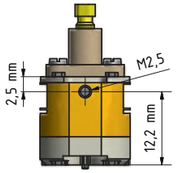
Side cut-away view



Front cut-away view



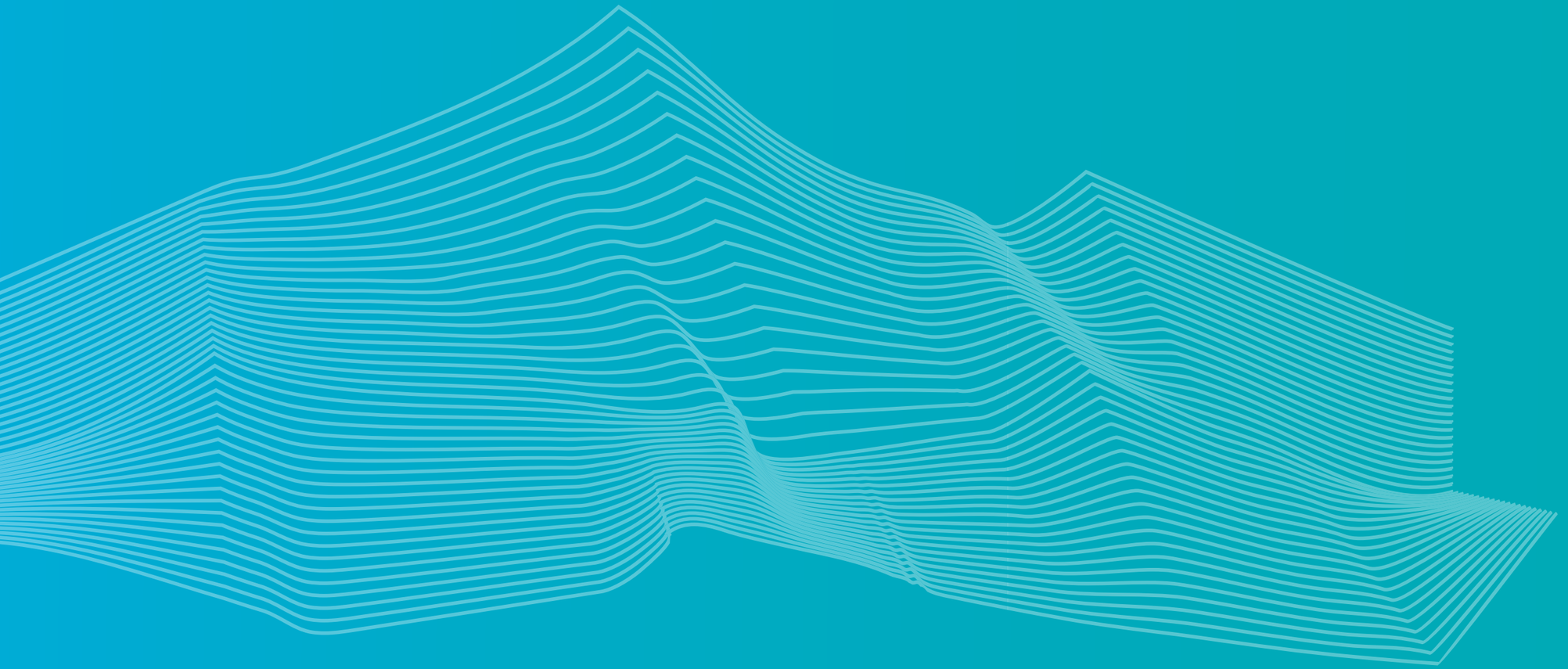
Back view



Size and Dimensions	
footprint; height	14 mm × 15 mm; 16 mm
weight	13g
Absolute resolution	
@ low Temperature (Kelvinox-Systems (0.01 K up to 6 K))	ΔL = 0.01 Å
@ PPMS	ΔL = 0.1 Å
Range of operation	
Temperature range	10 mK < T < 320 K
Magnetic field range	At least up to 38 T (max. tested field)

Measurable sample size	
footprint (max.)	(2.3 mm × 6 mm) or Ø = 3.3 mm
height	Less than 1 mm up to 2.75 mm
Materials	
Dilatometer-parts	copper beryllium
Insulating pieces; washers	vespel; sapphire
Options	
Any Cryostat	Dilatometer + attachments
PPMS	Dilatometer (can be rotated) complete with PPMS-probe and cables + software

Article | Rev. Sci. Instrum., in press (2017)
The world´s smallest capacitive dilatometer, for high-resolution thermal expansion and magnetostriction in high magnetic fields



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