LINSEIS

THERMAL ANALYSIS

MEGA LAB

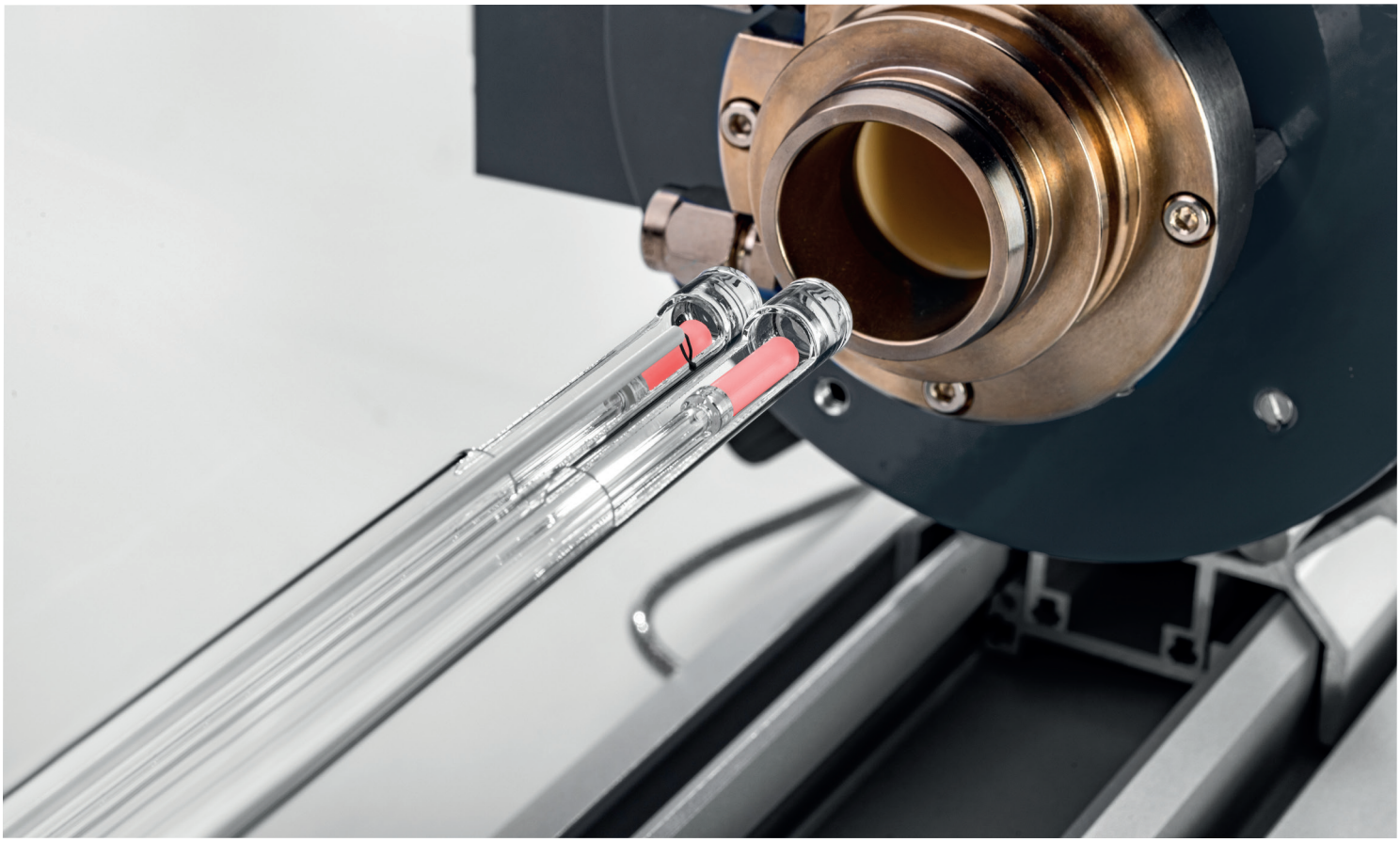
Tel. 2310855844, 2106452848

Email. contact@megalab.gr

www.megalab.gr

DILATOMETRY

DIL L76
DIL L75 Horizontal
DIL L75 Vertical

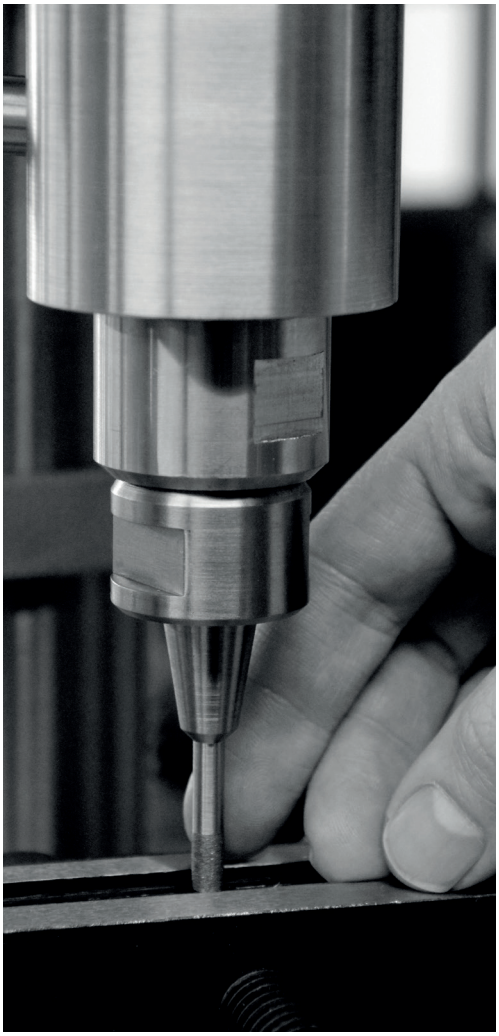


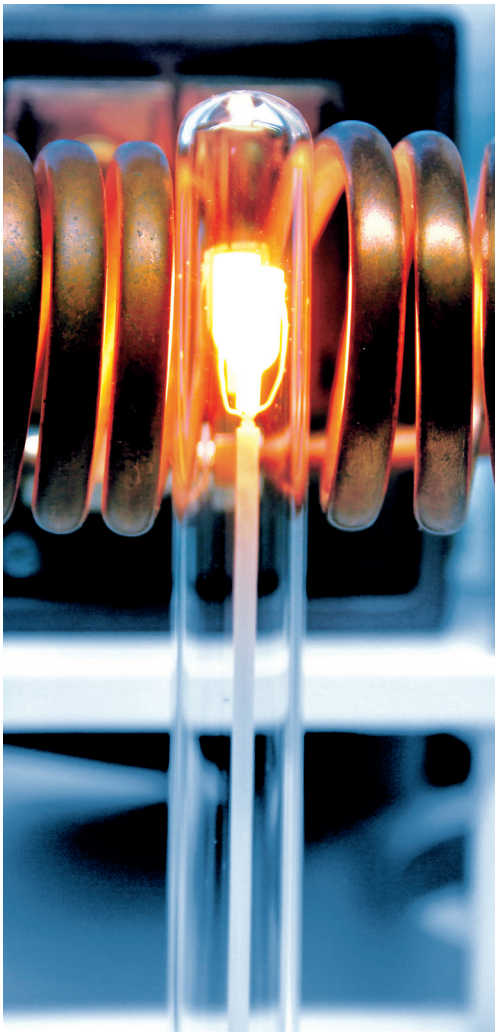
Since 1957 LINSEIS company has been delivering outstanding service, know how and leading innovative products in the field of thermal analysis and thermo physical properties.

Customer satisfaction, innovation, flexibility and high quality are what LINSEIS represents. Thanks to these fundamentals our company enjoys an exceptional reputation among the leading scientific and industrial organizations. LINSEIS has been offering highly innovative benchmark products for many years.

The LINSEIS business unit of thermal analysis is involved in the complete range of thermo analytical equipment for R&D as well as quality control. We support applications in sectors such as polymers, chemical industry, inorganic building materials and environmental analytics. In addition, thermo physical properties of solids, liquids and melts can be analyzed.
LINSEIS provides technological leadership. We develop and manufacture thermo analytic and thermo physical testing equipment to the highest standards and precision. Due to our innovative drive and precision, we are a leading manufacturer of thermal Analysis equipment.
The development of thermo analytical testing machines requires significant research and a high degree of precision. LINSEIS Corp. invests in this research to the benefit of our customers.

Claus Linseis
Managing Director





German engineering

The strive for the best due diligence and accountability is part of our DNA. Our history is affected by German engineering and strict quality control.

Innovation

We want to deliver the latest and best technology for our customers. LINSEIS continues to innovate and enhance our existing thermal analyzers. Our goal is constantly develop new technologies to enable continued discovery in science.

GENERAL

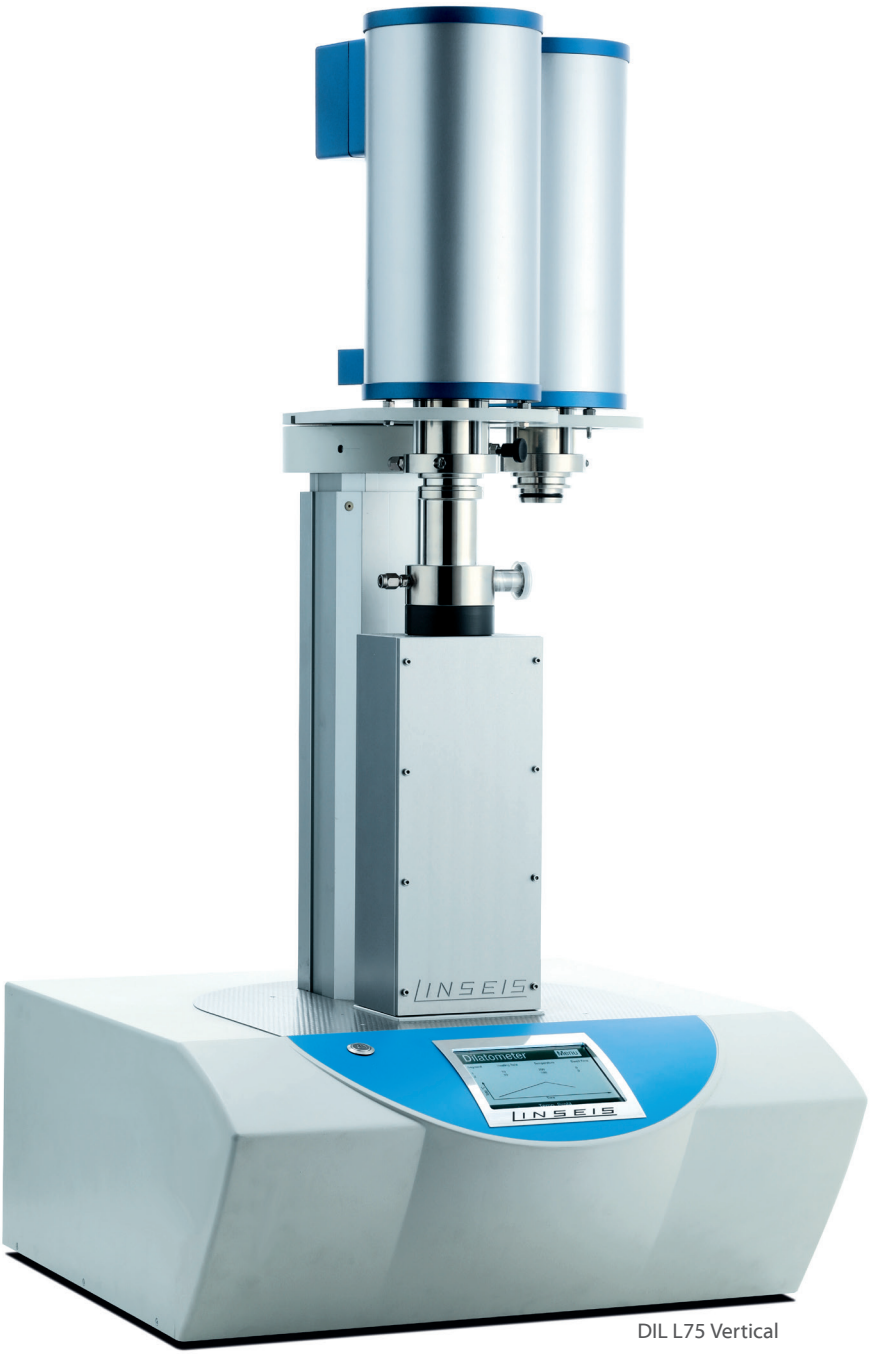
Dilatometry (DIL) is a technique in which a dimension of a substance (such as: ceramics, glasses, metals, composites, polymers and others) under no or negligible load is measured (e.g. expansion measurement or shrinkage measurement) as a function of temperature while the substance is subjected to a controlled temperature program in a specified atmosphere.

LINSEIS produces a wide range of Single-, Dual-, Differential-, Quattro-, Quenching-, Laser- and Optical Dilatometers in a temperature range from -263°C up to 2800°C and a resolution up to 0.05 nm.

Thanks to our years of experience (est. 1957), Linseis offers Dilatometers with an unbeaten precision variability and performance.

Dilatometers are frequently used for R&D and quality control of solids, liquids, powders and pastes to determine their:

- Determination of thermal expansion coefficient (cte)
- Linear thermal expansion (⌧l)
- Sinter-temperatures and sinter steps
- Determination of glass transition (tg)
- Phase changes
- Optimization of burning processes
- Volume changes
- Rate controlled sintering (rcs)
- Decomposition
- Density change



DIL L75 Vertical

depending on your Application, we offer the perfect solution:

Horizontal Dilatometer L76/L75Horizontal:

- Multipurpose system
- Highest temperature uniformity
- L75h is perfect for research & development

Vertical Dilatometer L75Vertical:

- Friction free sample holder
- Push-rod contact is always guaranteed
- Possible field of application Rate Controlled Sintering (rcs)
- Best arrangement for low -263°c and high temperature up to 2800°c applications

Optical Dilatometer L74 Optical*:

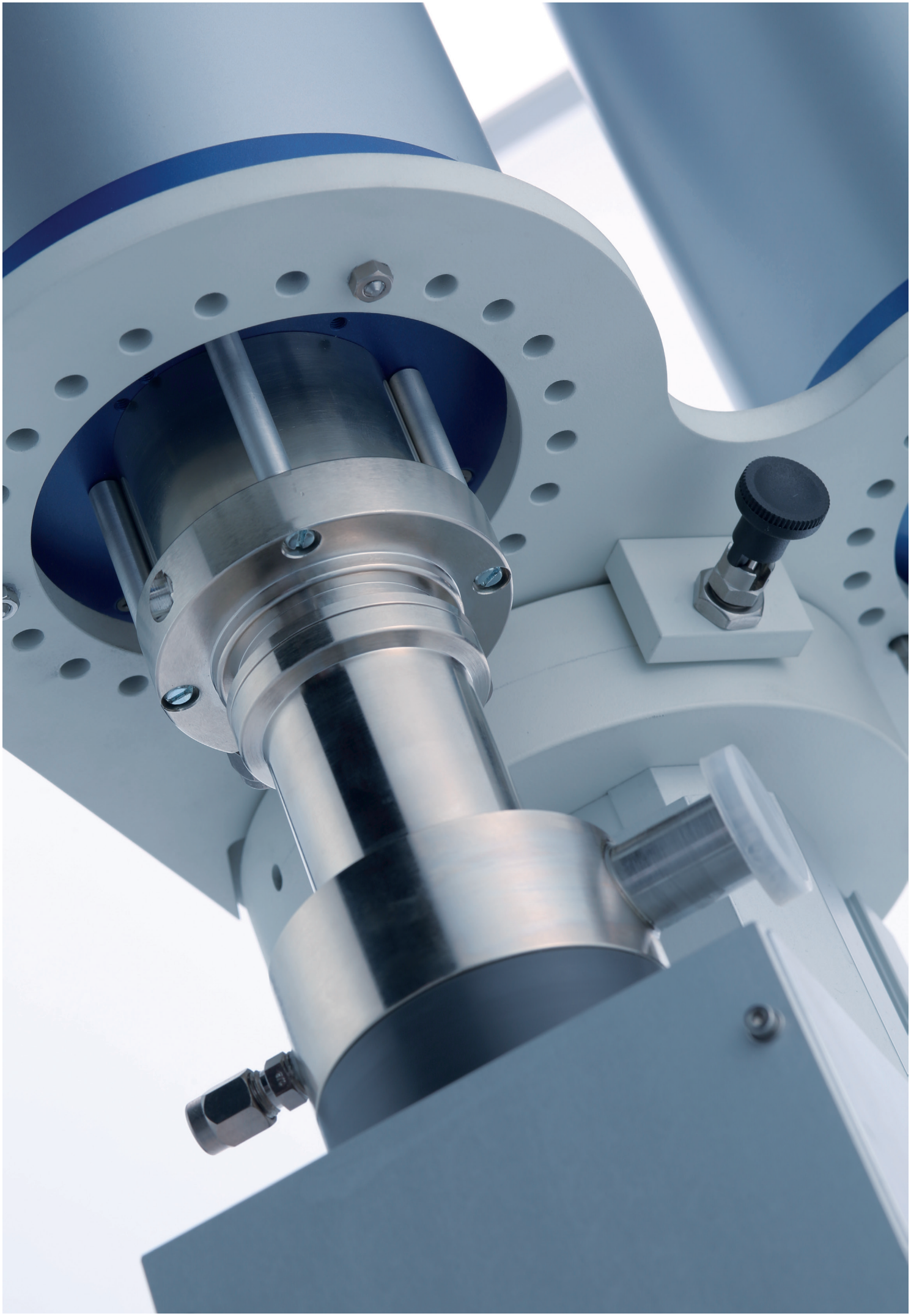
- Non-contact design
- Only choice for melting point determination
- Best choice for rate controlled sintering
- Can be used for additional applications: contact angle determination and heating microscopy
- Best choice for irregularly shaped and soft samples

Quenching and Deformation Dilatometer L78 Q/D/T*:

- Unreached heating and cooling rates ≤ 125 k/s
- Creation of cht/cct/ttt diagrams
- Deformation up to 22 kn

DIL L75 Horizontal

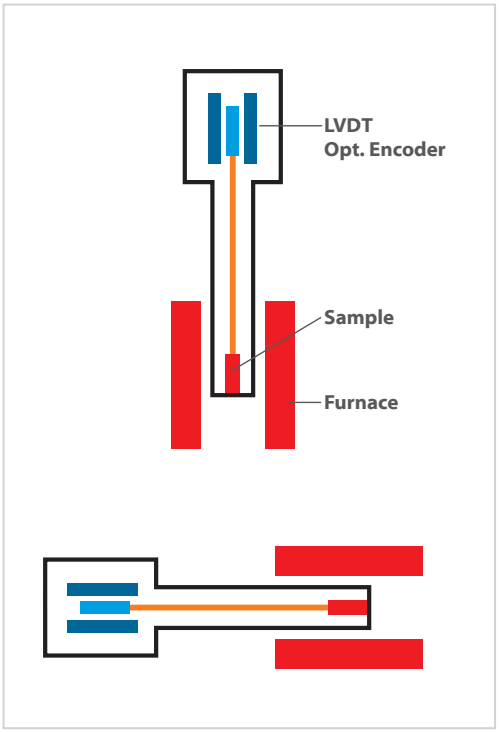
*see separate product brochure



HORIZONTAL VERSUS VERTICAL DILATOMETER

Horizontal arrangement

- Easy and robust design at a modest price
- From -180 to 2800°c. For applications requiring lower or hower temperatures vertical arrangement ist better suited.
- Available as single and double arrangement



Vertical arrangement

- Zero friction design (sample is only in contact with the end knob and the pushrod)
- Multi-furnace arrangement (up to three furnaces)...
  - to cover entire temperature range from -263°C to 2800°C
  - to increase throughput (hot furnace can be lifted automatically to switch to new cold furnace and start new measurement)
- Small footprint
- Available as single-, differential/double- and quattro arrangement (1, 2 or 4 samples at the same time)
- Perfect for low temperature measurements (furnace on the bottom - measurement compartment on top) to ensure natural gas path, cold air (falls down) below sensor compartment.
- Perfect for high temperature measurements (furnace on top - measurement compartment below) to ensure natural gas path, hot air (streams up) above sensor compartment.

COMPARING LVDT AND LINEAR OPTICAL ENCODER

LVDT

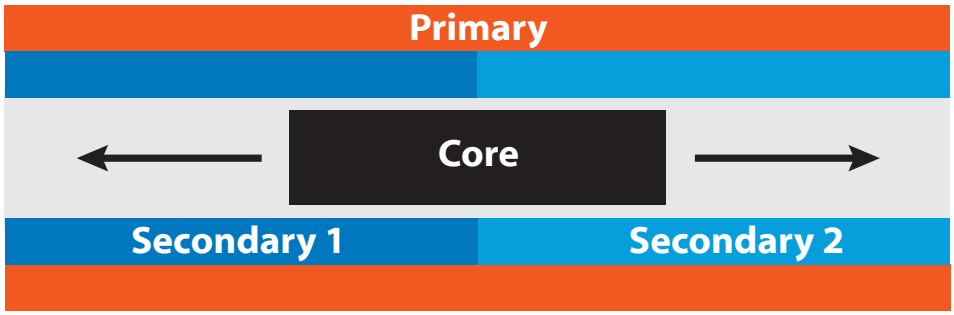
The LVDT (Linear Variable Differential Transformer) consists out of 3 coils, the LVDT body and the movable core. The primary coil is excited by a low frequency AC voltage. The two secondary coils are put in series with reversed polarity. The horizontal position of the core defines the amount of coupling between the primary and the secondary coils. When the core is in the center position, the induced voltages in the secondary coils have the same amplitude. Due to reversed polarity of the two coils the sum (output voltage) is zero. When the core moves, the coupling between primary and secondary coils changes. So, in one secondary coil the induced voltages increases, while in the other the voltage decreases. So, the sum of both is no longer zero. The sum of amplitude depends on the amount of movement of the core, while the phase (polarity) depends on the direction of the movement.

Advantage:

- The output signal is absolute and unique for each position, no reference movement necessary
- The core can be moved without any friction
- The resolution is infinitive, limited by the noise of the electronics used for signal conditioning
- Not sensitive better suited for applications in dirty environements (gas, vacuum, dust)

Disadvantage:

- Limited measuring range, e.g. +/- 2,5 mm
- Needs calibration



Linear Optical Encoder

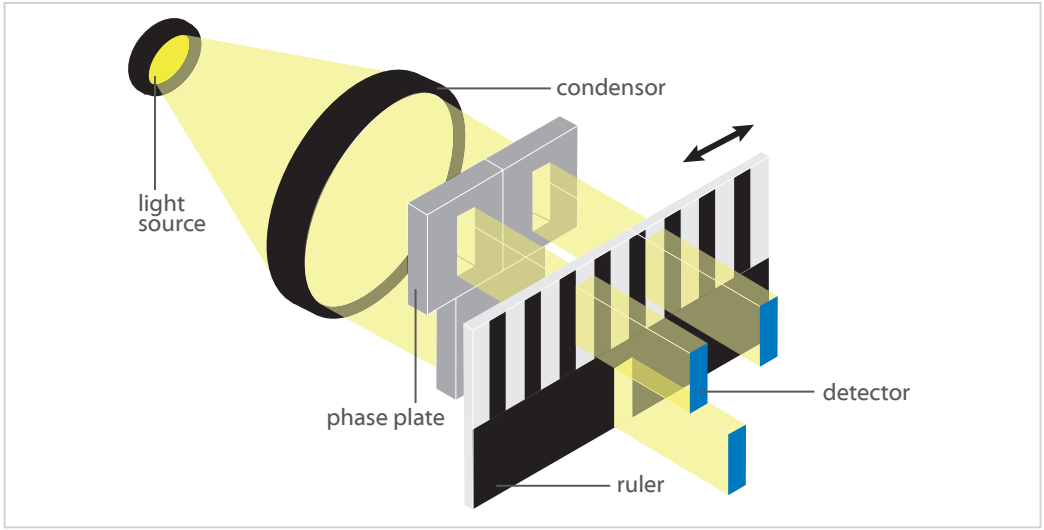
A linear optical encoder uses a ruler, made of glass or metal, with a special optical pattern on it. Usually transparent and none transparent, or reflecting and none reflecting lines are used. A light source shines to the ruler, and the bright/dark transitions are measured. The count of measured transitions corresponds to the displacement, while the phase contribution of the two detectors A and B depends on the direction of the movement.

Advantage:

- No calibration necessary
- No limit of measuring range
- Force modulation – offering tma capabilities
- Superior reproducibility

Disadvantage:

- The position change is measured relative, a zero position measurement for absolute position reading is necessary
- Limited resolution: the lower limit for the distance of the patterns on the ruler is app. 20nm. For higher resolutions the reading must be interpolated
- The optical detector system is sensitive to dust (production environment)

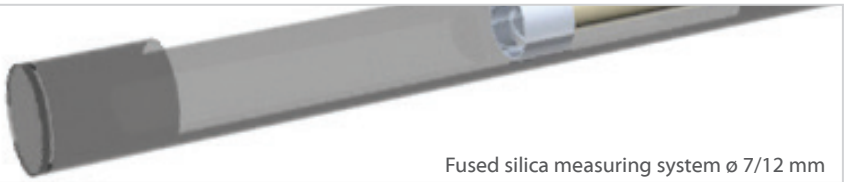


FEATURES

Exciting new features to simplify work

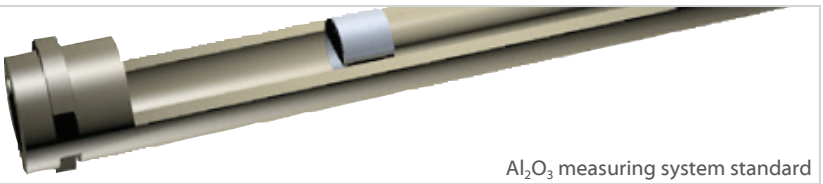
Measuring systems

Numerous different single, double or quattro measuring systems made of fused silica, Al_2O_3 or graphite are available.

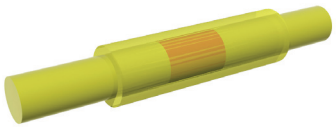


Fused silica measuring system ø 7/12 mm

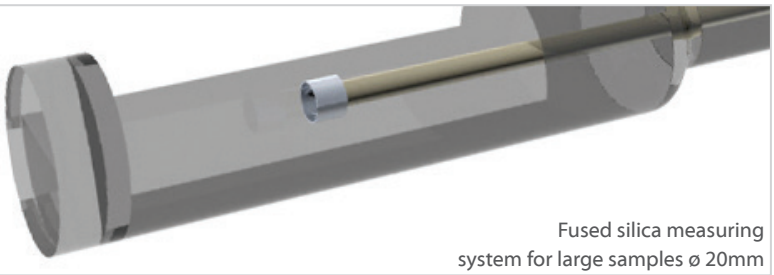
Al_2O_3 measuring system contact free



Al_2O_3 measuring system standard



Adapter for powders and pastes



Fused silica measuring system for large samples ø 20mm

Instrument design

Optimum sensor selection to ensure best measurement result for any given requirement. Integrates Mass Flow Controllers or gas dosing system. Thermostatically controlled measuring compartment disables environmental measurement influences.

MultiNudge

Our sample positioning feature ensures an optimum sample alignment. As the sample piston touches the sample several times it improves the orientation of the sample which is utmost important for a successful dilatometer measurement.

Automatic Contact Force Adjustment

When it comes to samples with large expansion or soft pressure sensitive samples a contact force adjustment during the measurement is critical to ensure excellent measuring results. This feature eliminates the influence of varying force during the measurement.

Vacuum and controlled atmosphere

The instrument design provide for high vacuum and inert, reducing, oxidizing or humidified atmosphere. Furthermore, the instrument can be pressurized up to 5 bar overpressure (option). Measurements can be done under corrosive conditions if proper conditions are respected. Residual gas analysis systems can be coupled via an optional heated capillary.

Evolved gas analysis

Optional gas analysis with MS, FTIR or GCMS is possible. This provides valuable additional information of the sample composition.

Wide temperature range -263°C to 2800°C

The LINSEIS Dilatometers can be equipped with up to three furnaces at the same time. A broad variety of different furnaces is available to enable measurements in the widest temperature range on the market.

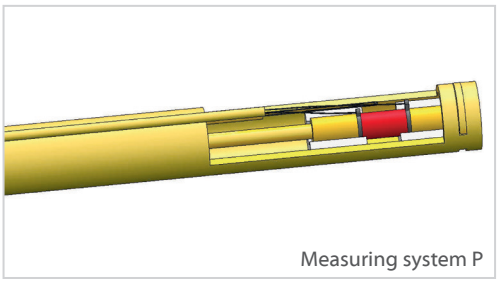
Starter kit

The starter kit includes a variety of tools such as scissors, cutting tools, anti-electrostatic tweezers, magnifier, crucible holder, pipette, rasps, spatula etc.

CUSTOMIZED DILATOMETERS

Dilatometer with electrical ports for Piezo elements

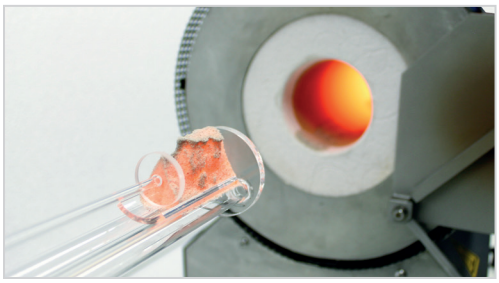
Piezo elements are semiconductors that change their mechanical properties if they are connected to a voltage. Depending on intensity and direction of voltage, piezo actors typically shrink or expand. They can be used as mechanical switches in valves or as a fuse for instance. Using a special Linseis L75 pushrod dilatometer, their behavior can be studied over temperature and vs voltage. Therefore, a standard dilatometer was modified by removing the vacuum pump and attaching electrodes through the vacuum connector into the sample chamber. The cables can then be attached to a power generator that can be controlled by software, while the sample is placed in a special sample holder at the normal sample position. The expansion and shrinkage of the piezo sample can then be measured depending on the given voltage at any temperature.



Measuring system P

Macro-Dilatometer for huge samples

The macro-dilatometer was developed out of a classic Linseis L75 horizontal pushrod-dilatometer to be able to measure samples that exceed the standard sample size. In the example below, a company who is developing casting molds for steel industry wanted to simulate the burning process of their molds by heating them to target temperature immediately. As they need a certain amount of material to get correct data, the samples were around 3-4 cm diameter wich is way more than a classic dilatometer sample would be. In the given example, the furnace was able to be heated to target temperature of 1000°C before the measurement system was inserted – like in the burning process of the mold, where the cold parts are moved into a hot furnace. The measurement starts before the sample sees the heat, allowing to measure the rapid sintering when it is moved into the furnace.



SOFTWARE

All LINSEIS thermo analytical instruments are PC controlled. The individual software modules exclusively run under Microsoft® Windows® operating systems.

The complete software consists of 3 modules: temperature control, data acquisition and data evaluation. The software incorporates all essential features for measurement preparation, execution, and evaluation of a dilatometer run.

Thanks to our specialists and application experts, LINSEIS offers comprehensive easy to understand user friendly application software.

Software-Features:

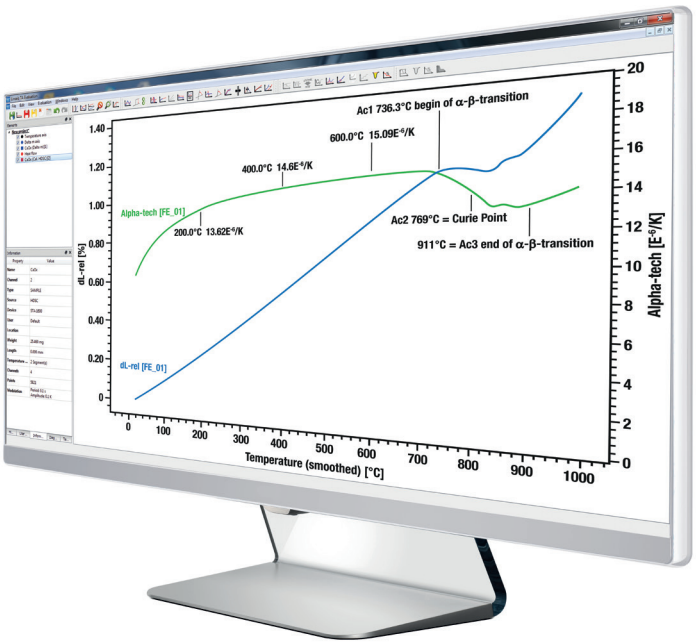
- Program capable of text editing
- Data security in case of power failure
- Thermocouple break detection
- Repetition measurements with minimum parameter input
- Evaluation of current measurement
- Curve comparison

Software

- Storage and export of evaluations
- Export and import of data ASCII
- Data export to MS Excel
- Multi-methods analysis (DSC, TG, TMA, DIL, etc.)
- Zoom function
- 1st and 2nd derivative
- Programmable gas control
- Statistical evaluation package
- Automatic axis re-scaling
- Softening point detection

DIL Features:

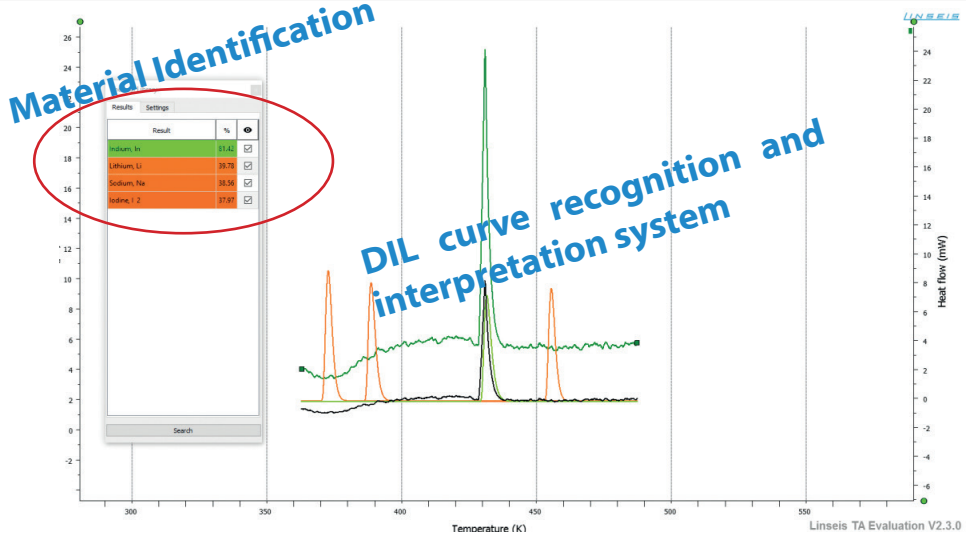
- Rate Controlled Sintering (RCS) software
- Interchangeable thermocouples for various atmospheres
- Sinter process evaluation
- Glass transition and softening point evaluation
- Softening point determination and system shut down
- Linear thermal expansion evaluation
- Several system correction features
- Automatic zero point adjustment
- Auto-scheduler for up to 16 sub-sequent runs



Thermal Library

The LINSEIS thermal library software package comes as an option for the well-known, user friendly LINSEIS Platinum evaluation software, that is integrated in almost all our instruments.

The thermal library allows for the comparison of the complete curves with a data base providing thousands of references and standard materials within only 1-2 seconds.



Measured and matching reference curves (green) and reference curves with poor fit (red).

Multi-Instrument

All LINSEIS instruments DIL, TMA, DSC, DTA, TGA, STA etc. can be controlled from one software template.

Multi-User

The administrator can generate different user levels providing different rights to operate the instrument. An optional log file is also available.

Report Generator

Convenient template selection to generate customized measurement reports.

Kinetic software

Kinetic analysis of DIL, TMA, DSC, DTA, TGA, STA etc. data for the study of the thermal behavior of raw materials and products.

Multi-Lingual

Our software is available in many different user exchangable languages, such as: English, Spanish, French, German, Chinese, Korean, Japanese, etc.

Data Base

Physical constants of new materials can be easily integrated by the user.

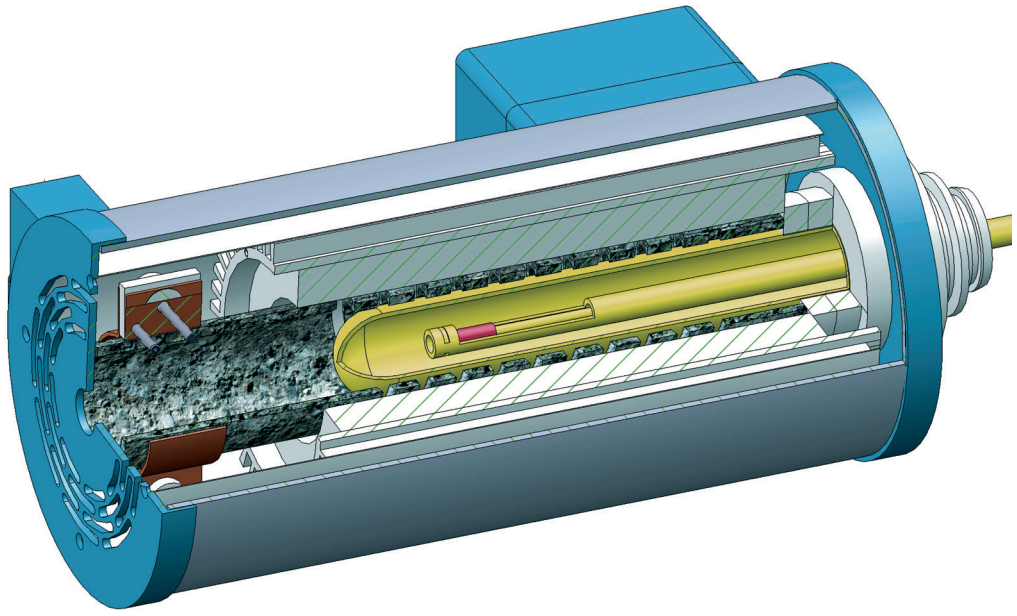
SPECIFICATIONS

	L76	L75 Horizontal	L75 Vertical	
Temperature range	RT up to 1600°C	-180 up to 2800°C	-263 up to 2800°C	
Delta L resolution	0.05 nm	0.03 nm	0.03 nm	LVDT
Measuring range	±2500 µm	±2500 µm	±2500 µm	LVDT
Contact force	50 mN up to 1N*	10 mN up to 1N	10 mN up to 1N	LVDT
Delta L resolution	-	0.1 nm	0.1 nm	Optical Encoder
Measuring range	-	±25000 µm	±25000 µm	Optical Encoder
Automatic sample lenght detection	no	yes	yes	Optical Encoder
Force modulation	no	yes	yes	Optical Encoder
Contact force	-	10 mN up to 5 N	10 mN up to 5 N	Optical Encoder
Heating rates	Based on furnace: • steel, copper, fused silicia, silicon carbide: 0.001 up to 50 K/min • graphite 0.001 up to 100 K/min			
Sample holder	user interchangeable, SiO_2, Al_2O_3, graphite All sample holders available as: • single sytem (one pushrod) • system with two pushrods • Al_2O_3 sample holder Fused silica and Al_2O_3 sample holders available as hollow tubes or massive rods			
Temperature /Accuracy / Precision / Resolution	1 K / 0.1 K / 0.001 K	1 K / 0.1 K / 0.001 K	1 K / 0.1 K / 0.001 K	
Thermal stability (isotherm)	± 0.02 K	± 0.02 K	± 0.02 K	
$\Delta L / L_0$ Repeatability	0.001%	0.001%	0.001%	
$\Delta L / L_0$ Accuracy	0.002%	0.002%	0.002%	
Force resolution	—	0.001 mN	0.001 mN	
Gas atmosphere	Inert, oxid., red.	Inert, oxid., red., vac.	Inert, oxid., red., vac.	
Software	latest Windows operating system older versions possible on request			

*manual adjust

FURNACES

Temperature	Type	Heating element	Atmosphere	Temperature sensor
-263°C – 300°C	L75/264 He	Thermo coax	inert, oxid., red., vac.	Semiconductor / PT 100
-180°C – 500°C	L75/264	Thermo coax	inert, oxid., red., vac.	Type K
-180°C – 700°C	L75/264/700	Thermo coax	inert, oxid., red., vac.	Type K
-180°C up to 1000	L75/264/1000	Thermo coax	inert, oxid., red., vac.	Type K
RT – 1000°C	L75/220	Kanthal	inert, oxid., red., vac.	Type K
RT – 1400°C	L75/230	Kanthal	inert, oxid., red., vac.	Type S
RT – 1600°C	L75/240	SiC	inert, oxid., red., vac.	Type S
RT – 1650°C	L75/240 PT	Platinum	inert, oxid., red., vac.	Type S
RT – 1750°C	L75/240 M	$MoSi_2$	inert, oxid., red., vac.	Type B
RT – 2000°C	L75/260	Graphite	N_2/Vac.	Type C and/or pyrometer
RT – 2400°C	L75/270	Graphite	N_2/Vac.	Pyrometer
RT – 2800°C	L75/280	Graphite	N_2/Vac.	Pyrometer



Linseis equipment for operation under water vapor and relative humidity

Fig 1: Relative Humidity Generator

L40 Water Vapor

For many applications in thermal analysis, the atmosphere plays an important role as it may affect the sample behavior or activate reactions. Humidity influence on building materials, storage time of pharmaceuticals and foods or influence on mechanical properties of polymers are just some of the most common examples.

Of course, the Linseis instruments are suitable for such experiments, however there is one fact that is often causing confusing and must be considered carefully: **The difference between water vapor and relative humidty. Relative Humidity Generators (Fig. 1) are most commonly used for experiments around room temperature, while water vapor applications are most often at higher temperatures.**

Difference between water vapor and relative humidity

When water is heated to its boiling point or higher than that, the water changes its aggregate form from liquid to gaseous. It is then existing as water vapor (steam). If this steam is introduced into any kind of reaction chamber or instrument, it is called **water vapor application**. In contrast, every gas can transport and contain a certain amount of water at a given temperature. **This is called humidity**. Considering air as an example, there is always an amount of water contained in the air, even below the boiling point of water, which is defined as grade of humidity or relative humidity. In the following chapters, the difference shall be shown:

Equipment for hydrogen control and safety

Linseis instruments are all designed for being used in hydrogen atmosphere with just a few adjustments.

The most important thing is a safety system that can ensure that there is no leakage and no explosive atmosphere is generated outside of the instrument. Therefore, the Linseis safety system uses hydrogen sensors that are coupled to an automatic gas control panel. If there is a leakage or unwanted hydrogen release, the instrument is automatically flooded with inert gas and the hydrogen valves are closed. This ensures a minimum risk level during operation. Besides that, the system contains a burn off unit where the gas outlet is connected to, to ensure that also the used gas of the measurement chamber is not just released into the environment. The system can also be operated with several gas combinations of inert gases and even water vapor besides hydrogen.

In summary, the Linseis H_2 control / safety system comes with the following benefits:

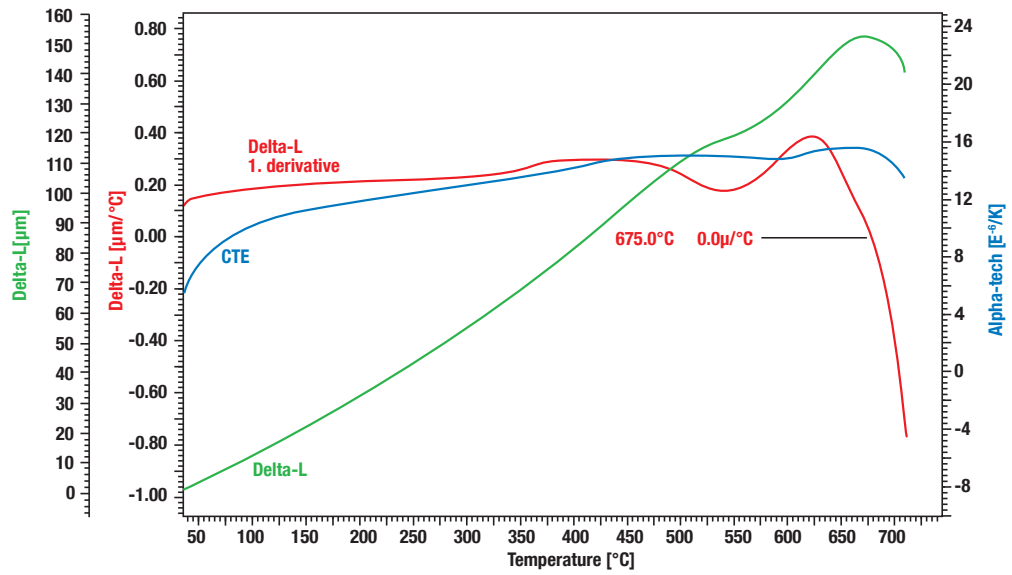
- Automatic evacuation function
- Gas flow control for multiple gases including water vapor and hydrogen
- Emergency shutdown function
- Hydrogen detector system
- Burn off unit

Simultaneous TGA-DTA/DSC measures both, heat flow and weight change of a sample as a function of temperature or time under controlled atmosphere. Simultaneous measurement of these two material properties not only improves productivity but also simplifies interpretation of the results.

The complimentary information obtained allows differentiation between endothermic and exothermic events which have no associated weight change (e.g., melting and crystallization) and those which involve a weight change (e.g., degradation).

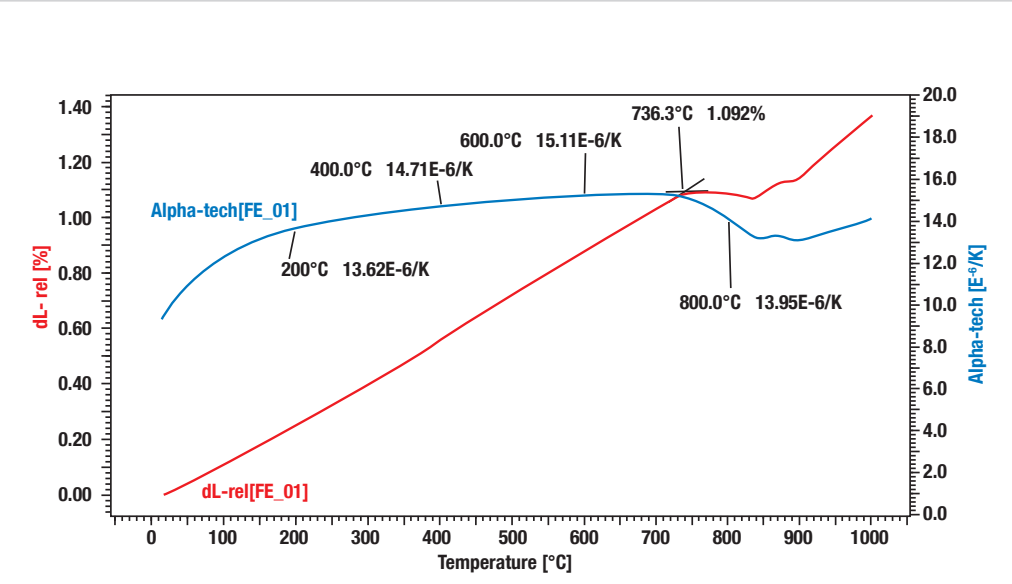
APPLICATIONS

Glass Ceramic



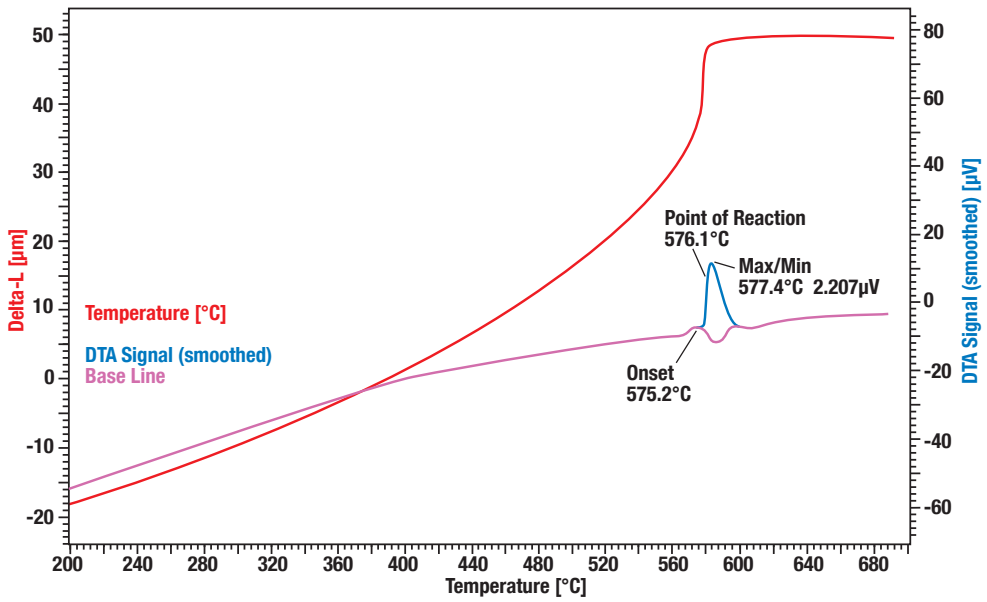
The dilatometric method is an excellent method to determine the thermal expansion (CTE) and the softening point of glass ceramic materials. Beside the absolute expansion and the expansion coefficient (CTE), you can find the first derivative of the absolute expansion. The temperature at which the derivate becomes zero corresponds to the maximum length of the sample and to the softening point of the material.

Iron



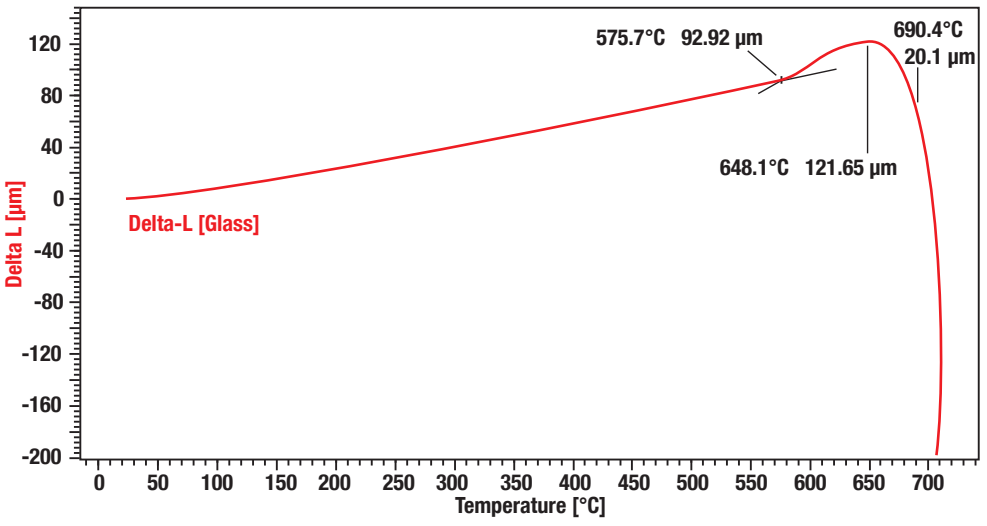
The linear thermal expansion (ΔL) and the CTE of the iron sample under argon atmosphere are evaluated. The heating rate was 5 K/min. Above 736.3°C (maximum temperature of CTE) shrinkage was detected, which is due to a change in the atomic structure, known as the Curie-point. The difference of measured and literature value can be attributed to contamination of the sample.

DTA - Feature



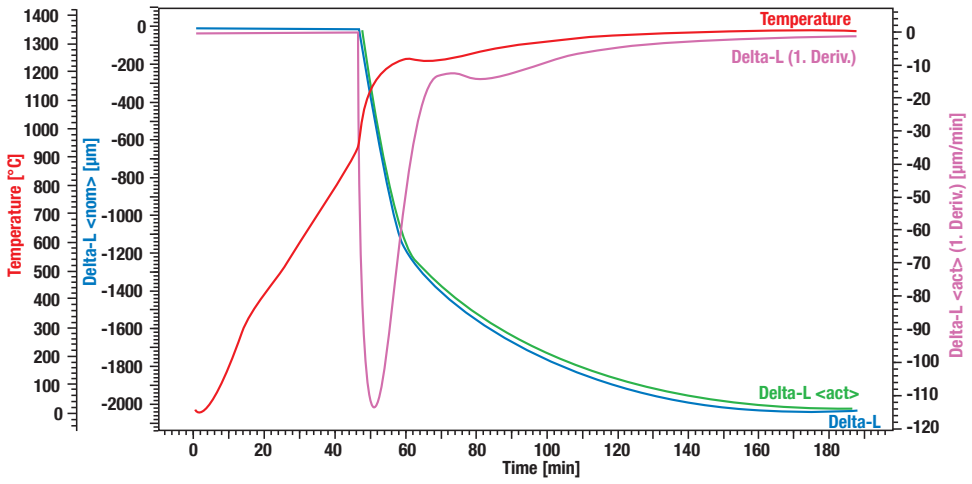
The thermal expansion of α-SiO_2 can be easily evaluated with the L75 Dilatometer. The additional DTA feature enables an in depth view of the thermal behavior of the material. The DTA measurement is a mathematical routine based on the sample temperature. Exo- and endothermic effects influence the change of the sample temperature during the dynamic heating or cooling cycle. The phase transition from α- to β-SiO_2 takes place at app. 575°C. The deviation of the measured temperature from the literature value (574°C) can be used for a temperature calibration.

Glass Sample, softening point



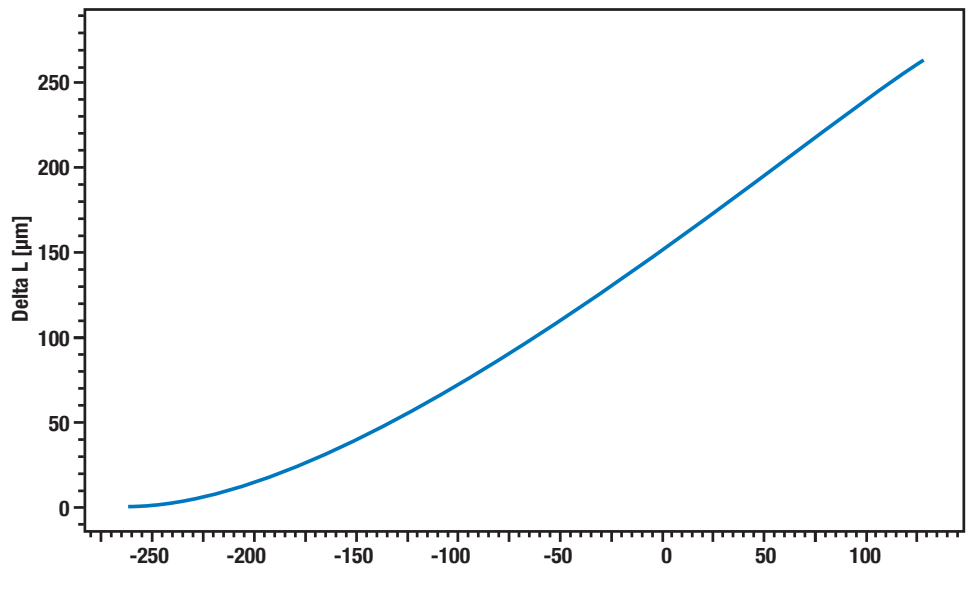
The glass sample was measured using the softening-detection feature. The heating step will be stopped by the software either if the target temperature is reached or if a shrinkage above a pre-defined threshold is detected. In this example, the threshold was set to -100µm meaning that in case that the sample length falls by more than 100 µm below the maximum length of the sample, the heating was interrupted and a cooling segment was started automatically. The softening point can be detected in an easy and safe procedure. The automatic stop of the heating avoids damages on the instruments due to sticking of the sample on the measuring system

Ceramics / Powder metallurgy



In production processes of high-tech ceramics a simulation of sinter processes is of high interest. When using the optional software package RCS (Rate Controlled Sintering) it is possible to program controlled sintering with a dilatometer as per PALMOUR III theory. The following application is a sintering process of ZrO_2. After approximately 60 minutes the main sintering step is finished and the heating rate can be slowed down. After approximately 160 minutes the final density of the material is reached and sintering finished.

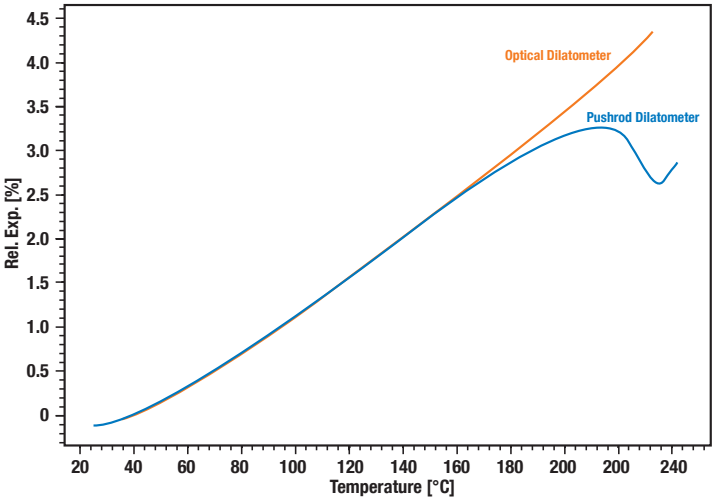
Copper



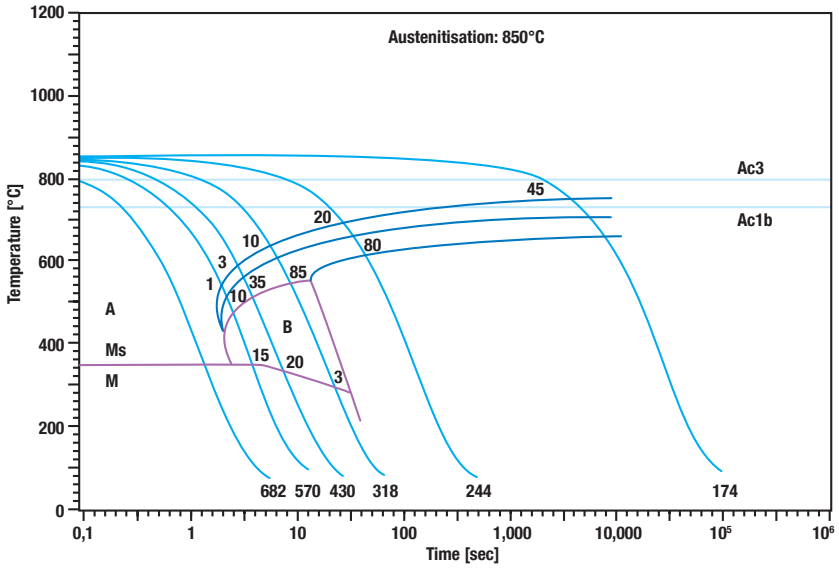
Expansion measurement of copper down to a temperature of 10 K using a Helium cryostat.

ALTERNATIVE DILATOMETERS

Optical versus Pushrod-Dilatometer



Determination of CCT with RITA Dilatometer



Picture © Dr. Sommer Werkstofftechnik GmbH, Issum

The inductive heating method of the LINSEIS RITA Dilatometer allows the usage of very fast heating and cooling rates. One steel sample like the stainless steel in the application example can be used to determine the CCT, TTT and CHT within only a few measurements. The diagram shows different cooling speeds from 850°C to Room Temperature. The same sample was cooled down several times and for each resulting curve the phase transition points were determined. The purple and dark blue curves are connecting those phase transition points and give the CCT curve for the sample.

(please look at our seperate L78 Quenching & Deformation Dilatometer brochure)

LINSEIS GmbH Germany
Vielitzerstr. 43
95100 Selb
Tel.: (+49) 9287 880 0
E-mail: info@linseis.de

LINSEIS Inc. USA
109 North Gold Drive
Robbinsville, NJ 08691
Tel.: (+1) 609 223 2070
E-mail: info@linseis.de

LINSEIS China
Kaige Scientific Park 2653 Hunan Road
201315 Shanghai
Tel.: 61 90 12 03
Tel.: 50 55 06 42
E-mail: info@linseis.com.cn

Linseis Thermal Analysis India Pvt. Ltd.
Plot 65, 2nd floor, Sai Enclave, Sector 23
Dwarka
110077 New Delhi
Tel.: +91 11 42883851
E-mail: sales@linseis.in

www.linseis.com

Products: DIL, TG, STA, DSC, HDSC, DTA, TMA, MS/FTIR, In-Situ EGA, Laser Flash, Seebeck Effect, Thin Film Analyzer, Hall-Effect
Services: Service Lab, Calibration Service

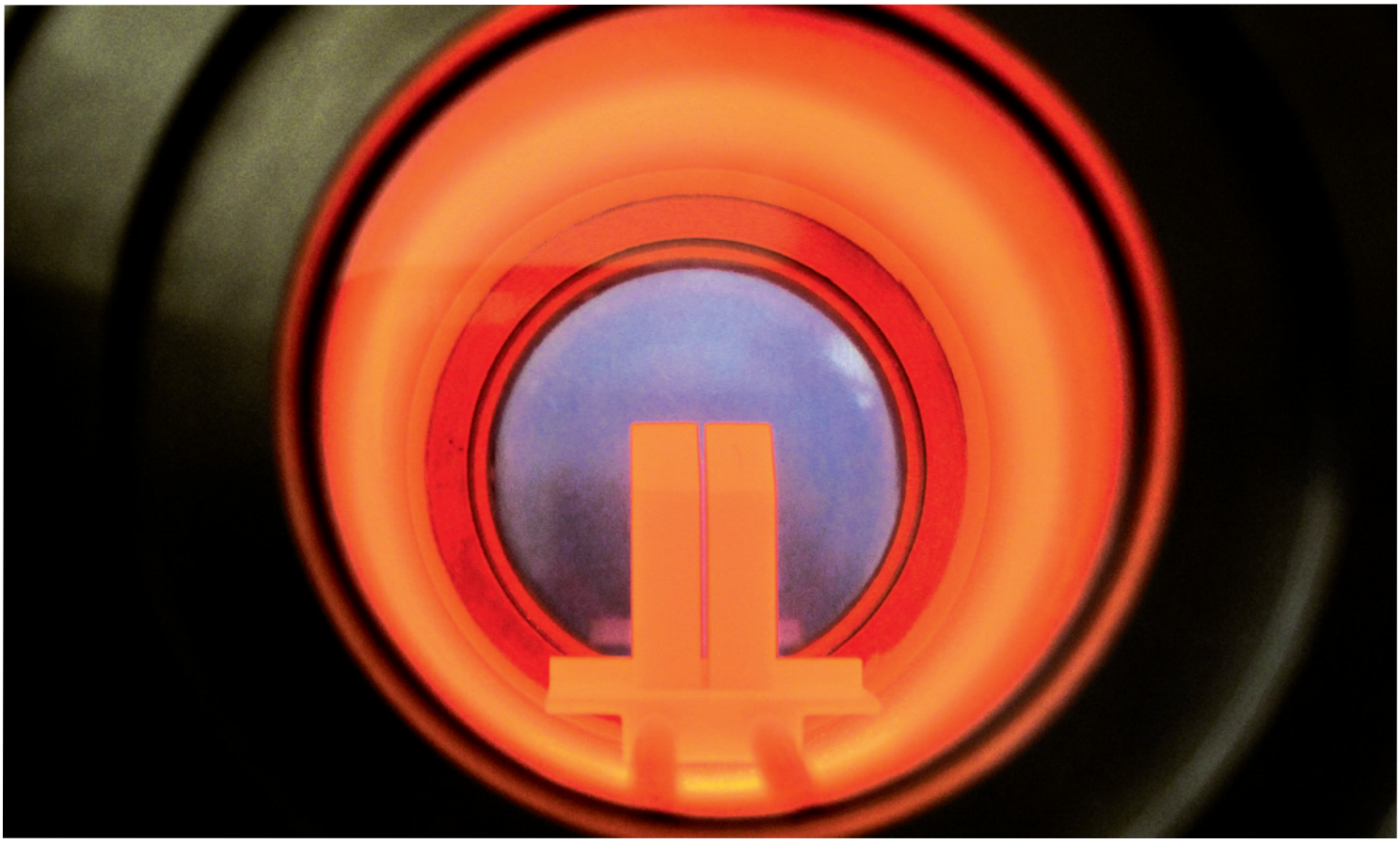
LINSEIS

LINSEIS

THERMAL ANALYSIS

Optical Dilatometer Heating Microscope

DIL L74

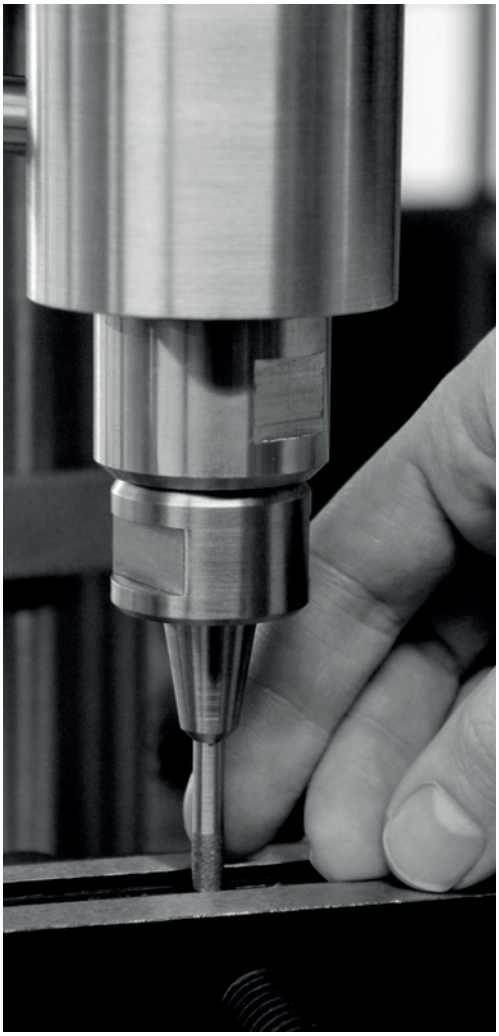


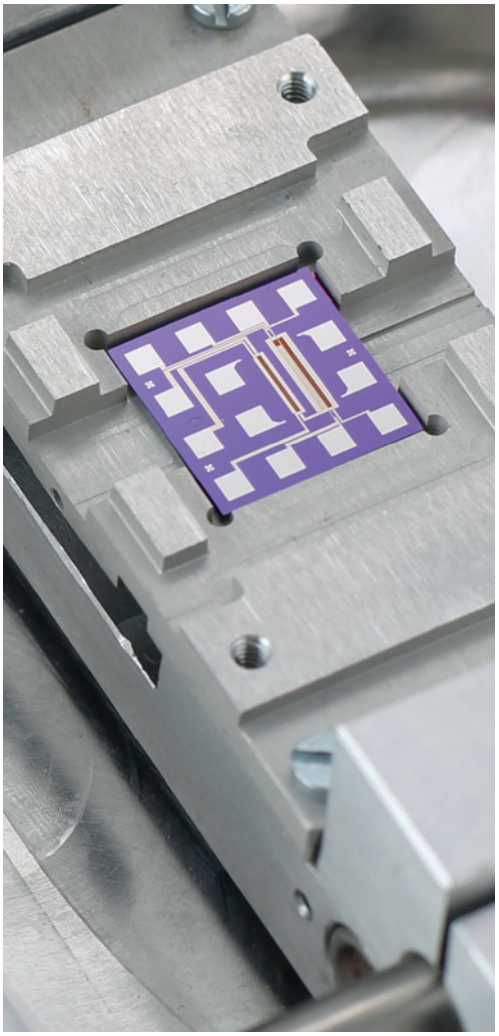
Since 1957 LINSEIS Corporation has been delivering outstanding service, know how and leading innovative products in the field of thermal analysis and thermo physical properties.

Customer satisfaction, innovation, flexibility and high quality are what LINSEIS represents. Thanks to these fundamentals our company enjoys an exceptional reputation among the leading scientific and industrial organizations. LINSEIS has been offering highly innovative benchmark products for many years.

The LINSEIS business unit of thermal analysis is involved in the complete range of thermo analytical equipment for R&D as well as quality control. We support applications in sectors such as polymers, chemical industry, inorganic building materials and environmental analytics. In addition, thermo physical properties of solids, liquids and melts can be analyzed.
LINSEIS provides technological leadership. We develop and manufacture thermo analytic and thermo physical testing equipment to the highest standards and precision. Due to our innovative drive and precision, we are a leading manufacturer of thermal Analysis equipment.
The development of thermo analytical testing machines requires significant research and a high degree of precision. LINSEIS Corp. invests in this research to the benefit of our customers.

Claus Linseis
Managing Director





German engineering

The strive for the best due diligence and accountability is part of our DNA. Our history is affected by German engineering and strict quality control.

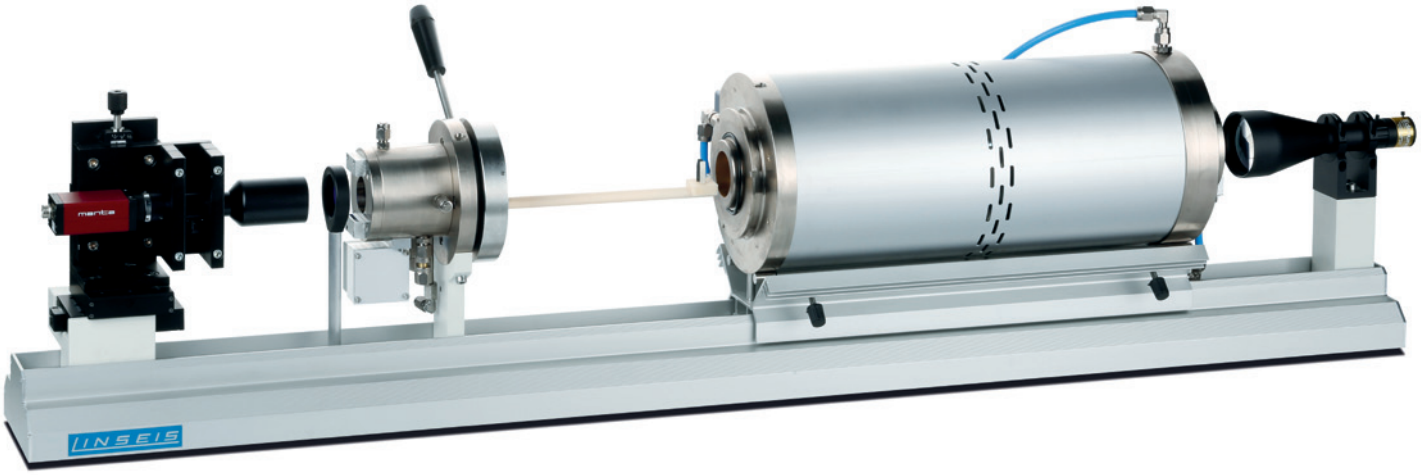
Innovation

We want to deliver the latest and best technology for our customers. LINSEIS continues to innovate and enhance our existing thermal analyzers. Our goal is constantly develop new technologies to enable continued discovery in Science.

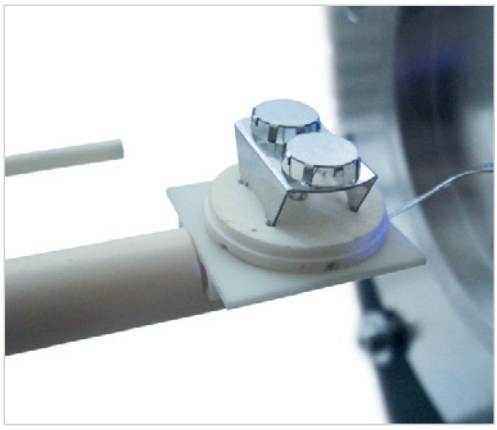
OPTICAL DILATOMETER

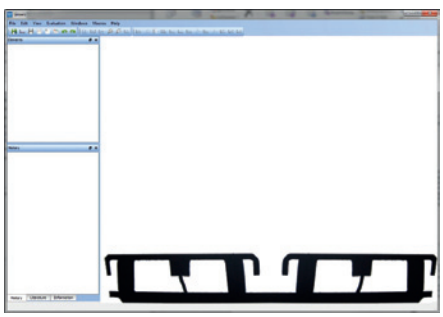
The Optical Research Dilatometer L74 was developed to meet the demanding applications of the glass, ceramics, metal and energy industry. A high resolution CCD camera enables a visual real time analysis of the sample expansion, either as single frame or as video sequences.

The big advantage of this method is that the sample is not burdened with any force. For soft samples or samples that melt during the measurement , this leads to a result, which is not distorted by the contact pressure.



DSC - Differential Scanning Calorimeter Option





DSC - Differential Scanning Calorimeter Option for Optical Dilatometer

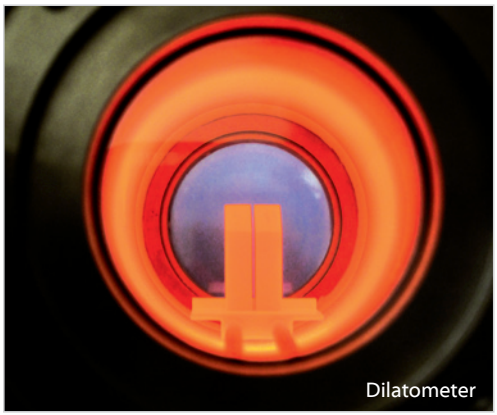
Several correction and analysis features are incorporated into the LINSEIS Evaluation Software. The unique horizontal design enables most demanding applications. The special solid-liquid adapter allows expansion / volume measurements of solids, liquids and solid – liquid phase transitions. There is also a special sample holder for measuring rigid foils available, which avoids measurement errors due to pushrod forces like in a classical dilatometer.

Application

- analysis of sintering processes (densification behavior as a function of temperature and time → sintering kinetics)
- analysis of the thermal expansion behavior (thermal expansion coefficient)
- investigation of the wetting- and spreading-behaviour of metallic- and glass-melts, slags and ashes on different substrates (metal, ceramic, glass)
- optical determination of the drop shape and contact-angle → determination of surface tension up to high temperatures
- analysis of the softening - and melting behavior (melting kinetic)
- investigation of corrosion behavior (metallic- and glass-melts, slags etc. on refractory materials)
- analysis of the ash melting behavior
- determination of viscosity curves of glasses
- analysis of sintering warpage (sintering of ceramic tapes and multilayers; co-sintering of metal-ceramic bi- and multi-layers)
- analysis of the infiltration behavior of metallic melts in ceramic materials (synthesis by melt-infiltration)
- analysis of melt filtration by porous ceramic materials
- investigation of the coating behaviour
- analysis of the brazing behavior and brazing tests, solder developement, glas-metal or ceramic sealing

Industries

- glass
- metal
- enamel coatings
- ceramics
- energy

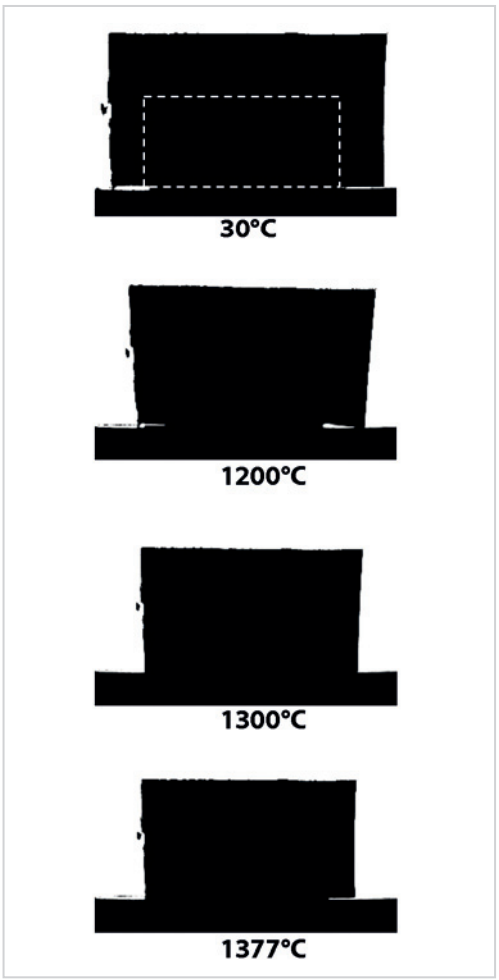

Dilatometer

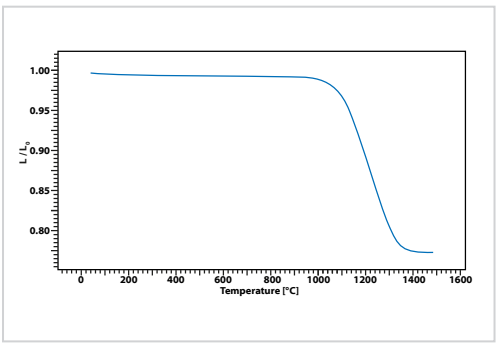
OPTICAL DILATOMETER

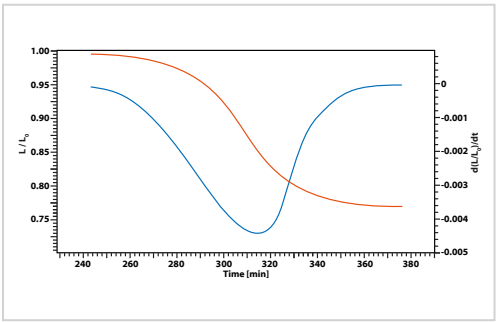
Sintering

The investigation of sintering processes using pushrod dilatometers has one disadvantage: There is always a force in z-direction that can cause a certain sinter direction. The optical dilatometer instead is able to measure a sinter process completely contact free and guarantees that the sintering process can take place without any influence. If you compare the results of the same substance that was sintered on an optical and on a pushrod dilatometer, there can be big differences because of this effect.

Sintering behaviour of ceramic tapes (ZrO_2)







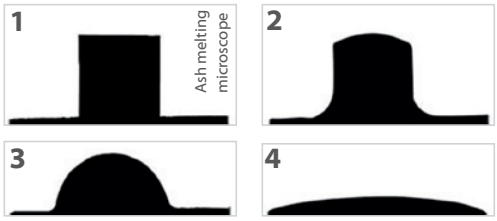
HEATING MICROSCOPE

Applications

- Ash fusion microscopy
- Observation and analysis of sintering processes
- Contact angle determination
- Microscopy at high temperatures and under different atmospheres

Ash melting microscope

Ash melting of a coal sample



1 – Softening temperature = edges are getting round
2 – spheric temperature = round shape of height that is as big as its baseline
3 – half sphere temperature = half sphere shape of height that is half the size of its baseline
4 – flow temperature = sample is nearly liquid, has only one third of the size of half sphere point

General

Solid ash fuels consist of inorganic compounds like silicon oxide and alkali oxides. Due to the high diversity of ash compositions it is nearly impossible neither to define a universal melting point nor to determine a fuel specific melting point. The melting behavior of ashes is heavily dependent on its chemical composition. The melting procedure of ashes takes place in a broader temperature range. Even if the slagging problems of power plants are different from each other, the melting behavior of ashes is useful to get a qualitative analysis of the slagging behavior of different coals what gives a result that can be applied to the corresponding boiler. The ash melting behavior of coals is determined according to DIN 51730, for bio mass there is a pre norm DIN CEN/TS 15730 that can be used as well. It defines four characteristic temperatures under oxidizing atmosphere.

Functional Principle

The principle of determination of the ash melting behavior is based on a sample that is melted under defined temperature ramps. The melting temperatures for stone coal are up to 1600°C, for bio mass and wood they are at around 1200°C to 1300°C and for culm containing bio mass they are even lower. The evaluation is done automatically according to DIN 51730 by monitoring of a shadow profile of the sample where the change of geometry is documented. By means of operating geometric factors, the resulting characteristic temperatures can be determined and be used for comparison of different coal qualities.

Fields of Application

- Measurements according to DIN 51730 (1984, 1998) / ISO 540-1995
- Characteristic temperatures plus start of sintering / sintering point
- Ash melting behavior
- Sintering behavior
- Dilatometric curves (e.g. shape, area)
- Softening- and melting behavior, moistening behavior
- Viscosity curve

Suitable for analysis of coal ashes, bio ashes, slags, as well as ceramic, enamel, clay ceramics, dental ceramics, grinding discs, special ceramics, fire proof ceramics, glass, steal, soldering pastes, stainless steel and fluxing agents.

SOFTWARE

Features -Software

In respect to thermal and mechanical sample treatment numerous different matematical functions can be selected.

- User-friendly
- Multi-methods analysis (DSC TG, TMA, DIL, etc.)
- Zoom function
- Online help menu
- Report generator
- Data export to MS Excel
- Export and import of data ASCII
- Program capable of text editing
- Data security in case of power failure
- Thermocouple break protection
- Repetition measurements with minimum parameter input
- Evaluation of current measurement
- Curve comparison up to 32 curves
- Storage and export of evaluations
- Programmable gas control
- Statistical evaluation package
- Smoothing of total or partial measurement
- Tangent intersection determination (automatic or manual)
- Free scaling

The information of a thermo analytical measurement can be increased when using the broad range of specialized Software.

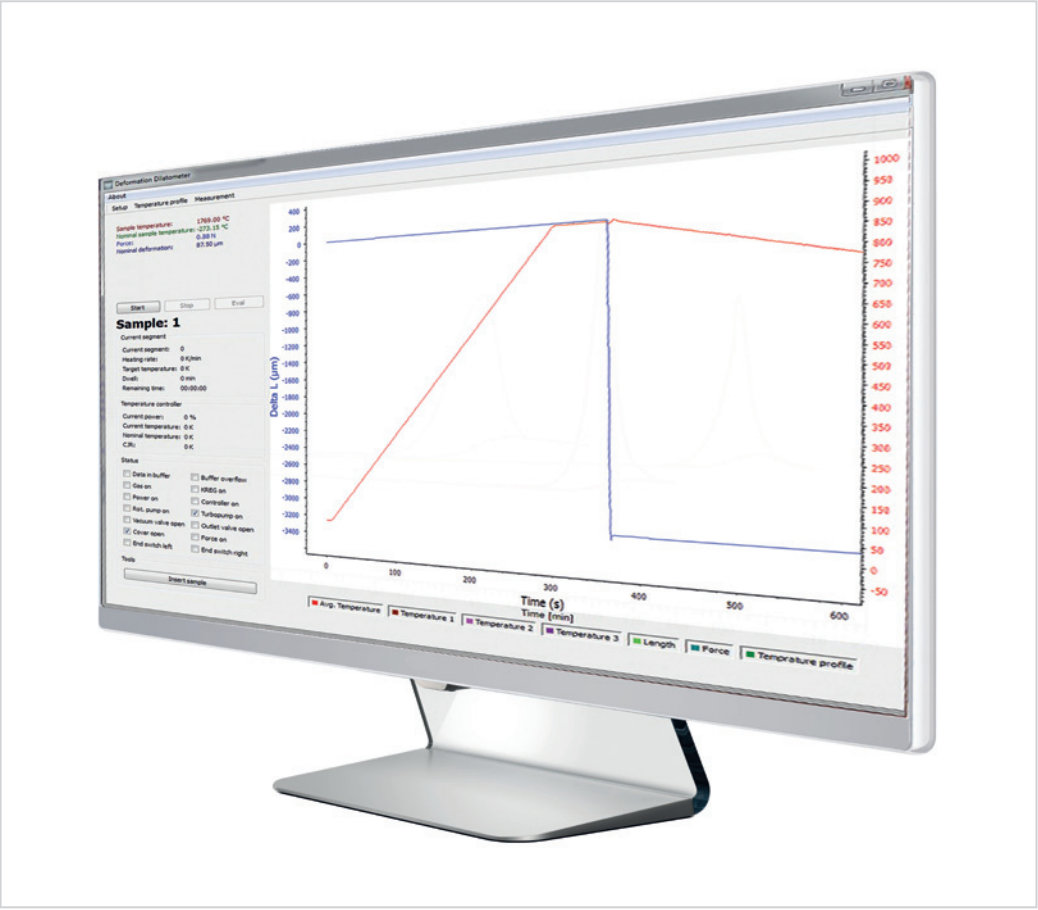
Software options

- Specific Heat determination (Cp)
- Rate Controlled Sintering (RCS)
- Calculated-DTA
- Quenching Dilatometer Software
- CHT / CCT / DCCT / TTT Diagrams
- Thermo Kinetics Software

Control and Evaluation Software

- Software package compatible with Windows 7 and 8
- Software for creation of CHT, CCT, DCCT and TTT diagrams
- all necessary measuring parameter are included in the menu structure
- Unlimited number of forming steps during measurement
- free choice of all control parameters
- Specification of temperature-time force-gradient and strain rate and deformation degree
- Control rate input by user or selection of industry parameter, i.e. quenching rates based on T 8/5 times
- Automatic force control on the basis of user defined functions
- individual commentaries
- heat up and cool down speeds
- end of the heating curve as well as duration of holding temperature
- programmable heating / cooling and isothermal segments
- function menus are easy to handle
- Graphical evaluation software with many functions to get complete results of all measured data

- Free assignment of axes
- The evaluation software includes freely scalable isothermal and continuous diagrams
- Manual entry of transition points
- Correction of individual data points
- Insertion of text
- ASCII Export
- Calculation of Delta L, Alpha physical, Alpha technical (CTE)
- Mathematical calculation of curves
- Statistical evaluation of curves with mean and confidence interval
- Print out of the results as curve or table
- Evaluation can be done simultaneously to an ongoing measurement / multi tasking
- Measuring data will be corrected through correction curve mal segments
- function menus are easy to handle
- Graphical evaluation software with many functions to get complete results of all measured data

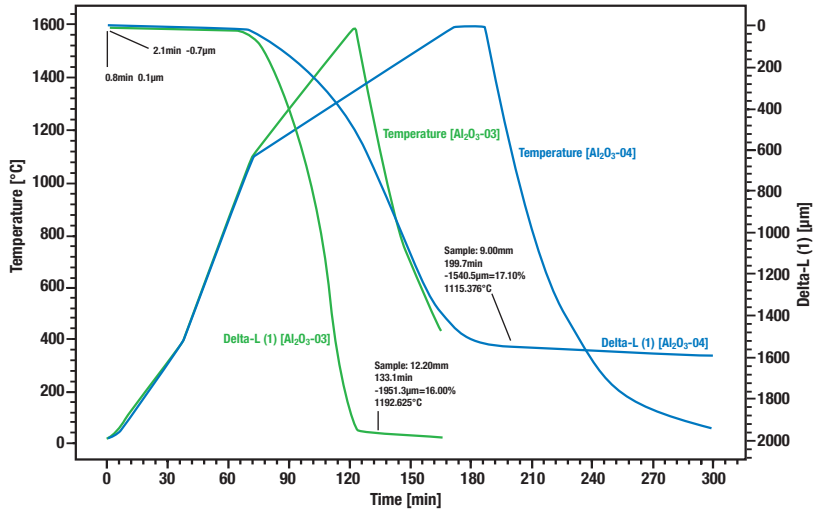


SPECIFICATIONS

	DIL L74
Maximum furnace temperature	RT up to 1600 / 1800 / 2000°C
Temperature at specimen	RT up to 1550 / 1700 / 2000°C
Heating rate	up to 50°C/min (depends on furnace)
Temperature resolution	0.2°C
Sample dimensions (WxHxD)	24 x 22 x 40 mm
Resolution	up to 1µm or 3ppm (with standard sample)
Vacuum	up to 10^{-5}mbar (depends on pump and selected furnace)
Hydrogen atmosphere	optional hydrogen saftey system available
Measuring range contact angle	0…180°; +/- 0.1°
Calibration standards	calibration standard with table included
Detection Modes	Sintering, Softening point, Deformation point, Sphere, Half-sphere, Melting Point, CTE coefficient of thermal expansion, Linear and Volumetric thermal expansion, Contact Angle, Surface tension, Volume, Symmetry, Asymmetry, Height, Width Ration, many others
International Standards	ASTM C372, ASTM D1857, CEN/TR 15404, BS 1016: Part 15, CEN/TS 15370-1, DIN 51730, IS 12891, ISO 540, NF M03-048

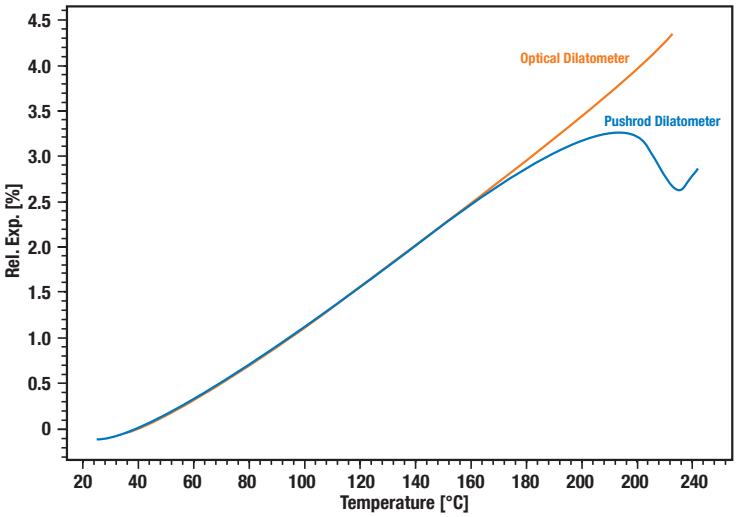
APPLICATIONS

Sintering of Alumina Oxide (Al_2O_3)



Up to a temperature of 1100°C no sintering behavior can be detected at both samples. With the following slower heating rate and a dwell time of 15 min at 1600°C sample two (blue curve) shows a shrinkage of 17.11%,

Comparison



Comparison between Conventional and Optical Dilatometer when evaluating the expansion of an epoxy resin into the melting stage.

LINSEIS GmbH Germany
Vielitzerstr. 43
95100 Selb
Tel.: (+49) 9287 880 0
E-mail: info@linseis.de

LINSEIS Inc. USA
109 North Gold Drive
Robbinsville, NJ 08691
Tel.: (+1) 609 223 2070
E-mail: info@linseis.de

LINSEIS China
Kaige Scientific Park 2653 Hunan Road
201315 Shanghai
Tel.: (+86) 21 5055 0642
Tel.: (+86) 10 6223 7812
E-mail: info@linseis.de

LINSEIS France
Bureaux Paris
52 Boulevard Sébastopol
75003 Paris
Tel.: (+33) 1 73.02.82.72
E-mail: info@linseis.de

Bureaux Lyon
2A Chemin des Eglantines
69580 Sathonay Village
Tel.: (+33) 4.26.68.70.55
E-mail: info@linseis.de

LINSEIS Poland
ul. Dabrowskiego 1
05-800 Pruszków
Tel.: (+48) 692 773 795
E-mail: info@linseis.de

www.linseis.com

Products: DIL, TG, STA, DSC, HDSC, DTA, TMA, MS/FTIR, In-Situ EGA, Laser Flash, Seebeck Effect, Thin Film Analyzer, Hall-Effect

Services: Service Lab, Calibration Service

03/18

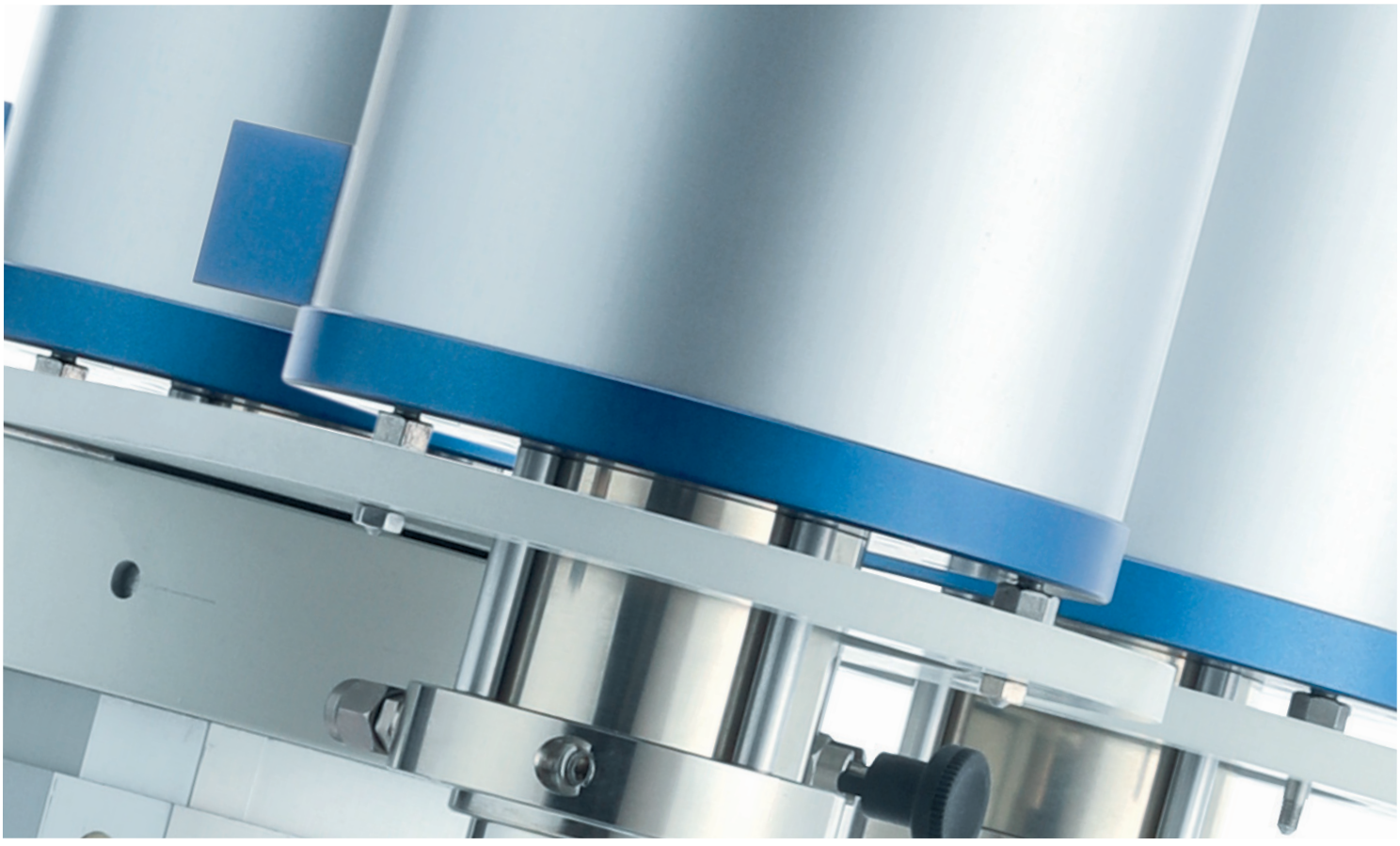
LINSEIS

LINSEIS

THERMAL ANALYSIS

DILATOMETRY

DIL L75 Quattro



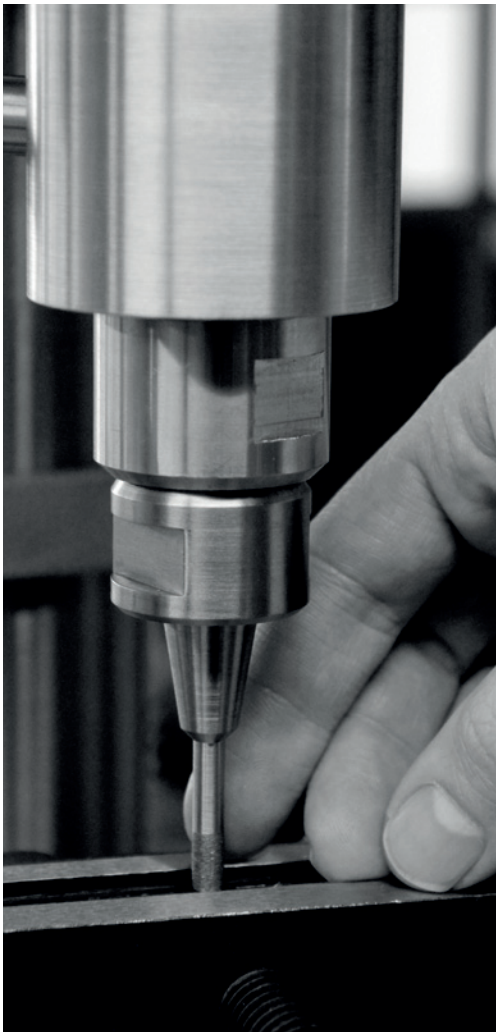
Since 1957 LINSEIS Corporation has been delivering outstanding service, know how and leading innovative products in the field of thermal analysis and thermo physical properties.

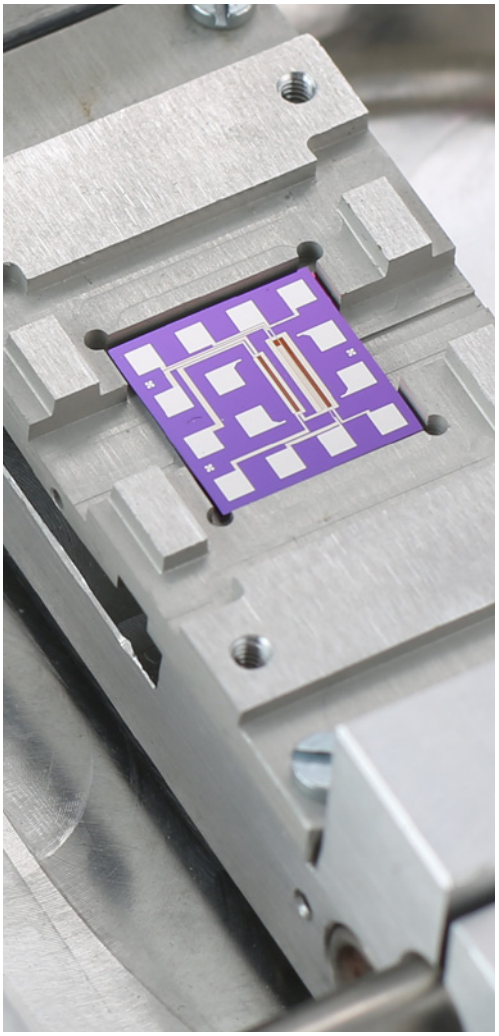
We are driven by innovation and customer satisfaction.

Customer satisfaction, innovation, flexibility and high quality are what LINSEIS represents. Thanks to these fundamentals our company enjoys an exceptional reputation among the leading scientific and industrial organizations. LINSEIS has been offering highly innovative benchmark products for many years.

The LINSEIS business unit of thermal analysis is involved in the complete range of thermo analytical equipment for R&D as well as quality control. We support applications in sectors such as polymers, chemical industry, inorganic building materials and environmental analytics. In addition, thermo physical properties of solids, liquids and melts can be analyzed.
LINSEIS provides technological leadership. We develop and manufacture thermo analytic and thermo physical testing equipment to the highest standards and precision. Due to our innovative drive and precision, we are a leading manufacturer of thermal Analysis equipment.
The development of thermo analytical testing machines requires significant research and a high degree of precision. LINSEIS Corp. invests in this research to the benefit of our customers.

Claus Linseis
Managing Director





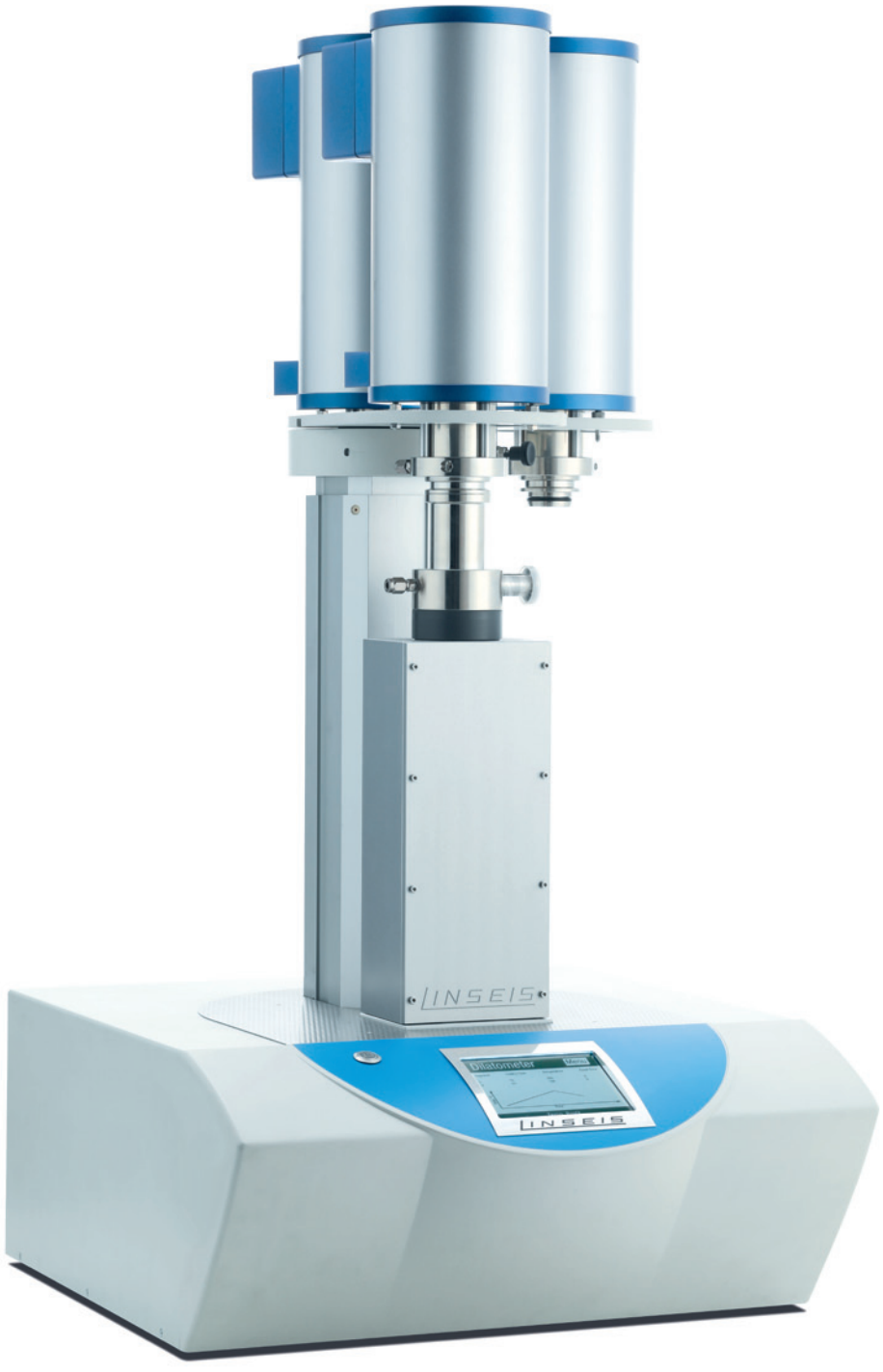
German engineering

The strive for the best due diligence and accountability is part of our DNA. Our history is affected by German engineering and strict quality control.

Innovation

We want to deliver the latest and best technology for our customers. LINSEIS continues to innovate and enhance our existing thermal analyzers. Our goal is constantly develop new technologies to enable continued discovery in Science.

DIL L75 QUATTRO



This dilatometer is a very unique instrument, which was developed for customers in the ceramics automotive industry.

These customers have to make a lot of quality control measurements in order to ensure ISO9000 standards. Especially companies manufacturing catalytic converter base ceramics for car exhaust systems are very interested.

The Quattro Dilatometer is built up with four seperate dilatometer measuring sensors, which can measure simultaneously either four seperate samples at one time, or three seperate samples against a NIST reference.

That means, the productivity of the Quattro Dilatometer is three times as high, if compared to the normally used dual push rod dilatometers. With a dual push rod dilatometer only one sample can be measured against the standard at each time.

In order to further increase the productivity, this dilatometer is built with two seperate furnaces. Whenever the first run od four samples is ready, a new, cool furnace is ready to immediatly start the next run.

There is another feature included in this Quattro Dilatometer, which is called an automatic furnace lift mechanism. This feature automatically lifts the furnace at the end of each measurement without any operator interaction.

This way the measuring system is already cool when the operator comes to change the samples. This again increases the productivity of the system.

The 32 bit software further developed to be able to programm the parameters for four samples on one screen. For each sample different sample length, file name, etc. can be stored, and are available for later evaluation.

The temperature programming is done through an expensive program part, for several stages, dwell times, heat up speeds etc. A software macro is supplied with automatic evaluation, to ensure that ready measuring data are available without time delay.

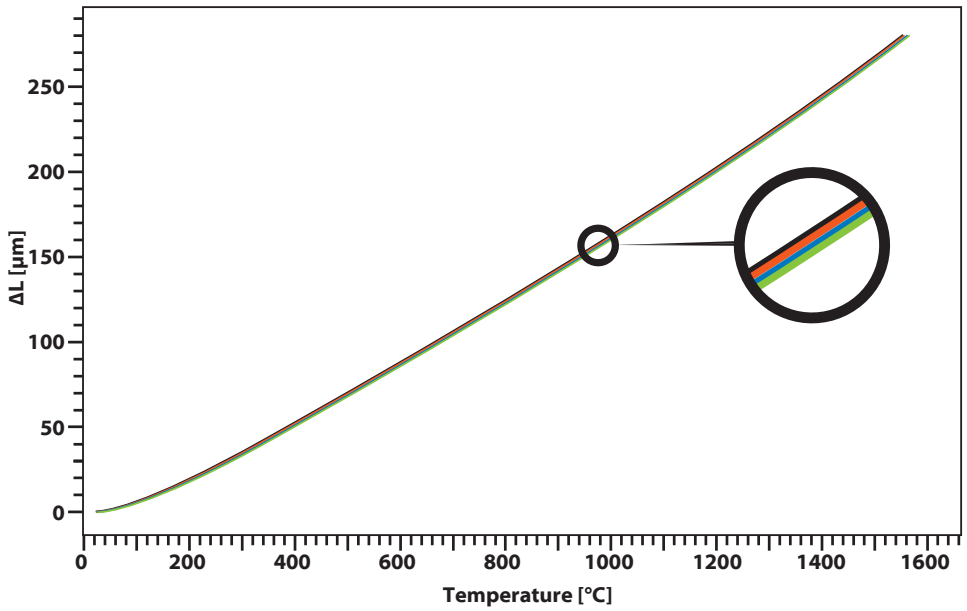
We are proud to say that as far as we know LINSEIS is the only supplier worldwide, that can offer this highly specialized dilatometer. This is another example of our powerful line of Thermal Analysis instruments.

TECHNICAL SPECIFICATIONS

	DIL L75 Quattro
Temperature range	-180°C up to 500 / 700 / 1000°C RT up to 1000 / 1400 / 1600 / 1750 / 2000 / 2400 / 2800°C
Number of samples	4
Heating/cooling rates	0.01K/min up to 50K/min (dependent on furnace)
Sample holders	fused silicia, Al_2O_3 < 1750°C
Sample length	max. 50mm
Sample diameter	max. 7mm
Measuring range	500 / 5000µm
Resolution	1.25nm
Atmospheres	inert, oxidizing, red., vac., static/dynamic
Electronics	integrated
Interface	USB

APPLICATIONS

Standard Expansion Measurement



LINSEIS GmbH Germany
Vielitzerstr. 43
95100 Selb
Tel.: (+49) 9287–880 - 0
Fax: (+49) 9287–70488
E-mail: info@linseis.de

LINSEIS Inc. USA
109 North Gold Drive
Robbinsville, NJ 08691
Tel.: (+1) 609 223 2070
Fax: (+1) 609 223 2074
E-mail: info@linseis.com

LINSEIS China
Kaige Scientific Park 2653 Hunan Road
201315 Shanghai
Tel.: (+21) 5055 0642
Fax.: (+21) 6806 3576

LINSEIS France
Bureaux Paris
52 Boulevard Sébastopol
75003 Paris
Tel.: (+33) 1 73.02.82.72

LINSEIS Poland
Dabrowskiego 1
05-800Pruzkow
Tel.: (+48) 678 21 15 344

www.linseis.com

Products: DIL, TG, STA, DSC, HDSC, DTA, TMA, MS/FTIR, In-Situ EGA, Laser Flash, Seebeck Effect, Thin Film Analyzer, Hall-Effect

Services: Service Lab, Calibration Service

07/17

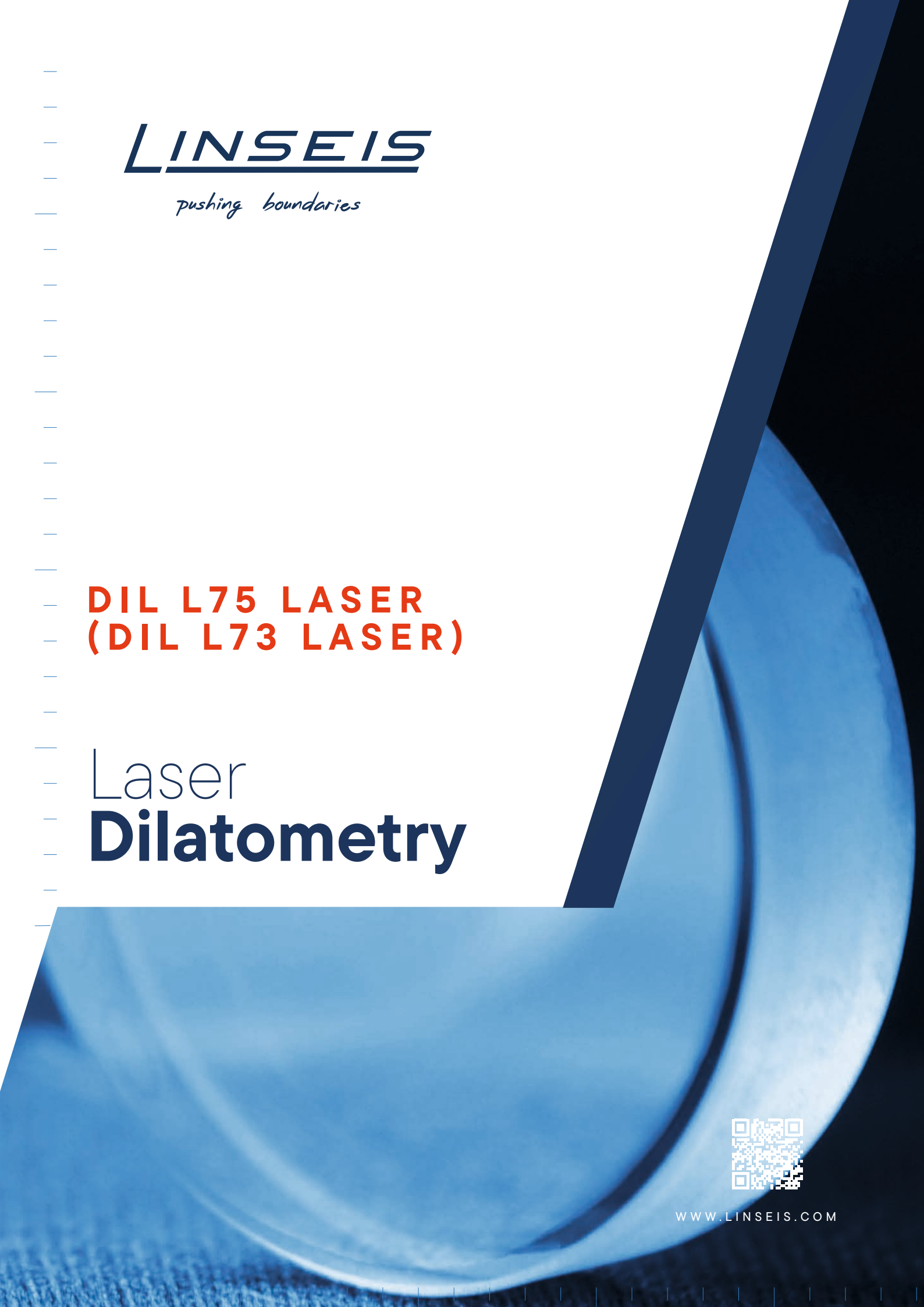
LINSEIS

LINSEIS

pushing boundaries

DIL L75 LASER (DIL L73 LASER)

Laser Dilatometry



WWW.LINSEIS.COM

Since 1957 LINSEIS Corporation has been delivering outstanding service, know-how and leading innovative products in the field of thermal analysis and thermo-physical properties.

Customer satisfaction, innovation, flexibility, and high quality are what LINSEIS represents. Thanks to these fundamentals, our company enjoys an exceptional reputation among the leading scientific and industrial organizations. LINSEIS has been offering highly innovative benchmark products for many years.

The LINSEIS business unit of thermal analysis is involved in the complete range of thermoanalytical equipment for R&D as well as quality control. We support applications in sectors such as polymers, chemical industry, inorganic building materials, and environmental analytics. In addition, thermophysical properties of solids, liquids, and melts can be analyzed.

Rooted in a strong family tradition, LINSEIS is proudly steered into its third generation, maintaining its core values and commitment to excellence, which have been passed down through the family leadership. This generational continuity strengthens our dedication to innovation and quality, embodying the essence of a true family-run business.

LINSEIS provides technological leadership. We develop and manufacture thermoanalytic and thermophysical testing equipment to the highest standards and precision. Due to our innovative drive and precision, we are a leading manufacturer of thermal analysis equipment.

The development of thermoanalytical testing machines requires significant research and a high degree of precision. LINSEIS Corp. invests in this research to the benefit of our customers.

C L A U S L I N S E I S

C E O D I P L . P H Y S .

Engineering & Innovation

To strive for the best due diligence and accountability is part of our DNA. Our history is affected by German engineering and strict quality control.

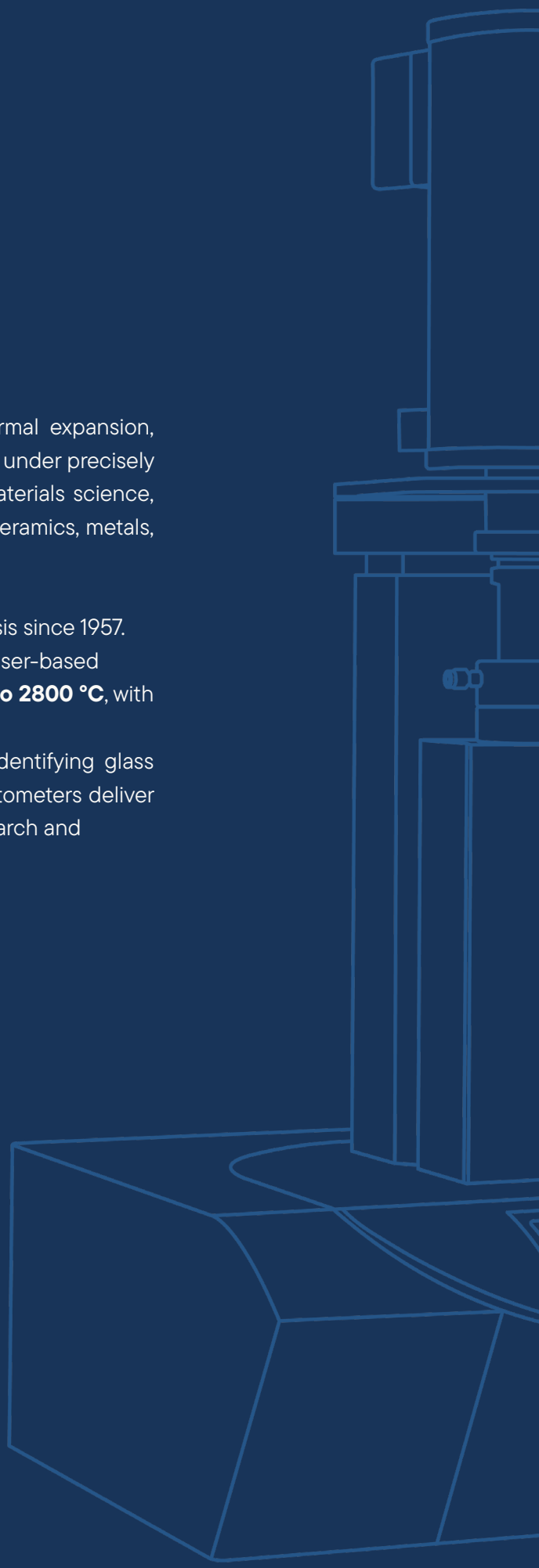
We want to deliver the latest and best technology for our customers. LINSEIS continues to innovate and enhance our existing thermal analyzers. Our goal is to constantly develop new technologies to enable continued discovery in Science.

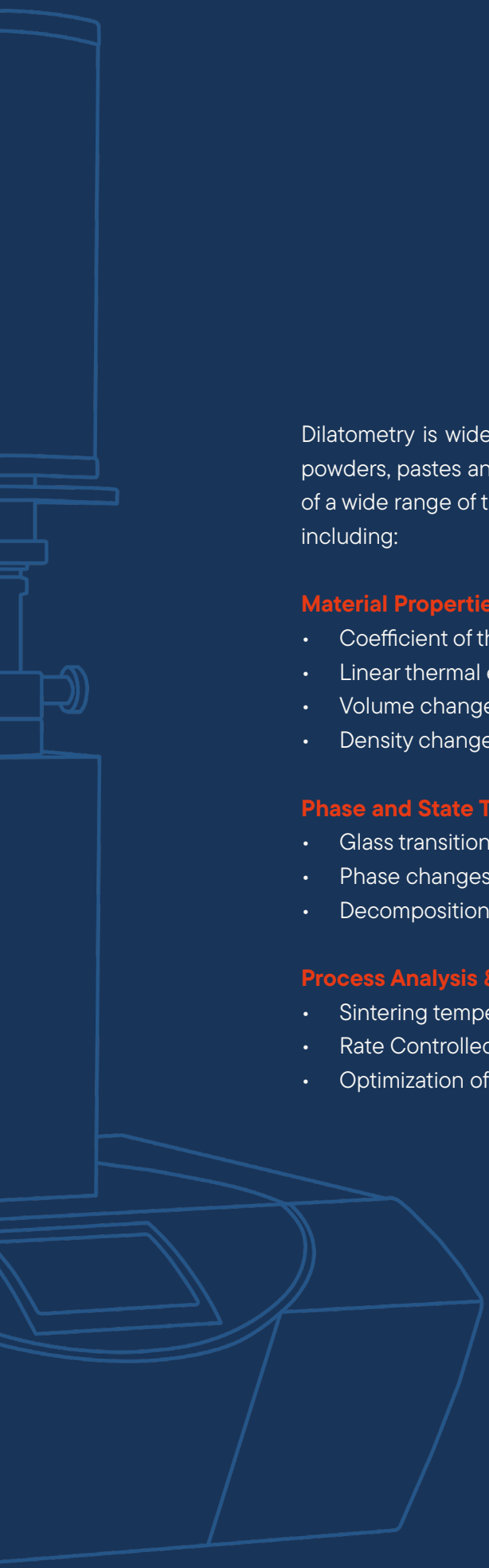
Dilatometry

Dilatometry (DIL) is a key technique for characterizing thermal expansion, shrinkage, phase transitions and sintering behavior of materials under precisely controlled temperature conditions. It plays a critical role in materials science, quality assurance and industrial process development across ceramics, metals, polymers, glasses and composites.

LINSEIS has been a leading innovator in thermo-physical analysis since 1957. Our portfolio includes single-, dual-, differential-, optical- and laser-based dilatometers covering a wide temperature range from **–263 °C to 2800 °C**, with resolutions down to 0.05 nm.
Whether determining thermal expansion coefficients (CTE), identifying glass transition points or monitoring sintering kinetics – LINSEIS dilatometers deliver the accuracy, stability and flexibility demanded by modern research and production environments.

- **Unmatched resolution**
- **Unmatched precision**
- **Absolute measurement technique**





Dilatometry is widely used in research, development and quality control for solids, powders, pastes and even liquids. The technique enables the precise determination of a wide range of thermo-mechanical properties and process-critical transitions, including:

Material Properties

- Coefficient of thermal expansion (CTE)
- Linear thermal expansion (ΔL, δl)
- Volume changes and densification
- Density change during heating

Phase and State Transitions

- Glass transition temperature (Tg)
- Phase changes and structural transformations
- Decomposition reactions

Process Analysis & Control

- Sintering temperature and shrinkage steps
- Rate Controlled Sintering (RCS)
- Optimization of firing and heat treatment processes

LINSEIS Contract testing

LINSEIS general dilatometry series

Horizontal Dilatometer L75/L76:

- Multipurpose system
- Highest temperature uniformity
- L75 Horizontal is perfect for Research and Development

Vertical Dilatometer L75:

- Friction free sample holder
- Push-rod contact is always guaranteed
- Possible field of application: Rate Controlled Sintering (RCS)
- Best arrangement for low and high temperature applications

  From -263 °C up to 2800 °C

Dilatometry Overview

Classic vs. Laser Dilatometer

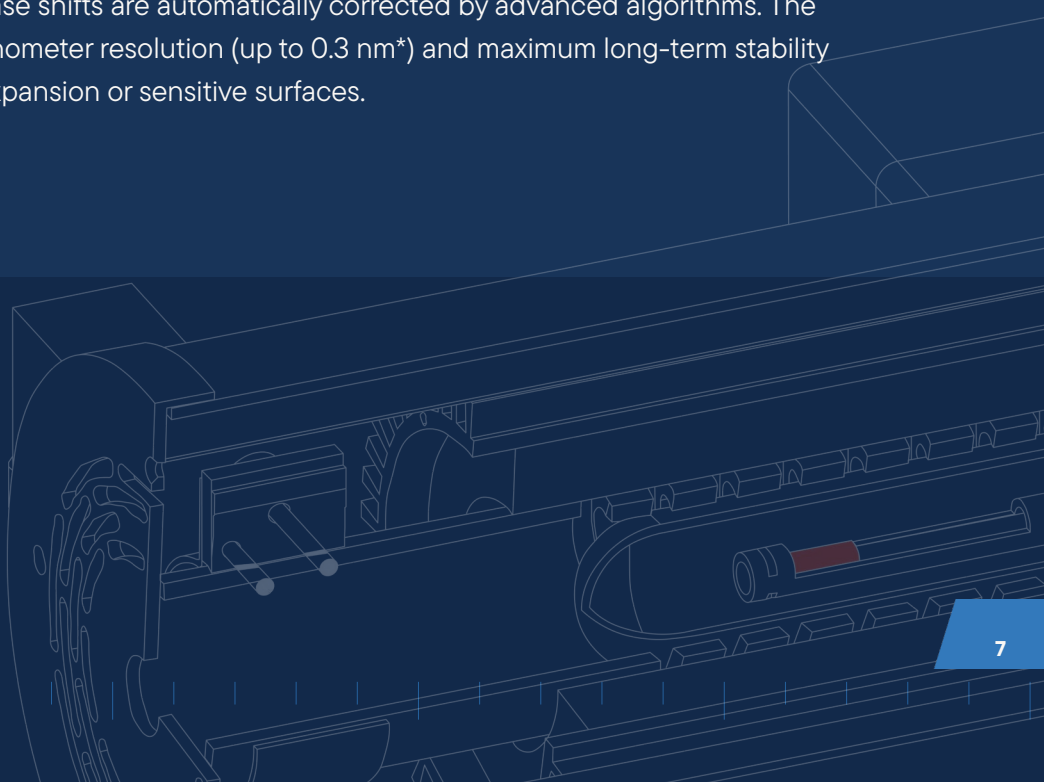
Classic push-rod dilatometers measure the change in length of a sample via mechanical contact. Two sensor systems record the initial length (L_o) and the thermal change in length (ΔL):
L_o is determined using an optical encoder that detects position changes relative to a reference point via incremental coding. ΔL is measured using a high-resolution LVDT that converts the position of a movable core into an electrical signal. This dual-sensor approach combines the large measuring range and directional sensitivity of the optical encoder with the high resolution and repeatability of the LVDT, effectively balancing their respective strengths and limitations.

Despite compensation for hysteresis, non-linearities, drift and offset, the system remains sensitive to mechanical and thermal influences. To compensate for these, calibration with reference standards is necessary.

Laser dilatometers represent a fundamental advance in this area:
They measure L_o and ΔL simultaneously and absolutely; without contact, using laser interferometry. The total length change is calculated directly from the phase shift of two superimposed laser beams. This completely eliminates mechanical couplings and calibration artifacts.

Optical errors such as offset or phase shifts are automatically corrected by advanced algorithms. The result: measurements with sub-nanometer resolution (up to 0.3 nm*) and maximum long-term stability – even for samples with very low expansion or sensitive surfaces.

* tested in laboratory environments



Absolute length measurement using interferometric path difference

The **LINSEIS DIL L75 Laser (DIL L73 Laser)** uses a homodyne Michelson interferometer with a frequency-stabilized helium-neon laser (λ=632.8 nm) to directly detect thermally induced length changes. The high coherence length of the laser allows precise detection of minimal path differences as phase shifts (γ_{ref}) in the interference signal – even with varying sample geometries and complex surfaces, without the linearity deviation of classic LVDT sensors. With a resolution of up to 0.3 nm*, the absolute length of the sample (s) is dynamically recorded in relation to the temperature profile.

*tested in laboratory environments

$$s = \frac{1}{k_{IF} k_1} \gamma_{rel} = \frac{\lambda}{k_{IF}} \cdot \frac{\gamma_{rel}}{2\pi}$$

s = Sensitivity

k_{IF}= Interference constant

γ_{rel}= Phase shifts

k_1= Wave number of radiation

λ = Wavelength of the laser

Design and measuring principle

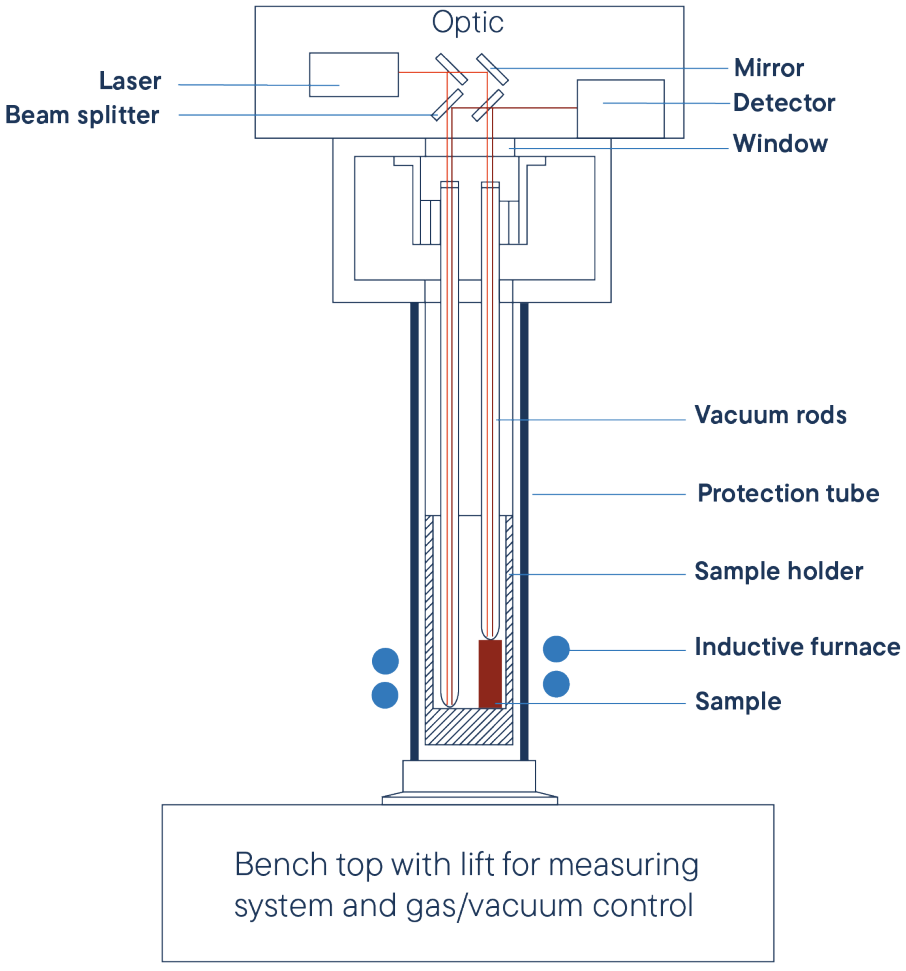
The **DIL L75 Laser (DIL L73 Laser)** is based on a highly stable metrology frame in which the interferometer and sample form a closed measuring circuit. This is fully retracted into the furnace, forming a vacuum- and pressure-tight measuring chamber – ideal for analyses under defined atmospheres.

The vertical arrangement uses gravity as a constant reference value. A finely adjustable sample contact pressure ensures reproducible contact conditions for every measurement. The entire geometry is designed for maximum stability – optical disturbances caused by kinking, bending or tilting are effectively minimized.

The heating furnace is thermally limited to the relevant sample area. Thanks to LINSEIS many years of furnace expertise, the system achieves homogeneous temperature distribution, high heating rates and precise control – without influencing the optical measurement technology.

Measuring system of an DIL L73 Laser

The measuring system is based on a vertically aligned laser interferometer. The laser beam enters the evacuated measuring chamber through an optical window and is precisely aligned with the sample via mirrors. The sample is located in a holder inside a protective tube and is heated by an inductive furnace. Evacuated quartz rods ensure an optically pure measuring path and prevent refractive index and convection influences. The completely closed chamber enables measurements under inert gas, vacuum or reactive atmospheres.




deliv
outst
ser


ering
anding
vice

Unique features

Vacuum and controlled atmosphere

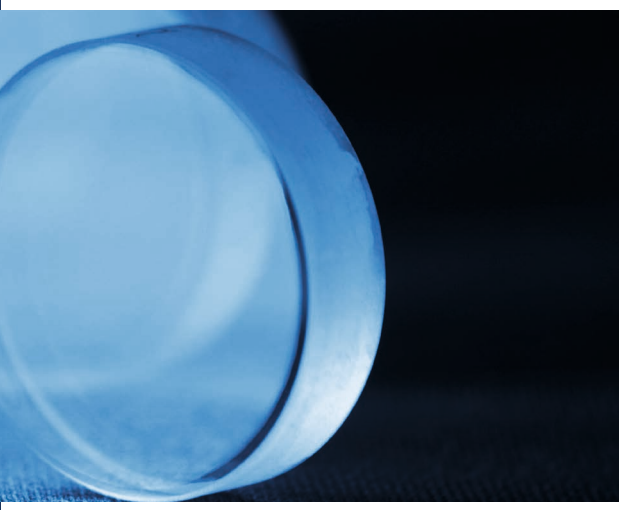
The pressure- and vacuum-tight measuring chamber supports high vacuum, inert, reducing, oxidising and humidified conditions. atmospheres.

Stable and precise displacement signal

The measurement provides an absolute, linear signal, free from hysteresis and drift effects. Integrated signal stabilization with automatic corrections of offset, amplitude and frequency reliably suppresses interference such as noise, laser drift or modulation errors. This ensures stable and highly accurate results at all times.

Wide temperature range -180 °C to 1000 °C

A welded Type K thermocouple directly on the sample provides the actual local temperature and allows the expansion behavior to be precisely assigned to the thermal signal. This enables precise furnace control with simultaneous measurement signal validity—even at high heating and cooling rates.



Integrated LINSEIS platform

The integrated LINSEIS software offers a comprehensive solution, combining both hardware and software for maximum process security and precision. By providing a unified platform, it ensures seamless integration of components and devices from external partners, resulting in a highly robust system.

Customization

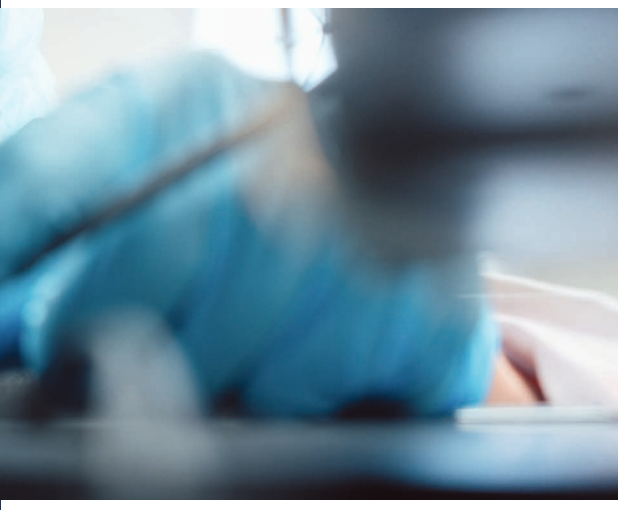
Close collaboration with the customers to tailor unique solutions, leveraging LINSEIS expertise to meet their specific needs.

Service

Our international presence across every continent enables us to deliver the best and fastest service possible.

Accessories

Accessories available include equipment for precise sample preparation and calipers for manually or electronically inputting sample length. There are also gas supply units available in manual, semi-automatic or MFC-controlled versions. Other accessories include the rate-controlled sintering (RCS) software module, various rotary and turbomolecular vacuum pumps, and LN_2-based cooling systems.



High precision
Laser interferometer for sub-nanometer resolution

Contactless laser measurement
Adjustable measuring force on the sample, non-contact determination of the expansion

Wide temperature range
Operation from RT to 1000 °C/
-180 °C to 500 °C/
-180 °C to 1000 °C/

User friendly software
Comprehensive data analysis and reporting

Extended cooling options
Air, liquid, nitrogen or closed cooling circuit

Technical **Specifications**

Feature	Value
Temperature range	-180 °C up to 500 °C/ -180 °C up to 1000 °C/ RT up to 1000 °C
Resolution	0.3 nm*
Heating/cooling rates	0.01 K/min to 50 K/min**
Sample length	up to 50 mm
Sample diameter	up to 7 mm
Sample holder	fused silica
Atmosphere	inert, oxic., red., vac.
Interfaces	USB

* tested in laboratory environments

** depends on furnace

DIL L75 (DIL L73) Laser

Software

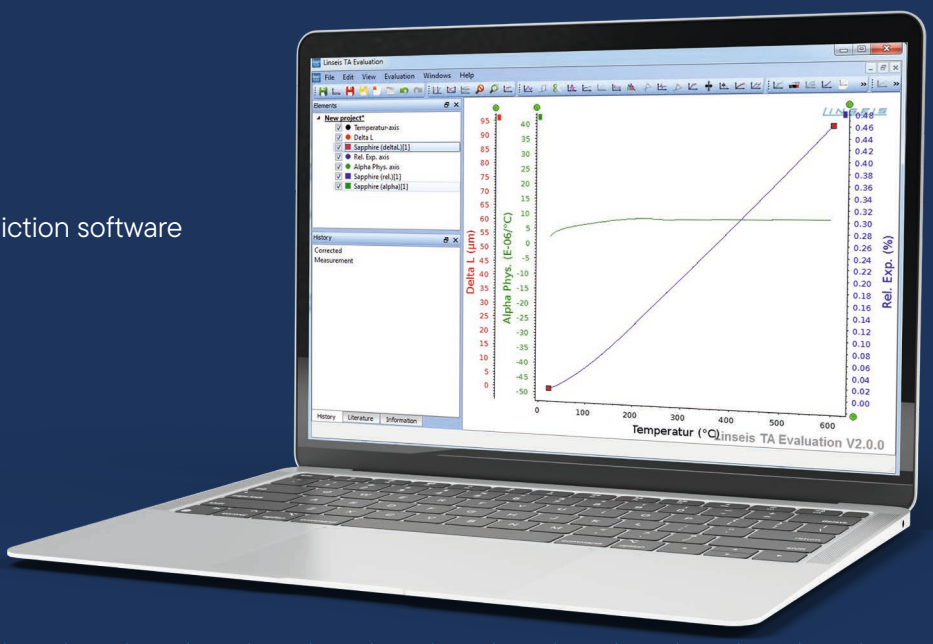
All LINSEIS thermo analytical instruments are PC controlled. The individual software modules exclusively run under Microsoft® Windows® operating systems. The complete software consists of 3 modules:
temperature control, data acquisition and data evaluation. The 32 bit software incorporates all essential features for measurement preparation, execution and evaluation of a Thermogravimetric measurement. Thanks to our specialists and application experts, LINSEIS was able to develop comprehensive easy to understand user friendly application software.

Features-Software:

- Program capable of text editing
- Data security in case of power failure
- Thermocouple break detection
- Repetition measurements with minimum parameter input
- Evaluation of current measurement
- Curve comparison up to 32 curves
- Storage and export of evaluations
- Export and import of data ASCII
- Data export to MS Excel
- Multi-methods analysis (DSC TG, TMA, DIL, etc.)
- Zoom function
- 1st and 2nd derivation
- Programmable gas control
- Statistical evaluation package
- Free scaling
- Automatic calibration
- Optional kinetic and lifetime prediction software packages

DIL Features:

- Rate Controlled Sintering (RCS) software
- Interchangeable thermocouples for various atmospheres
- Sinter process evaluation
- Glass transition and softening point evaluation
- Softening point determination and system shut down
- Linear thermal expansion evaluation
- Several system correction features
- Automatic zero point adjustment
- Auto-scheduler for up to 16 subsequent runs



The **LINSEIS Thermal Library** is available as an optional extension to the well-established and user-friendly **LINSEIS LiEAP** (Linseis Evaluation and Acquisition Platform) software, which is integrated into almost all of our instruments. With the Thermal Library, sample materials can be identified within just 1–2 seconds by comparing the measurement curve against a comprehensive database containing thousands of references and standard materials.

Multi-Instrument

LINSEIS instruments such as DIL, DSC, STA, TGA & LFA can be controlled with the same powerful LiEAP software platform.

Report Generator

Convenient template selection to generate customized measurement reports.

Kinetic software

Kinetic analysis of DIL, DSC, DTA, TGA, EGA (TG-MS, TG-FTIR) data for the study of the thermal behavior of raw materials and products.

Multi-Lingual

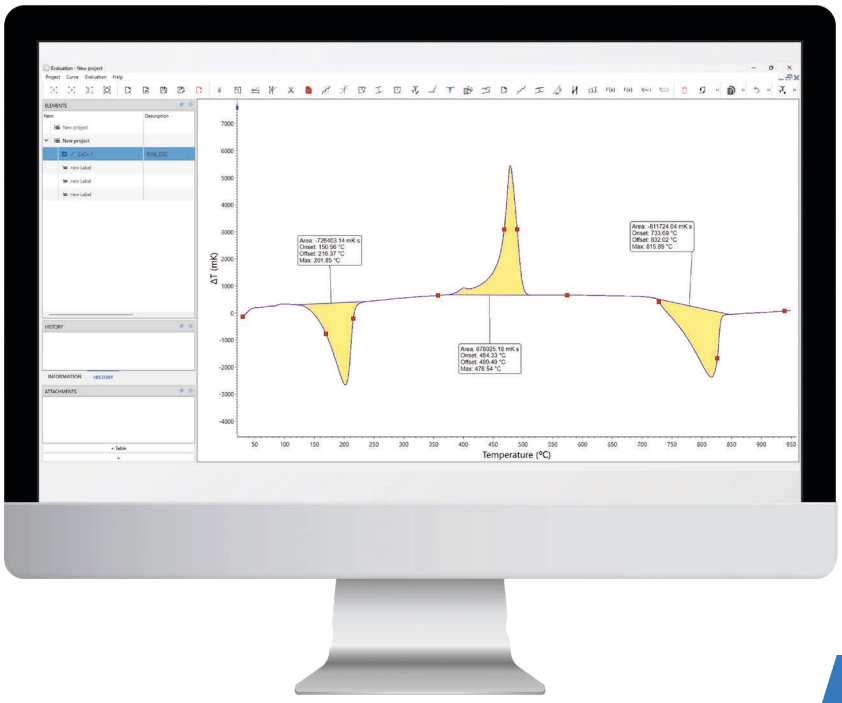
Our software is available in many different user exchangable languages, such as: English, Spanish, French, German, Chinese, Korean, Japanese, etc.

Multi-User

The administrator can generate different user levels providing different rights to operate the instrument. A optional Log file is also available.

Database

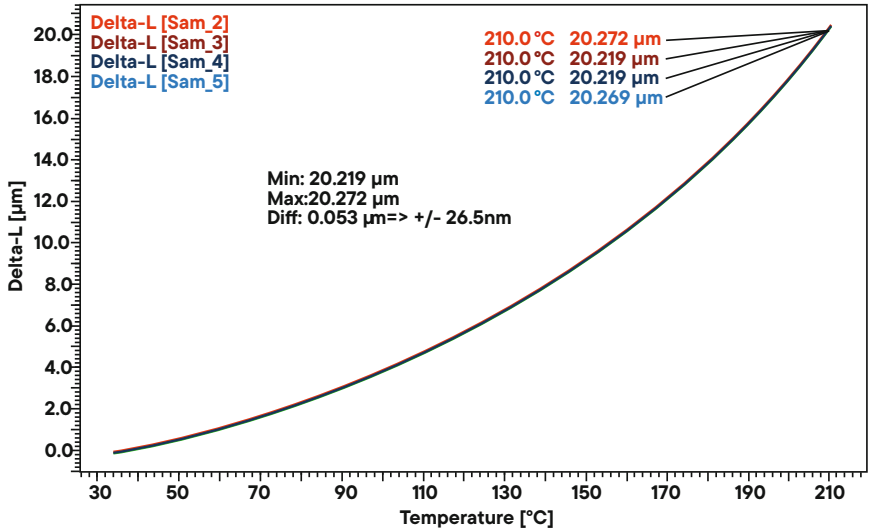
State of the art database design enables easy data handling.



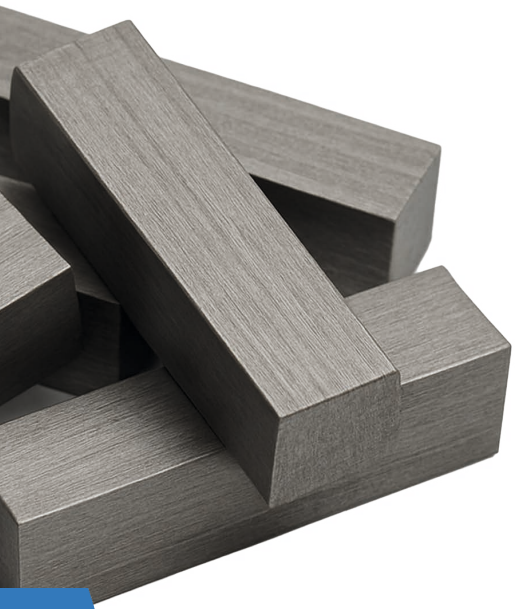
More Applications

Applications

Reproducibility of an Invar sample



An Invar sample was measured with four times from room temperature up to 210 °C in air using a LINSEIS L73 Laser dilatometer.
To assess reproducibility, the results of the four consecutive runs were compared. The system demonstrated an outstanding reproducibility of 0.01 % of the full measurement range, as illustrated in the adjacent figure. Compared to a conventional push-rod dilatometer, the laser-based system achieved a 33-fold improvement in reproducibility. In addition to its superior precision, the laser dilatometer provides absolute expansion values without the need for baseline correction or reference materials.



LINSEIS

pushing boundaries

LINSEIS GmbH Germany

Vielitzerstr. 43
95100 Selb

Tel.: (+49) 9287 880 0
E-mail: info@linseis.de

LINSEIS Inc. USA

109 North Gold Drive
Robbinsville, NJ 08691

Tel.: (+1) 609 223 2070
E-mail: info@linseis.com

LINSEIS China

Kaige Scientific Park
Room 120, Building T3, No.1220
Yuqiao Road, Pudong, Shanghai

Tel.: (+86) 61 90 12 03
Tel.: (+86) 50 55 06 42
E-mail: info@linseis.com.cn

LINSEIS India

Plot 65, 2nd Floor, Sai Enclave,
Sector 23, Dwarka05-800
110077 New Delhi

Tel.: (+91) 11 42883851
E-mail: sales@linseis.in

WWW.LINSEIS.COM

10/2025

LINSEIS

pushing boundaries

DIL L78 Q
DIL L78 Q/D
DIL L78 Q/D/T

Thermo-pyhsical testing

Quenching & Deformation

WWW.LINSEIS.COM

Since 1957 LINSEIS Corporation has been delivering outstanding service, know-how and leading innovative products in the field of thermal analysis and thermo-physical properties.

Customer satisfaction, innovation, flexibility, and high quality are what LINSEIS represents. Thanks to these fundamentals, our company enjoys an exceptional reputation among the leading scientific and industrial organizations. LINSEIS has been offering highly innovative benchmark products for many years.

The LINSEIS business unit of thermal analysis is involved in the complete range of thermoanalytical equipment for R&D as well as quality control. We support applications in sectors such as polymers, chemical industry, inorganic building materials, and environmental analytics. In addition, thermophysical properties of solids, liquids, and melts can be analyzed.

Rooted in a strong family tradition, LINSEIS is proudly steered into its third generation, maintaining its core values and commitment to excellence, which have been passed down through the family leadership. This generational continuity strengthens our dedication to innovation and quality, embodying the essence of a true family-run business.

LINSEIS provides technological leadership. We develop and manufacture thermoanalytic and thermophysical testing equipment to the highest standards and precision. Due to our innovative drive and precision, we are a leading manufacturer of thermal analysis equipment.

The development of thermoanalytical testing machines requires significant research and a high degree of precision. LINSEIS Corp. invests in this research to the benefit of our customers.

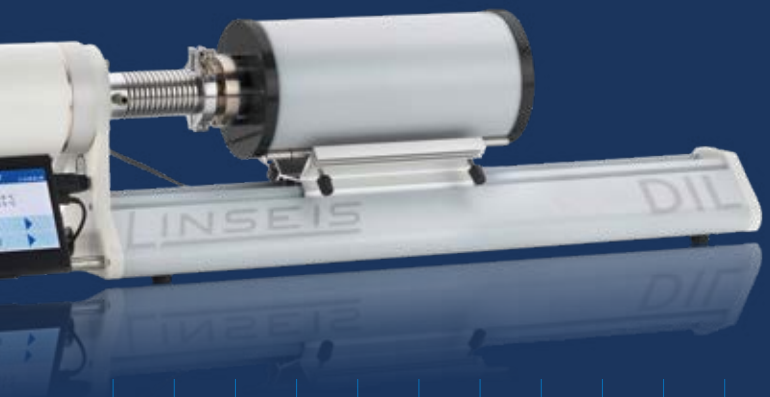
C L A U S L I N S E I S

C E O D I P L . P H Y S .

Engineering & Innovation

To strive for the best due diligence and accountability is part of our DNA. Our history is affected by German engineering and strict quality control.

We want to deliver the latest and best technology for our customers. LINSEIS continues to innovate and enhance our existing thermal analyzers. Our goal is to constantly develop new technologies to enable continued discovery in Science.



Thermal **physical testing**

Many metals behave like elastic objects over a certain temperature range. This range varies for different metals and is influenced by factors such as mechanical properties, atmospheric exposure (corrosion), grain size, heat treatment and working temperature.

Materials Testing Applications

- Hot/Warm Tensile Testing
- Hot Compression Testing
- Stress vs. Strain Curves
- Thermal Cycling/Heat Treatment
- Dilatometry/Phase Transformation
- Stress Relaxation Studies
- Creep/Stress Rupture
- Quench Dilatometry
- Deformation Dilatometry

Process simulation capabilities

- Hot Rolling
- Forging
- Extrusion
- Heat Treatment
- Quenching

High value metals must be extremely reliable and perform consistently under a variety of harsh and hostile conditions. It is necessary for our customers to be able to reliably analyze the properties of different metals. The results of these tests are then applied to the various environments in which the metals will be used. In this way, the manufacturing process can be optimized to produce a durable material.

Quenching and Deformation in Metallurgy

Quenching is the rapid cooling of a heated materital in a quenching medium (in our chase gas) to achieve. In metallurgy, quenching is one of the critical steps in the heat treatment of a metal and is typically used to harden the final product, e.g. steel.

DIL L78 Q (Quenching)

TTT- CCT- CHT - Diagram

There are three main types of transformation diagram that are useful in selecting the optimum steel and processing route to achieve a given set of properties. These are Time Temperature Transformation (TTT), Continuous Cooling Transformation (CCT) and Continuous Heating Transformation (CHT) diagrams.

DIL L78 Q/D/T (Deformation and Tension)

Metal Deformation

When a sufficient load is applied to a metal or other structural material, it causes the material to change shape. This change in shape is known as deformation.
It is caused either by the mechanical action of external forces or by various physical and physiochemical processes. The deformed or mechanically worked metals are far superior to cast metals.

Tensile (load) tests and stress-strain curves

Stress-strain curves are an extremely important graphical measure of the mechanical properties of a material. The graph gives us many mechanical properties such as e-moduls, tensie strength and yiel strength.

The stress-strain diagram expresses a relationship between a load applied to a material and the deformation of the material caused by the load. The stress-strain diagram is determined by tensile testing. Tensile tests are performed in tensile testing machines (DIL L78 Q/D/T), which provide a controlled, uniformly increasing tensile force applied to the specimen.

DIL L78 Q

Our quenching dilatometers allow us to simulate production processes with complex temperature profiles for optimizing steels, alloys, and other metals. Especially for steels, many phase transitions come along with a change in density or at least a change in the expansion coefficient of the material. The simultaneous dilatation measurement of the L78 makes it therefore possible to detect phase transitions of the micro sturcture of the sample during the heat treatment cycle. This is of great importance for the optimization of your production processes.

DIL L78 Q

The DIL L78 **Q** is the basic version of the L78 series and allows for fast heating and **Q**uenching of samples and can be used for creating CHT, CCT and isothermal transformation diagrams

DIL L78 Q/D/T

DIL L78 Q/D

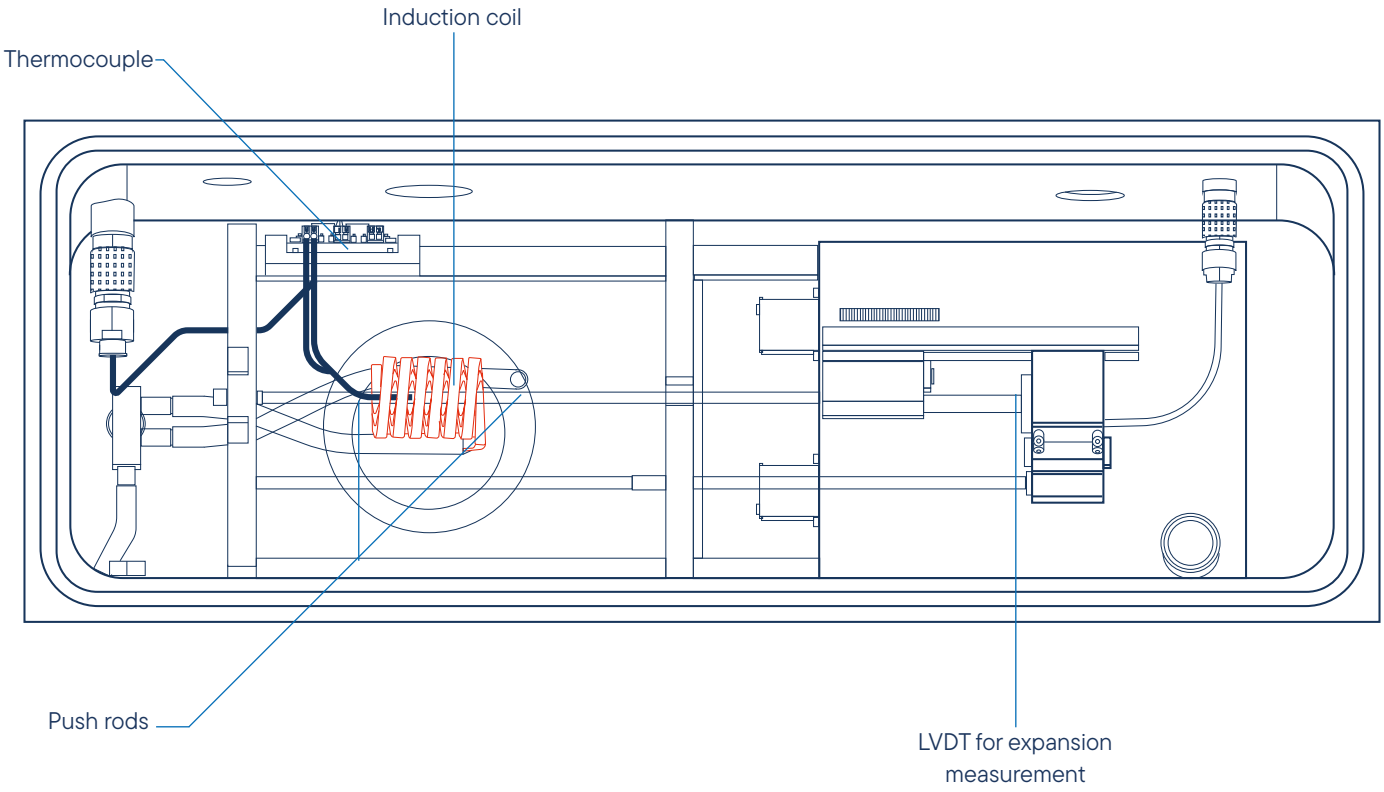
The L78 **Q/D** allows, in addition to the **Q**uenching dilatometer, for **D**eforming samples by applying compression.

DIL L78 Q/D/T

The L78 **Q/D/T** allows the full range of thermomechanical treatments: **Q**uenching, **D**eformation by compression, and **T**ensile testing.

Quenching mode

- Very low force
- CTE - Coefficient of Thermal Expansion
- Creation of TTT diagrams
- Determine phase changes at different cooling rates
- Maximum cooling: 4000 °C/s (hollow sample and maximum achievable cooling rate
- Low temperature option (T_{min} = -150 °C)
- Optional Laser speckle measurement of expansion (patent no. DE 10 2017 216 714.9)

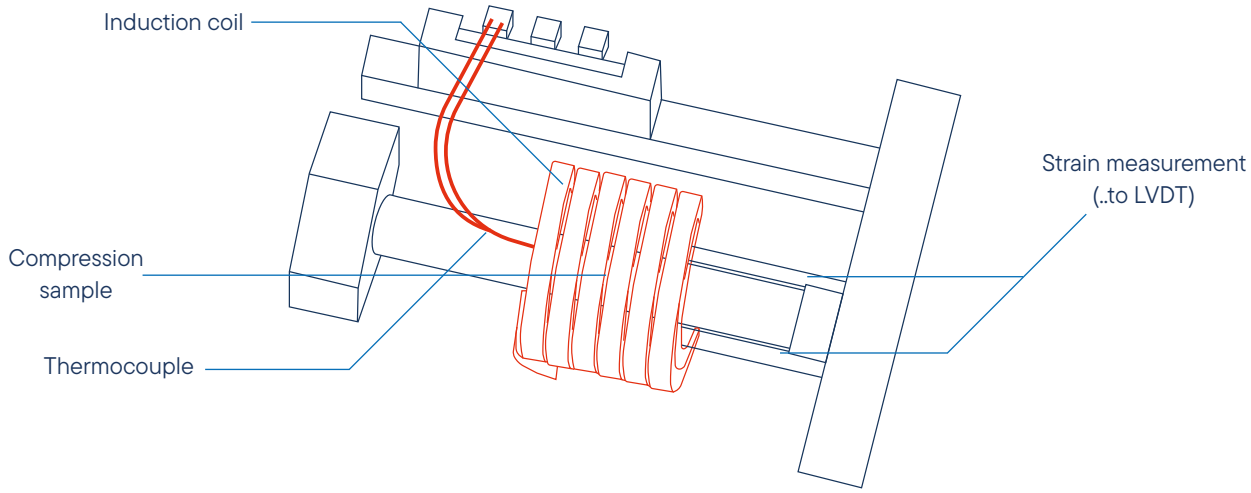


Accessories for Quenching mode

- Various turbomolecular pumps (standard and high flow)
- Thermocouple welder (optional inert gas mode)
- Cryogenic add-on (-150 °C in quench mode)
- Laser speckle option for 2-dimensional strain measurement
- -150°C in quenching mode, -50°C in tension und deformation mode

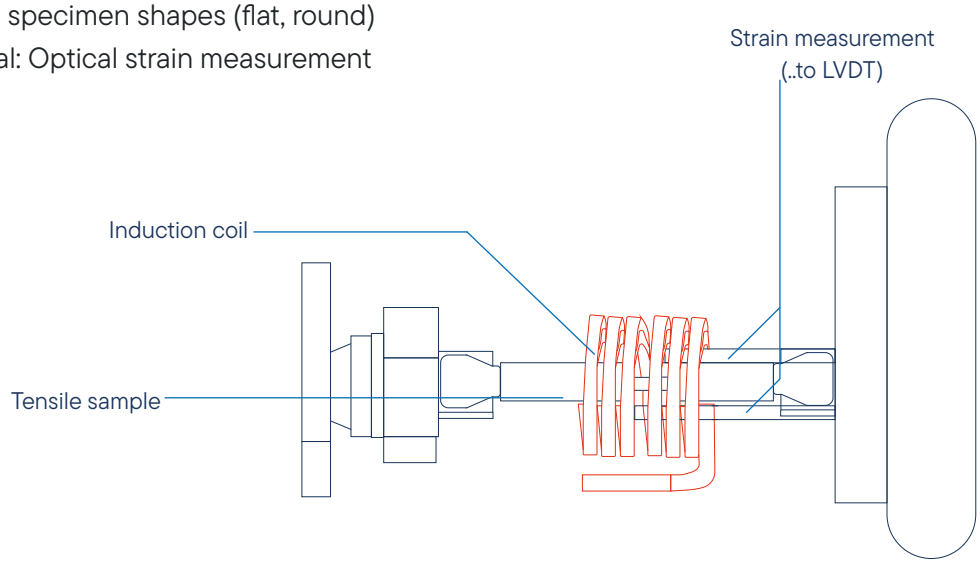
Deformation mode

- Simulation of manufacturing processes with mechanical stress such as hot rolling or forging
- Maximum cooling rate: 125 °C/s
    - Maximum force: 22 kN (compression)
    - Compression rate: 0.005 - 100 mm/s (more on request)



Tensile mode

- E-modulus determination
- Fracture Tests
- Maximum cooling rate: 125 °C/s
- Maximum force: 22 kN (tension)
- Tensile speed: 0.005 - 100 mm/s
- Various specimen shapes (flat, round)
- Optional: Optical strain measurement

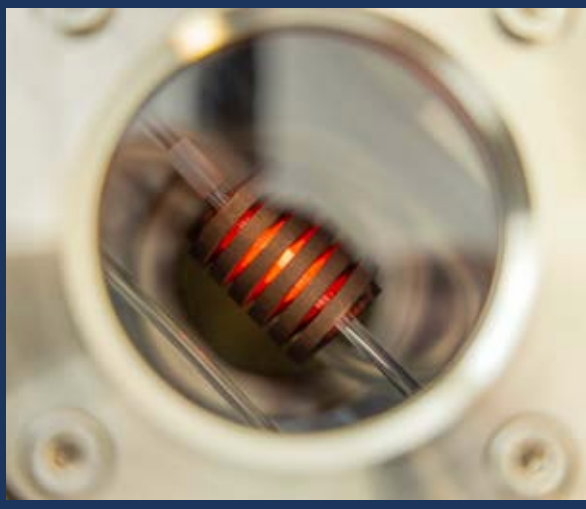



deliv
outst
ser


ering
anding
vice

Unique features

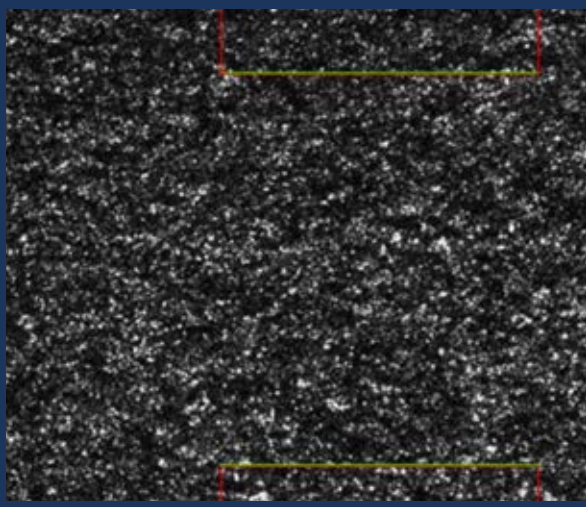
Patented Precision with Speckle Analysis
The DIL L78 sets a new benchmark in thermal analysis with its patented speckle measurement technology. This innovative, non-contact method ensures unmatched precision in detecting minute displacements and deformations during thermal expansion processes. Perfect for applications demanding the highest level of accuracy.



Maintenance-Free Electrical Actuator
Designed for durability and reliability, the DIL L78 Q/D/T features a maintenance-free electrical actuator. Unlike traditional systems, this actuator eliminates the need for regular servicing, reducing downtime and operational costs, while ensuring smooth and consistent performance.

Laser Ultrasound Integration
The DIL L78 is equipped to combine seamlessly with laser ultrasound technology, enabling non-invasive, contact-free measurements with exceptional resolution. This powerful integration makes it ideal for challenging materials and complex analysis tasks, expanding the boundaries of thermal investigation.

DSC – Differential Scanning Calorimetry
Differential Scanning Calorimetry (DSC) is the most popular thermal analysis technique. It measures endothermic and exothermic transitions as a function of temperature.



Endothermic = heat flows into a sample
Exothermic = heat flows out of the sample

Accessoires

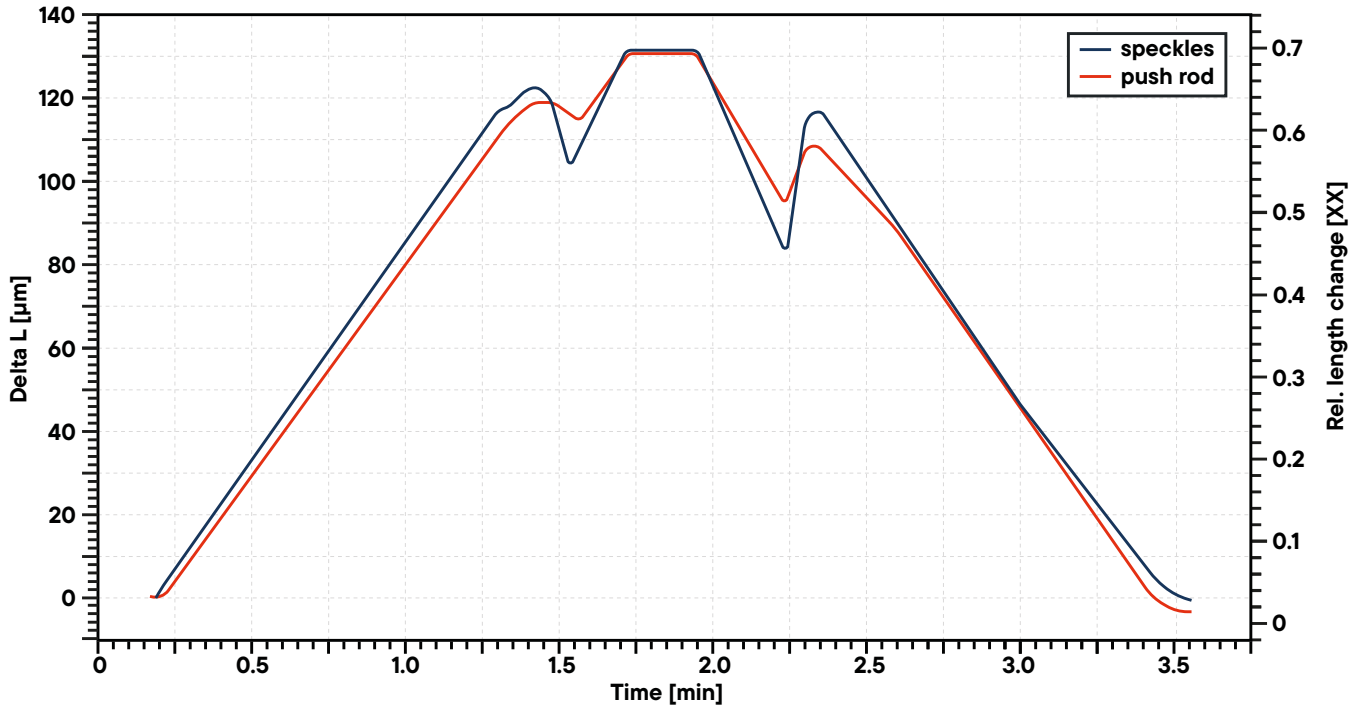
Laser speckle measurement of dilatation

- Optical Displacement Sensor / Optical Extenso-meter
- Camera observes speckle patterns generated by laser
- Camera images are evaluated after measurement
- Size and position of areas are user definable
- Up to 2 megapixel resolution
- Determination of anisotropy
- No markers required on sample
- 2D dot matrix for selectable areas
- Measure directly on the sample surface (no edge required)
- 2-dimensional measurement possible
- Small measurement area → small temperature gradient
- Length measurement very close to the thermo-couple is possible
- Relatively small gap in the coil required

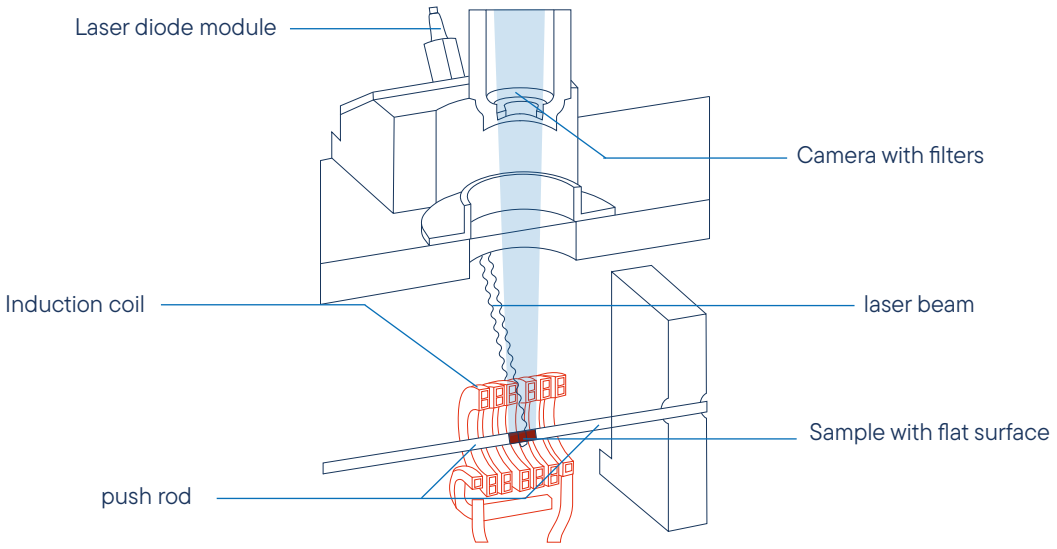
Technical Specifications

Resolution	1024x1024 px
Image size	1.6 x 1.6 mm³ ... 11 x 11 mm²

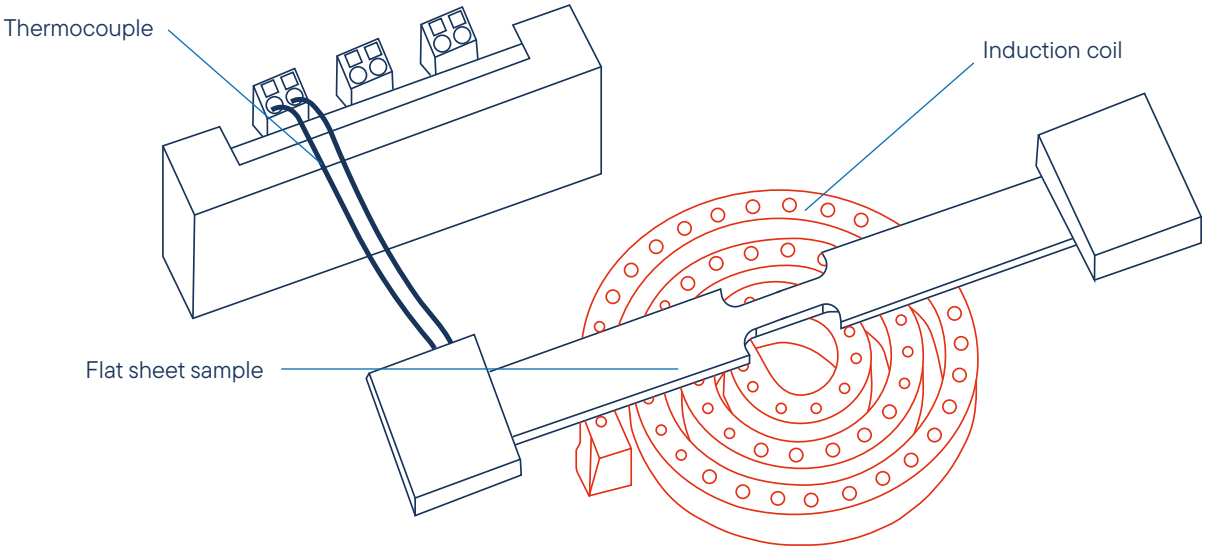
Comparison speckels vs push rod measurement



Quenching mode design



Tensile mode design



Non-destructive laser ultrasonic NDT technology

Real-time insight into the grain growth

The laser ultrasonic (LUS) nondestructive testing (NDT) technique allows in-situ grain size analysis based on the evaluation of the frequency-dependent ultrasonic attenuation *α(f)*, which is mainly caused by grain boundary scattering due to the applied method. The frequency-dependent ultrasonic attenuation is modeled by the following power law:

$$\alpha(f) = a + bf^n$$

The attenuation coefficient *α(f)* is composed of an absorption coefficient α, a scattering coefficient *b*, the frequency *f* and the exponent *n*, where the absorption coefficient describes the internal friction losses and the scattering coefficient is the interesting grain size parameter (proportional to the mean grain size).
The exponent *n* results from the ratio of the acoustic wavelength to the mean grain size, where three types of scattering can be distinguished, Rayleigh (*n*=4), stochastic (*n*=2) and geometric scattering [1].

The relationship between the scattering coefficient and the grain size of interest *D* is modeled as follows:

$$\alpha(f) = a + C(D - D0)^{n-1} f^n$$

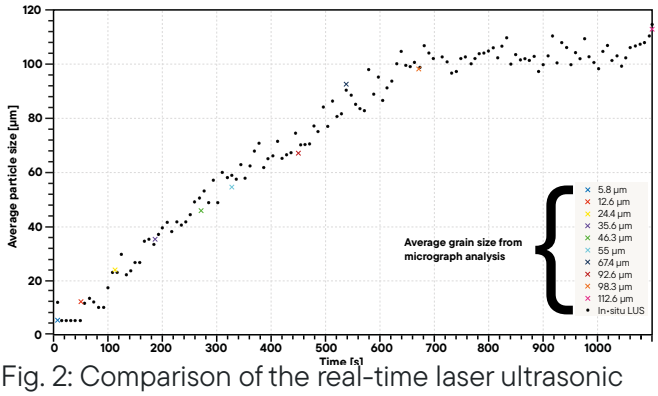


Fig. 2: Comparison of the real-time laser ultrasonic grain size calculations (points) with the micrograph analysis of quenched samples (colored X markings) of plain carbon steel AISI 1045

The scattering coefficient *b* is the product of the material dependent parameter *C* and the relative change in mean grain size *D*-*D*0 (*D*0 - initial grain size). Calibration of the model using mean grain size values from micrographs at specific temperature conditions yields the parameter *C* [2].

Figure 2 shows an impressive comparison of these real-time LUS results (dots) with several time-consuming micrograph analyses (colored X markers).

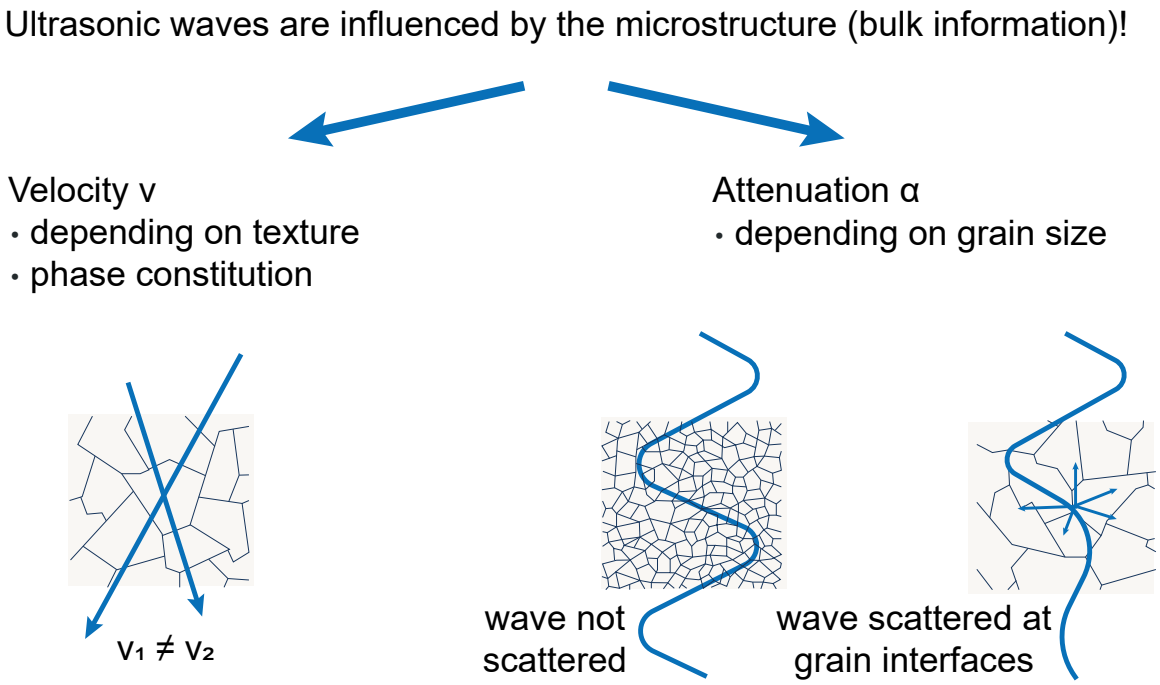
source:
[1] S. Sarkar, A. Moreau, M. Militzer, and W. J. Poole, "Evolution of austenite recrystallization and grain growth using laser ultrasonics," Metall. Mater. Trans. A Phys. Metall. Mater. Sci., vol. 39 A, no. 4, pp. 897–907, 2008, doi: 10.1007/s11661-007-9461-6.

[2] T. Garcin, J. H. Schmitt, and M. Militzer, "In-situ laser ultrasonic grain size measurement in superalloy INCONEL 718," J. Alloys Compd., vol. 670, pp. 329–336, 2016, doi: 10.1016/j.jallcom.2016.01.222.

Laser ultrasonic measurements and data analysis using this attenuation model provide real-time (in-situ) insight into the grain growth of a material during thermal cycling.
In-situ laser ultrasonic testing replaces time-consuming measurements and provides results in real time.

Real-time, in-situ measurement of:

- Recrystallization
- Grain growth
- Grain size
- Phase transitions
- Elastic constants



Software

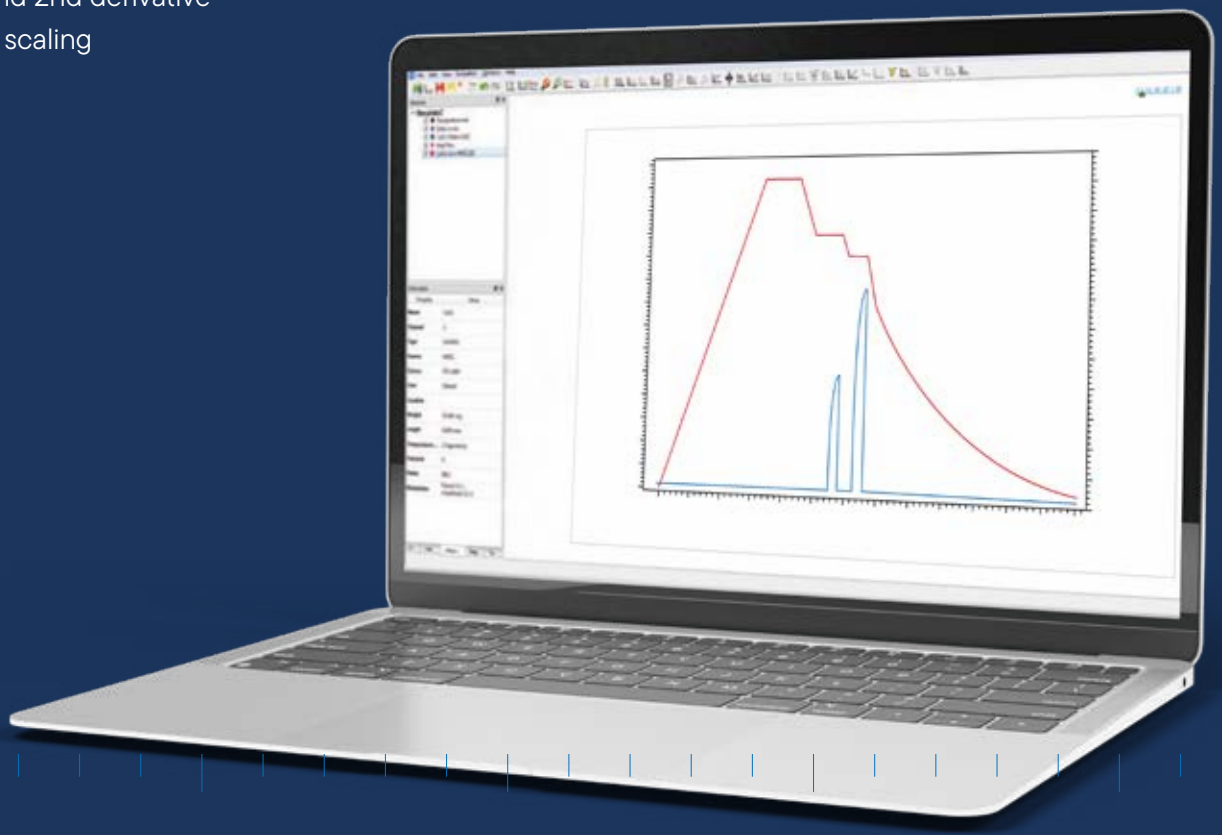
Our intuitive software interface ensures effortless operation, even for complex measurements. With its streamlined workflow, comprehensive data analysis tools, and real-time monitoring capabilities, the software empowers users to achieve reliable results with minimal training.

General Features

- Program capable of text editing
- Data security in case of power failure
- Thermocouple break protection
- Repetition measurements with minimum parameter input
- Evaluation of ongoing measurement
- Storage and export of evaluations
- Export and import of data ASCII
- Data export to MS Excel
- Multi-methods analysis (DSC TG, TMA, DIL, etc.)
- Zoom function
- 1st and 2nd derivative
- Free scaling

DIL Features

- Display of relative/absolute shrinkage or expansion curves
- Presentation and calculation of technical/ physical expansion coefficient
- Semiautomatic evaluation functions
- Special Software package for creation of CCT / CHT / TTT diagrams




pus
bound


shing
laries

Technical Specifications

L78 Q (Quenching)

Furnace	Induction Furnace
Temperature range	-150 °C up to 1600 °C (more on request)
Temperature measurement	up to 3 thermocouples welded to sample
Price range	$$
Sample geometry	ø 3 mm hollow: 3.5 mm OD / 3 mm ID 10 mm long
Sample geometry (optional for heat treatment)	10x10x60 mm (others on request)
Heating rate	≤ 4000 K/s*
Cooling rate	≤ 4000 K/s*
Length change measurement	+/- 1.2 mm
Data sampling (for temperature, length, force)	up to 1 kHz
Length change resolution	5 nm
Data resolution	24-bit
Instrument dimensions	60x60x110 cm (without accessories)
Power supply	16 A, 208-230 V

*maximum heating/cooling rate, hollow sample

L78 Q/D (Quenching+Deformation)

Furnace	Induction Furnace
Temperature range	-150 °C up to 1600 °C (quenching mode) Sample dependent 1750 °C
Price range	$$$
Sample geometry quenching	ø 3 mm rec. hollow: 3.5 mm OD / 3 mm ID 10 mm long
Sample geometry compression	solid samples, diameter 5 mm, 10 mm long
Heating rates	≤ 125 K/s
Cooling rates	≤ 125 K/s
Lenght change measurement Compression mode	+/- 5 mm
Length change measurement Quenching mode	+/- 1.2 mm
Length measurement resolution	5 nm (optional 1nm)
Compression force	22 kN (max)
Stroke rate	0.005 - 100 mm/s (more on request)
True strain (compression mode)	-0.02 to -1.2
Data sampling (for temperature, length, force)	up to 1 kHz
Mechanical control modes	stroke, force, true strain rate

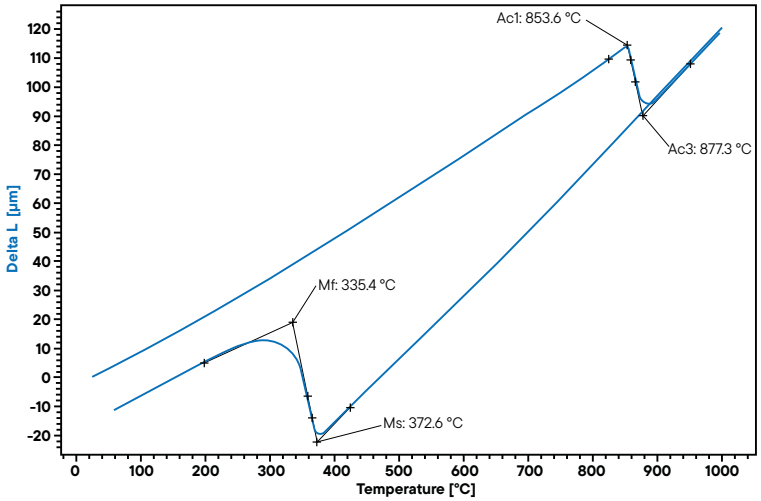
L78 Q/D/T (Quenching, Deformation and Tensile)

Furnace	Induction Furnace
Sample geometry quenching	Ø 3 mm rec. hollow: 3.5 mm OD / 3 mm ID 10 mm long
Sample geometry compression	solid samples, diameter 5 mm, 10 mm long
Sample geometry tensile	round, flat sheet
Heating rates	≤ 125 K/s
Cooling rates	≤ 125 K/s
Length change measurement compression mode	+/- 5 mm
Length change measruement quenching mode	+/- 1.2 mm
Length measurement resolution	5 nm (optional 1 nm)
Heating rates	≤ 125 K/s
Cooling rates	≤ 125 K/s
Compression/tensile force	22 kN (max)
Stroke rate (compression and tensile)	0.005 - 100 mm/s (more on request)
True strain (compression mode)	-0.02 to -1.2
Data sampling (for temperature, length, force)	up to 1 kHz
Mechanical control modes	stroke, force, true strain rate

DIL L78 Overview

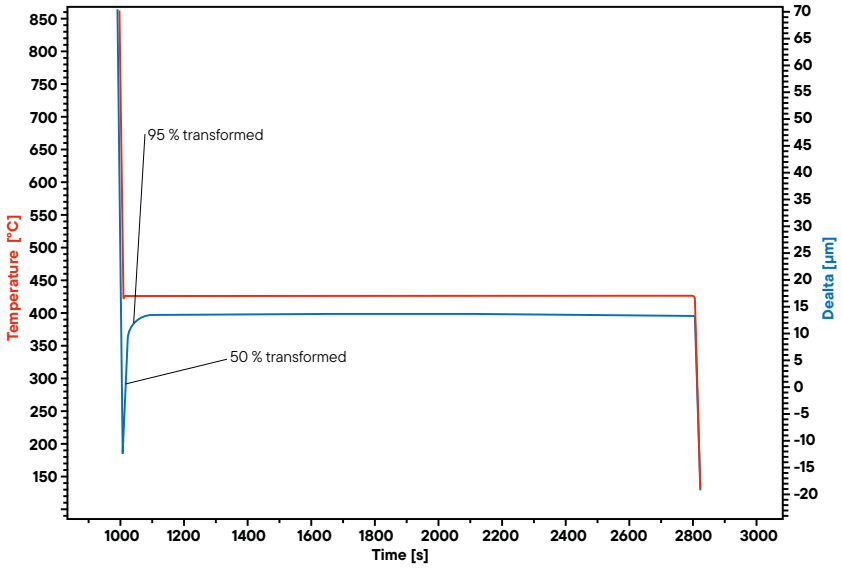
Applications
DIL L78 RITA

Steel Phase Transformation



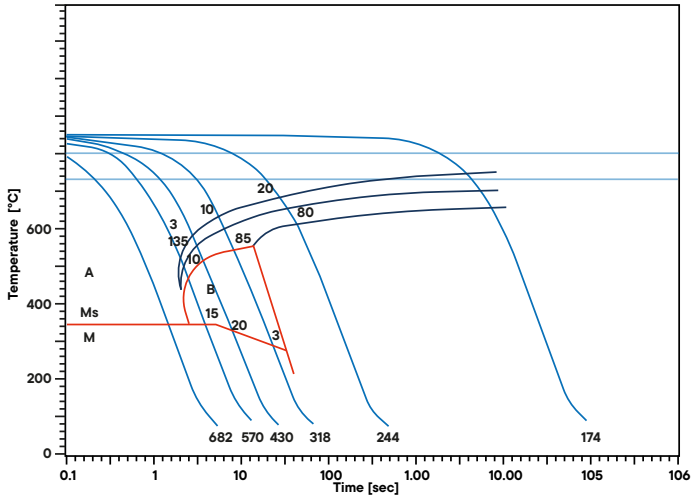
For creating a CCT diagram, the sample is quenched at different cooling rates. Depending on the cooling rate the sample may transform into different microstructures. The sample temperature and transformation start and end temperatures are transferred into the CCT diagram.

Isothermal transformation



The graphic on the left side shows length and temperature of a sample for creating a TTT diagram. While sample temperature remains constant the sample transforms into a different microstructure.

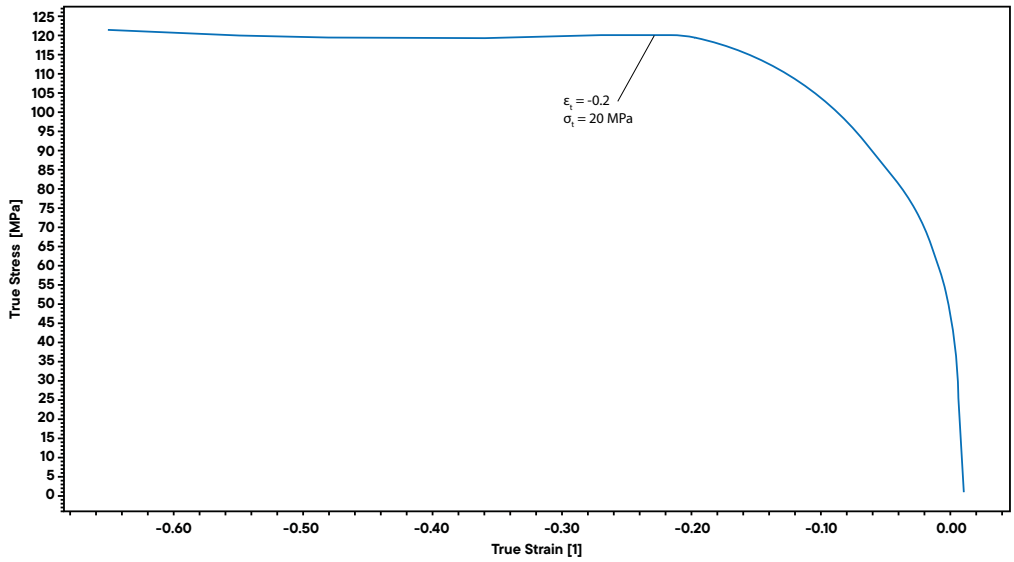
Continuous Cooling Transformation Diagram (CCT)



Picture © Dr. Sommer Werkstofftechnik GmbH, Issum

The CCT phase diagram represents the phase transformation of a material when it is cooled at various controlled rates. CCT diagram allow the prediction of the final microstructure of the measured steel. This crystalline structure determines the physical properties of the material. The L78 Q and L78 Q/D is the ideal tool to observe small dimensional changes under extreme conditions of controlled cooling. With the intuitive Software it is easy to prepare CCT, CHT and TTT diagrams from the test results.

Flow curve



The diagram shows the mechanical stress that is applied to the sample while the sample is compressed at a constant displacement rate or at a constant true strain rate. The sample shown here was compressed at 5 mm/s at 100 °C.

Linseis Service Lab

LINSEIS

pushing boundaries

LINSEIS GmbH Germany

Vielitzerstr. 43
95100 Selb

Tel.: (+49) 9287 880 0
E-mail: info@linseis.de

LINSEIS Inc. USA

109 North Gold Drive
Robbinsville, NJ 08691

Tel.: (+1) 609 223 2070
E-mail: info@linseis.de

LINSEIS China

Kaige Scientific Park
Room 120, Building T3, No.1220
Yuqiao Road, Pudong,Shanghai

Tel.: (+86) 61 90 12 03
Tel.: (+86) 50 55 06 42
E-mail: info@linseis.com.cn

LINSEIS India

Plot 65, 2nd Floor, Sai Enclave,
Sector 23, Dwarka05-800
110077 New Delhi

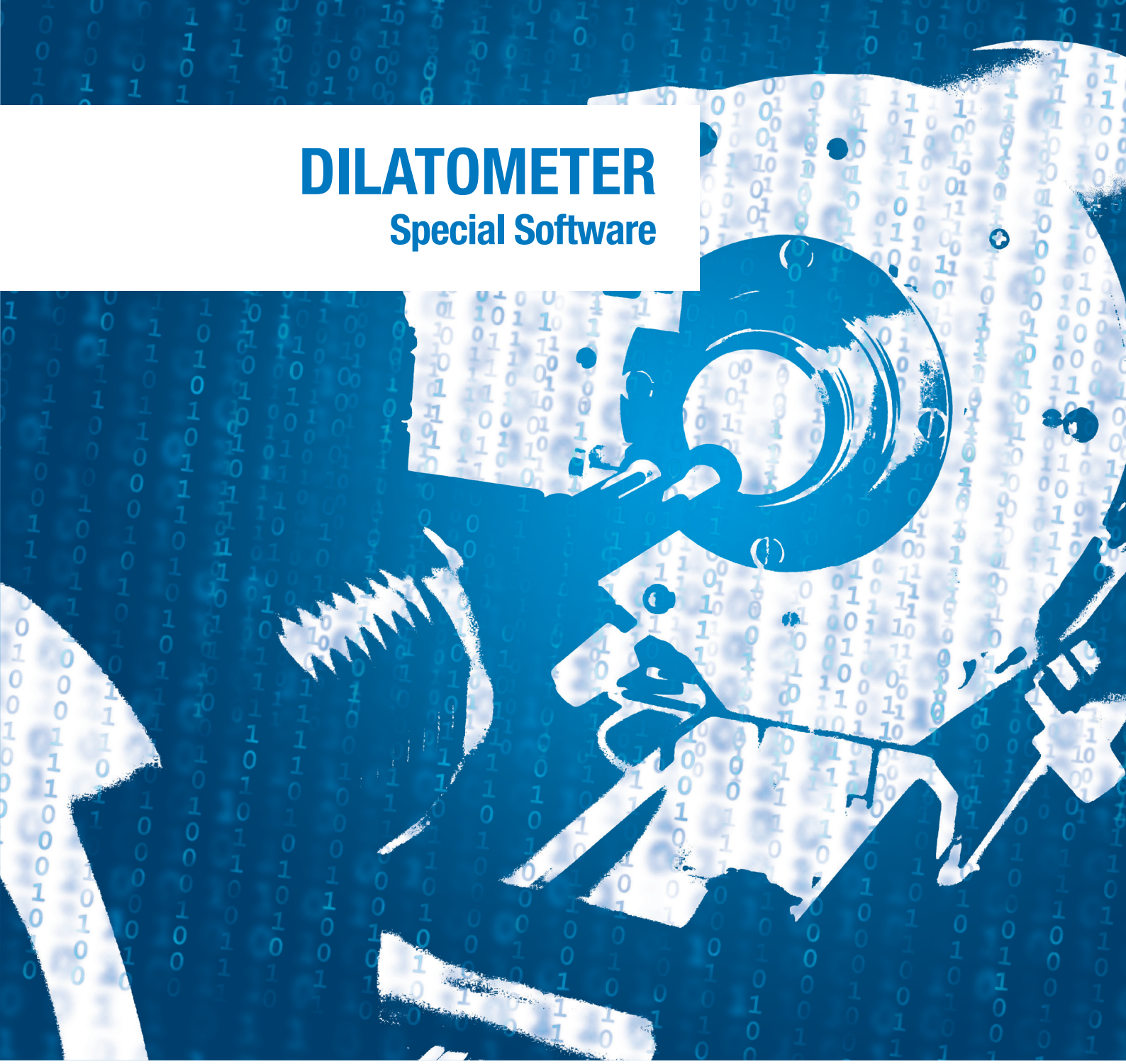
Tel.: +91-11-42883851
E-mail: sales@linseis.in

WWW.LINSEIS.COM

05/2024

DILATOMETER

Special Software

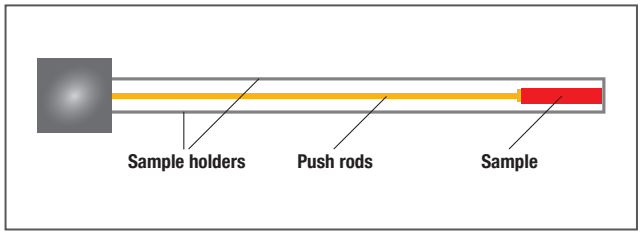


LINSEIS

Software for Dilatometers

Softening Point Software for Dilatometers

All dilatometer delivered since 01. 11. 2002 has a new feature included in the WIN-DIL software. Softening point feature to determine the softening point of a sample is a standard feature now. It is now part of the standard functions of the WIN/DIL software program at no extra cost.



The feature not only determines the softening point of the sample, but it alsoprotects the measuring system from a sample melting sample. With the softening point feature is activated, if a sample softens or shrinks more than the preset amount the controller will switch to a cooling cycle.

The softening of the sample is detected when the expansion of the sample reaches a maximum and starts shrinking again. The amount of shrinking after a maximum can be freely programmed. It is also possible to program different shrinkage factors for each heating stage.

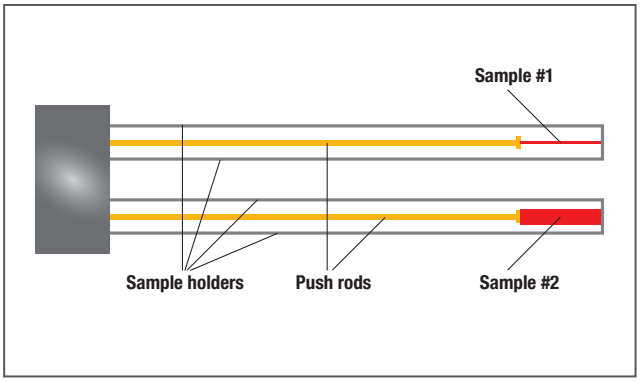
The normal temperature control program enables 16 different segments with different heating rates, cooling rates, and dwell times.

The same software feature can also control for expansion events. This is another way of controlling the dilatometer if an event occurs.

L75 / SDC
Simultaneous Dilatometer Calorimeter

With the newly developed LINSEIS SDC Software it is possible to get results on a Dilatometer not only for expansion coefficients (CTE). Using the same hardware you can measure the caloric properties of the sample, heat capacities, enthalpies and phase transitions are available. The SDC Software utilizes the dual sample Dilatometer's capability. Two samples of the same material, same length, and different diameters are used.

Because both samples have different volume and mass, (different heat capacity) the temperature that can be measured at both samples during a heating or cooling phase are different. The larger sample is temperature wise "behind" the smaller sample. As the temperatures measured at both samples are thus different at specific times, the corresponding delta L / expansion signal is also different. The principle of the SDC Software is to maintain a constant length difference between sample one and sample two throughout the test. This is accomplished by varying the applied heating and/or cooling rate.



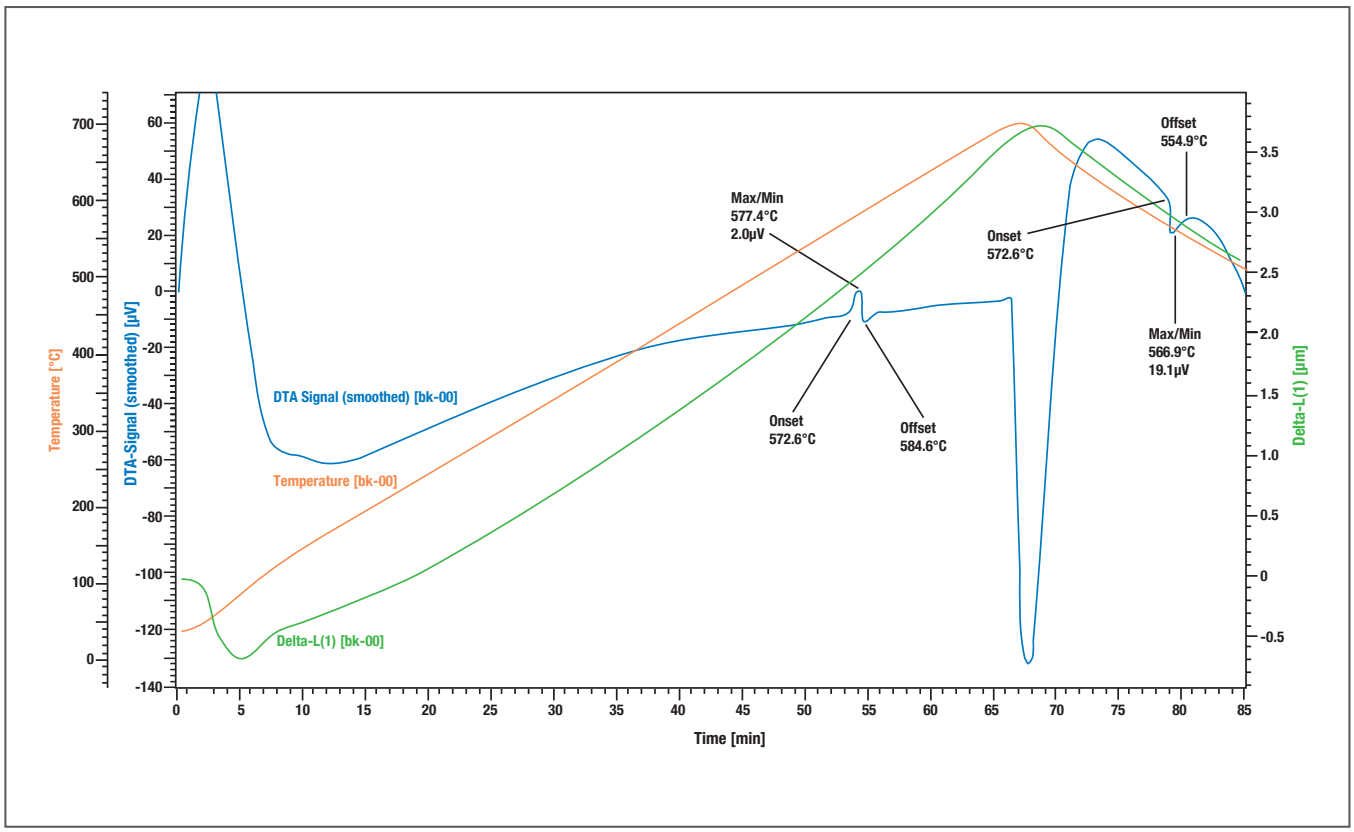
The heating and/or cooling profile is now proportional to the heat capacity of the sample material. The result are Endothermic and exothermic peaks displaying phase transitions of the sample based on the resulting heating and/or cooling rates. Absolute values can be obtained by running calibration two samples of known heat capacity and known mass.

L75 / SDD
Simultaneous Dilatometer DTA

Standard dilatometer measurement with additional DTA evaluation.

By means of this software any normal installed Linseis Dilatometer is now able to achieve additional DTA information / enthalpy values out of Dilatometer runs. Typical Dilatometer measurements usually determine the expansion delta L and expansion coefficient CTE of a sample. Very often the samples display an endothermal or exothermal reaction. These reactions cause a very small effect to the normally constant heating or cooling rate. For example if the sample requires energy during a phase transition, it will draw this energy from of the Dilatometer measuring system. In turn the furnace controller will compensate for this heat loss in order to obtain a constant heat up rate. These small deviations in the constant heating rate and the real temperature signal which is obtained from a heat loss or gain result in the DTA signal. The actual measured values are compared to a calculated heating or cooling curve. Using this procedure it is possible to get caloric enthalpy measurements from a Dilatometer. On next page we show an example of this software where the Alpha / Beta transition of quartz is shown. The sample had a mass

of 450mg and a volume of 3x4x5mm. The transition is endothermic during the heating phase and exothermic during the cooling phase. The measured value of the onset temperature is 573°C and it is identical to the literature value. To get these results, a normal Dilatometer measurement file is loaded. Next the Dilatometer file is changed into a DTA curve format. DTA evaluation can now be displayed using normal procedure for evaluating onset and offset temperatures.



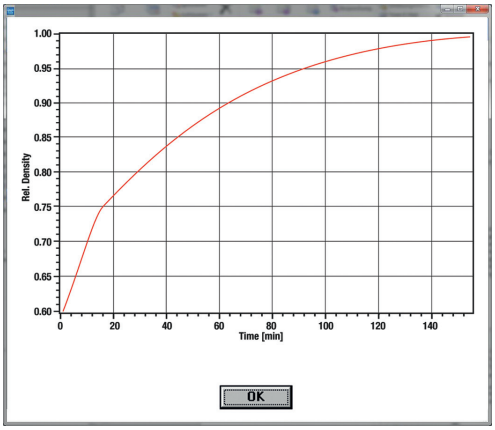
LINSEIS RCS – Rate Controlled Sintering

What is RCS

RCS is an add on for the standard dilatometer software. While during a dilatometer measurement the change in length of the sample during a given temperature profile is measured, RCS uses a quite different approach: For a given change in length profile (densification profile) the required temperature profile is determined.

The purpose of RCS is to determine the optimal sinter process, especially the optimal temperature/time profile. The aim of this optimization is to achieve the most possible final density in the shortest time at least energy consumption. The procedure used is based on the sinter theory of PALMOUR III (CERAM.MICROSTRUCT., PROC.INT. MATER.SYMP.6th 1976, WESTVIEW PRESS). According to this method, the sinter process is performed in a given densification profile. This profile is (with some restrictions) user definable, according to PALMOUR III:

- Two densification stages with a high and constant densification rate
- A third stage with a linear decreasing densification rate, until the desired final density is reached



Sample of a sinter profile
1. Stage: *60..75% density, densification rate: 1E-2/min, time: 15min*
2. Stage: *75..80% density, densification rate: 4E-3/min, time: 12.5min*
3. Stage: *80..100% density, final densification rate: 4e-4/min, time: app. 128min*

How RCS works

By varying the sample temperature it is attempted to adjust the real densification of the sample to the given densification profile: If the real density is lower than the set density, the temperature is raised to achieve a higher densification rate. If the real density higher than the set density, the temperature is lowered to decrease the densification rate. The result is a temperature/time profile for an optimal sinter process.

The determination of the actual density is done by a length measurement of the sample, similar to a dilatometer measurement. An isometric sinter behavior is assumed (same densification in all three axis):

$$d_t = \frac{d_a \cdot l_0^3}{l_t^3}$$

d_t = *rel. density at time t,*
d_a = *rel. initial density,*
l_0 = *initial length [mm],*
l_t = *length at time t [mm]*

The calculation of the set density as a function of time is done by the following equations:

- 1. and 2. Sinter stage (linear densification):

$$d_t = d_a + \Delta d \cdot t$$

d_t = *rel. density at time t,* d_a = *rel. initial density of actual sinter stage,*
Δd = *densification rate [1/min], t = time [min]*

- 3. Sinter stage (exponential decreasing densification rate):

$$d_t = d_a + \tau \cdot \Delta d_e \cdot (1 - e^{\frac{-t}{\tau}})$$

d_t = *rel. density at time t*
d_a = *rel. initial density 3. sinter stage*
Δd_e = *final densification rate [1/min]*
t = *time [min]*
τ = *time constant:* $\frac{d_e - d_a}{\Delta d_e - \Delta d_a}$

d_e = *rel. final density*
d_a = *rel. initial density 3. sinter stage,*
Δd_a = *densification rate 2. sinter stage [1/min]*
Δd_e = *final densification rate [1/min]*

The transition form the first to the second sinter stage can be smoothed if desired – a moving average is calculated over app. 5% of the time before and after the transition, to achieve a steady course of the sinter profile. For determining the sample length, a simplified correction method (related to the standard dilatometer method) is used, since the correction must be performed online during the measurement: No zero correction is performed, the correction of the expansion of the sample holder and the sample itself is done by a single, constant factor:

$$l_{corr} = (l_0 + \Delta l) \cdot K \cdot (T - 20)$$

l_{corr} = corrected length [mm]

l_0 = initial length [mm]

Δl = measured change in length [mm]

K = expansion coefficient entered [1/K]

T = actual temperature [°C]

The resulting absolute error (due to the simplified correction method) is usually small, related to the change in length of the sample during sintering. The complete sinter procedure consists out of three phases:

- Preheating of the sample, up to the temperature the sinter process starts
- The sinter phase itself
- A dwell time, holding the final temperature reached during sintering
- A cooling phase

The acquisition and storage of the measured values may be selected for the different phases of the sinter procedure. The time, the temperature, the measured change in length and the theoretical length for the given sinter profile are stored.

Determination of the required parameters for sintering

For sintering there are, except the desired sinter profile, some additional parameters required also:

- The sample length in [mm]
- The relative initial density (green density) of the sample
- The temperature value, sintering starts
- The expansion coefficient required for correction of the sample length

The sample length is usually measured with a slide gauge or a micrometer screw, like done for a dilatometer measurement also. The initial density is calculated from the ratio of the absolute initial density to the absolute, theoretical final density of the sample:

$$d_{arel} = \frac{d_{aabs}}{d_{eabs}}$$

d_{arel} = relative initial density

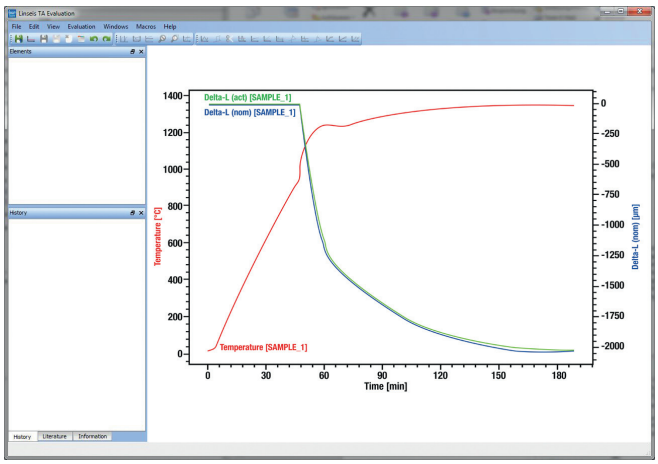
d_{aabs} = absolute initial density [g/cm³]

d_{eabs} = absolute final density [g/cm³]

For determination of the start temperature and the expansion coefficient two standard
dilatometer measurements are required:

- Measurement and evaluation of a none-sintered (green).sample, determination of the temperature where expansion of the sample changes to shrinkage
- Measurement and evaluation of a sintered sample. Determination of the expansion coefficient (Ak_{tech}) at the maximum required sintering temperature. If the evaluation of the measurement is performed without piston correction, the resulting Ak_{tech} is the coefficient to be entered directly for correction purpose (difference between expansion sample – expansion sample holder).

All determined parameters are entered together with the desired sinter profile in the sinter parameter dialog.



Sample sinter measurement:
The trace Delta-L<act> shows the measured and corrected length of the sample, Delta-L<nom> is the theoretical length profile for the desired sinter behavior. The trace Temperature is the resulting temperature profile.

LINSEIS GmbH
Vielitzerstr. 43
95100 Selb
Germany
Tel.: (+49) 9287–880 - 0
Fax: (+49) 9287–70488
E-mail: info@linseis.de

LINSEIS Inc.
109 North Gold Drive
Robbinsville, NJ 08691
USA
Tel.: (+1) 609 223 2070
Fax: (+1) 609 223 2074
E-mail: info@linseis.com

Products: DIL, TG, STA, DSC, HDSC, DTA, TMA, MS/FTIR, In-Situ EGA, Laser Flash, Seebeck Effect
Services: Service Lab, Calibration Service

www.linseis.com

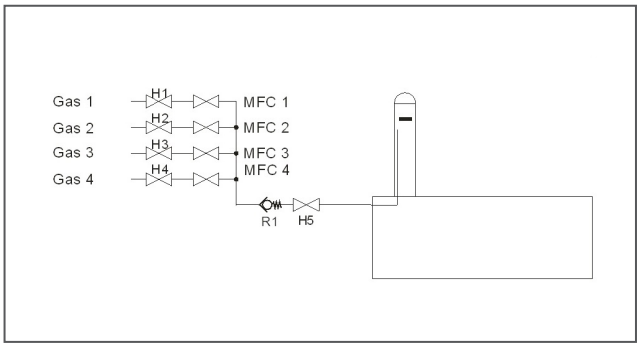
Dilatometer

L 75 High Pressure

LINSEIS

General

The LINSEIS high-pressure dilatometer L75/HP enables completely new applications in thermal analysis. The system can measure expansions (length changes) in the temperature range from RT up to 1100/1400/1800°C (customized systems on request) and in the pressure range up to 500 bar. This device is the world's only available high-pressure dilatometer. A steam generator and camplex gas control system are optional available.



An get even more informations and extend your measeurement, an analysis of the effluent gases can be done by using a QMS or FTIR system at any time. But the coupling is more than only the sum of the separate parts. You can benefit from LINSEIS coupling knowledge and integrated hard- and software concept. For the interpretation of the results, different libraries are available.

Software

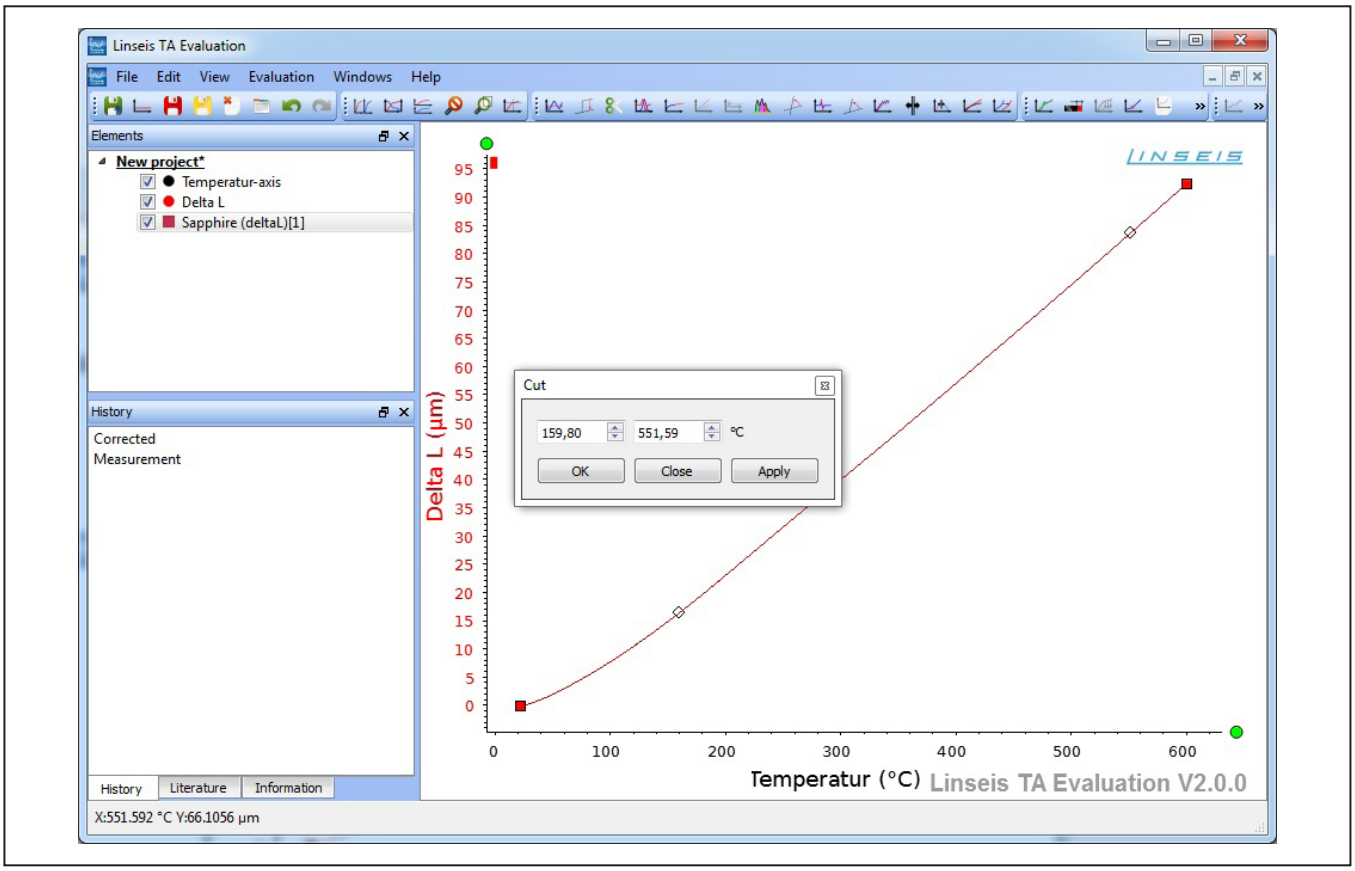
All LINSEIS thermo analytical instruments are PC controlled. The individual software modules exclusively run under Microsoft® Windows® operating systems. The complete software consists of 3 modules: temperature control, data acquisition and data evaluation. The 32 bit software incorporates all essential features for measurement preparation, execution, and evaluation of a Dilatometer measurement. Thanks to our specialists and application experts, LINSEIS was able to develop comprehensive easy to understand user friendly application software.

Gerneral features:

- Program capable of text editing
- Data security in case of power failure
- Thermocouple break protection
- Repetition measurements with minimum parameter input
- Evaluation of current measurement
- Curve comparison up to 32 curves
- Storage and export of evaluations
- Export and import of data ASCII
- Data export to MS Excel
- Multi-methods analysis (DSC TG, TMA, DIL, etc.)
- Zoom function
- 1 and 2 derivation
- Programmable gas control
- Statistical evaluation package
- Free scaling

DIL-features

- Glass transition and softening point evaluation
- Softening point detection with automatic software controlled system shut down
- Display of relative/absolute shrinkage or expansion curves
- Presentation and calculation of technical / physical expansion coefficient
- Rate Controlled Sintering (RCS) Software
- Sinter process evaluation
- Semiautomatic evaluation functions
- Several system correction features
- Automatic zero point adjustment
- Automatic software controlled sample pressure adjustment



Technical Specifications

	DIL L75 HP / 1	DIL L75 HP/2
Temperature range*	RT up to 1100°C	RT up to 1400/1800°C
Max. pressure	150 bar	100 bar
Vacuum	10^{-4} mbar	10^{-4} mbar
Sample holder	fused silicia < 1100°C Al_2O_3 < 1750°C	fused silicia < 1100°C Al_2O_3 < 1750°C
Max. sample length	50 mm	50 mm
Sample diameter	7/12/20 mm	7/12/20 mm
Adjustable sample pressure	up to 1000 mN	up to 1000 mN
Measuring range	500 / 5000 µm	500 / 5000 µm
Resolution	0.125 nm	0.125 nm
Options	Pressure controllable Gas Mixing System (MFC´s)	Pressure controllable Gas Mixing System (MFC´s)
Atmosphere	inert, oxid.**, red., vac.	inert, oxid.**, red., vac.

** different furnace*
*** not possible with graphite heater*

LINSEIS GmbH
Vielitzerstr. 43
95100 Selb
Germany
Tel.: (+49) 9287–880 - 0
Fax: (+49) 9287–70488
E-mail: info@linseis.de

LINSEIS Inc.
109 North Gold Drive
Robbinsville, NJ 08691
USA
Tel.: (+1) 609 223 2070
Fax: (+1) 609 223 2074
E-mail: info@linseis.com

LINSEIS China
Kaige Scientific Park 2653 Hunan Road
201315 Shanghai
Tel.: (+86) 21 505 506 428 004
Fax.: (+86) 21 680 635 76

LINSEIS France
Bureaux Paris
52 Boulevard Sébastopol
75003 Paris
Tel.: (+33) 173-028 272

www.linseis.com

Products: DIL, TG, STA, DSC, HDSC, DTA, TMA, MS/FTIR, In-Situ EGA, Laser Flash, Seebeck Effect, Thin Film Analyzer, Hall-Effect

Services: Service Lab, Calibration Service

LINSEIS