

Thermal Analysis

Thermophysical Testing, Cure Monitoring, Adiabatic Calorimetry



Leading Thermal Analysis.

NETZSCH

Analyzing and Testing

Since 1962, NETZSCH-Gerätebau GmbH has consistently provided our customers with the latest thermal analysis techniques, the broadest range of best-quality products, the most complete technical support and the most comprehensive service.

Thanks to our proficient R&D team, NETZSCH Analyzing & Testing consistently offers the “utmost”: the most complete product line, the widest temperature range and the highest measurement pressure, to name a few. The series of patents and international R&D awards which we have received attest to our products’ leadership in terms of technique and quality.

Besides the products themselves NETZSCH also provides localized software, operation manuals and application references. Seminars and users’ meetings are also organized by our specialists, and we offer a series of advanced training programs on demand.

Our branches, representative offices and application laboratories worldwide offer our customers excellent R&D and technical support, wherever on the globe they may be.

At NETZSCH, we regard customer satisfaction as our first priority. We are looking forward to working with you.

All materials change their physical properties and their chemical characteristics under the influence of temperature.

Thermal Analysis methods systematically analyze these changes by application of programmed temperature variations for heating and cooling, and by application of specified sample atmospheres and pressures. The properties most often studied are specific heat and enthalpy changes, weight loss or weight gain, Young's modulus, thermal expansion or shrinkage and gas evolution.

Knowledge of the thermophysical properties of solids and liquids has become very important for a sustainable energy industry and process economy. Thermal conductivity and thermal diffusivity measurements for insulating and for good conducting materials supply the data basis for engineering calculations and practical application of construction parts. The temperature-contingent information on material properties determined by Thermal Analysis methods allows conclusions to be drawn regarding the identification of materials as well as their purity and composition, polymorphism and structural changes, thermal stability and temperature limits

of application, aging behavior, thermo-mechanical behavior and viscoelastic properties, and processing conditions for shaping, casting, molding and extrusion. This comprehensiveness in material characterization encompasses all kinds of applications of Thermal Analysis for samples of organic, inorganic and biological origin. It is a very seldom occurrence that a sample cannot be tested successfully with any of the Thermal Analysis techniques.

NETZSCH Analyzing & Testing is focused on the development of versatile, reliable and sensitive instruments for material research, development, quality control, and process safety failure analysis. Our broad application know-how is transferred to our customers by means of demonstration or contract testing, application books for different materials or industrial branches, or directly and personally in seminars, workshops and users' meetings.

In addition to laboratory techniques for Thermal Analysis and Thermophysical Properties, NETZSCH also offers online process control techniques for reactive resin systems based on the change of dielectric properties and ion mobility.

Thermal Analysis

- DSC/DTA
- TGA
- STA (TG - DSC)
- DIL
- TMA/DMA
- DEA
- EGA (MS/FTIR Coupling)

Thermal Diffusivity and Conductivity

- LFA
- HFM/GHP
- TCT

Cure Monitoring

- DEA

Adiabatic Reaction Calorimetry

- Accelerating Rate Calorimetry
- APTAC

Refractory Testing

- RUL/CIC
- HMOR
- PCE

Advanced Software

- *Thermokinetics*
- Thermal Simulations
- Component Kinetics
- Peak Separation
- Purity

Differential Scanning Calorimetry (DSC) - **F1** Series
Thermogravimetry (TG) - **F1** Series





TG 209 **F1 Iris**[®]

TG 209 **F1 Iris**[®]

The TG 209 **F1 Iris**[®] is a vacuum-tight, top-loading thermo-microbalance with direct temperature measurement at the sample crucible. The water-cooled micro-furnace allows fast heating and cooling for a high sample throughput.

The TG 209 **F1 Iris**[®] can be equipped with the Automatic Sample Changer (ASC) for 64 crucibles. Unstable samples can be loaded in sealed crucibles, which are opened by the piercing device just before starting a measurement. Sample specific measurements and evaluations are fully controlled by a flexible macro in the innovative 32-bit *Proteus*[®] software.

A unique feature of the TG 209 **F1 Iris**[®] is the ability to couple it to both a mass spectrometer (MS) and a FTIR spectrometer, either individually or simultaneously – even when equipped with the ASC.

- Temperature range: 10°C to 1000°C
- Weighing range: 2000 mg
- Resolution: 0.1 µg
- *Auto-Vac*[®]-ready
- Vacuum: 10⁻² mbar
- 3 mass flow controllers
- Cooling speed <10 min (1000°C to 100°C)
- *c-DTA*[®] and *SuperRes*[®] software
- Same ASC as for DSC 204 **F1 Phoenix**[®]
- Perfect coupling to MS/FTIR

DSC 204 **F1 Phoenix**[®]

The premium DSC 204 **F1 Phoenix**[®] integrates a number of new hardware and software techniques which can be used in application fields such as polymers, foods, pharmaceuticals, inorganics, metals, composite materials, and so on.

- Temperature range: -180°C to 700°C
- Detection limit: 0.1 µW
- Choice of sensors:
 - τ-Sensor (high resolution)
 - µ-Sensor (high sensitivity)
- Unique gas-tight DSC furnace ensures purity of measuring atmosphere and MS/FTIR coupling
- 3 integrated mass flow meters for gas control and recording
- Cooling systems: compressed air, intracooler (down to -85°C) and LN₂/GN₂ (down to -180°C)
- Unique *BeFlat*[®] and *ISSP*[®] techniques
- Temperature modulation
- UV/VIS extension for photo calorimetry
- Upgradable with Automatic Sample Changer (ASC) for up to 64 samples and references



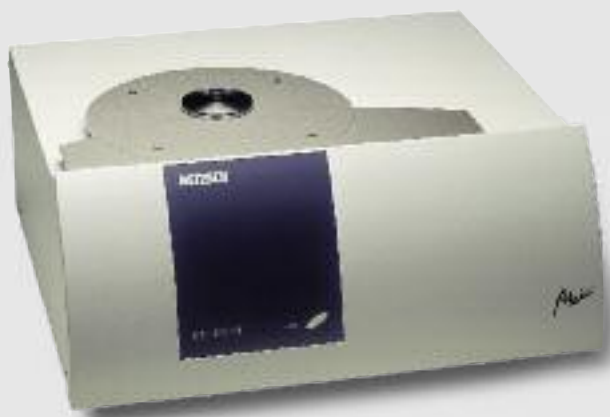
DSC 204 **F1 Phoenix**[®] with ASC

DSC, TG - **F3** Series

High-Pressure DSC

Thermomechanical Analysis (TMA)

Dynamic-Mechanical Analysis (DMA)



DSC 200 **F3** Maia®

DSC 200 **F3** Maia®

The DSC 200 **F3** Maia® is the ideal tool for day to day work in your laboratory. As a member of our new value line this instrument is a reliable entry-level heat flux DSC for:

- Product Development
- Quality Assurance
- Failure Analysis

- Temperature range: -170°C to 600°C
- Automatic gas switching
- Cooling: air, liquid N₂, intracooler
- Automatic sample changer (ASC) for up to 20 samples and references
- Easy-to-use
- Wide range of accessories
- Low cost of ownership



TG 209 **F3** Tarsus with ASC

TG 209 **F3** Tarsus

The TG 209 **F3** Tarsus simplifies thermogravimetry by featuring high performance at low operational and instrumental outlay.

The combination of safe sample loading, flexibility in atmospheres, fast heating programs, direct temperature measurement at the sample and high resolution comprises a high performance TG for daily use.

- Temperature range: RT to 1000°C
- Weighing range: 2000 mg
- TGA-resolution: 0.1 µg
- Atmospheres: inert, oxidizing
- *c-DTA*® and *SuperRes*® software
- Same ASC as for DSC 200 **F3** Maia®

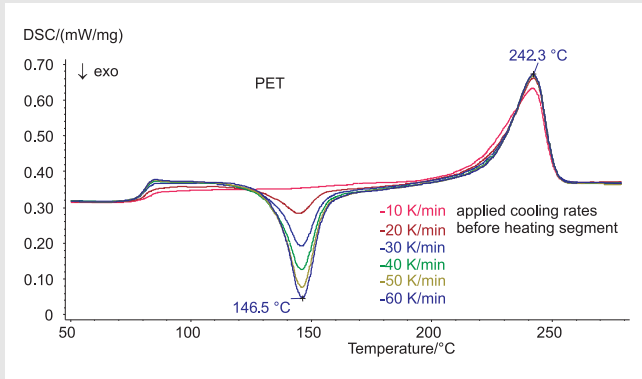


DSC 204 HP **Phoenix**®

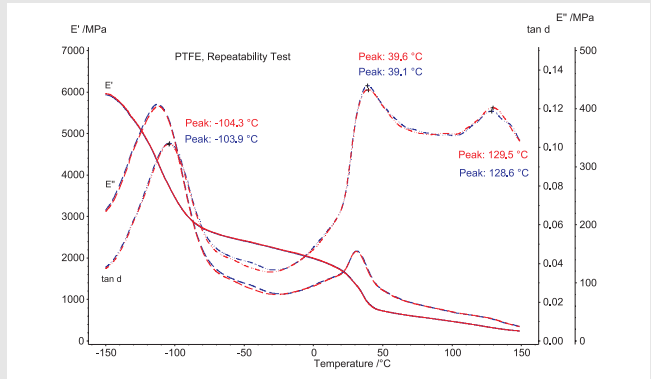
DSC 204 HP **Phoenix**®

The DSC 204 HP **Phoenix**® features the highest working pressure (up to 15 MPa). The measurement can run under precisely controlled static or dynamic atmosphere. It is especially well-suited for application fields such as energy materials (e.g. hydrogen storage) and petrochemistry (e.g. oxidation of oils).

- Temperature range: -150°C to 600°C
- Pressure range: vacuum up to 15 MPa
- Atmosphere: static and dynamic, inert, reducing, oxidizing
- Pressure precision: 0.02 bar
- Precise flow control under high pressure



Polyethylene terephthalate (PET) is a semi-crystalline thermoplastic polymer with a relatively slow crystallization rate. In the DSC experiments, the various levels of amorphousness (T_g 75°C to 85°C) and crystallinity (recrystallization 146°C, melting 242°C) are apparent. The samples were cooled from the melt in the DSC 204 F1 Phoenix® with the intracooler at different rates as shown prior to the heating.



A PTFE bar of 10.03 mm width by 2.13 mm height was tested in the 3-point bending mode with support distance 40 mm. In the temperature range -150°C to +150°C, three transitions are found. The DMA detects these transitions with much higher sensitivity and reproducibility compared to DSC or TMA.

TMA 202/402

TMA is the generic term for thermoanalytical methods used for measuring mechanical characteristics of a sample with a constant or oscillating load while the sample is subjected to a controlled temperature program.

The fields of application of the TMA 202/402 are diverse. Due to the high resolution of the inductive displacement transducer and the quality of the components used, measurements even on thin layers can be carried out without any problem.

- Vertical mounting with selectable pushrod load of 0.1 cN to 200 cN
- Exchangeable furnaces for the temperature ranges of -150°C to 500°C and from ambient temperature to 1000°C (TMA 402)
- Easily exchangeable sample carriers and probes
- Mechanical adjustment of the measuring head so that the sample length can be set between 1 µm and 50 mm (TMA 402)
- Highest resolution 0.0625 nm (TMA 402)



TMA 402

DMA 242 C

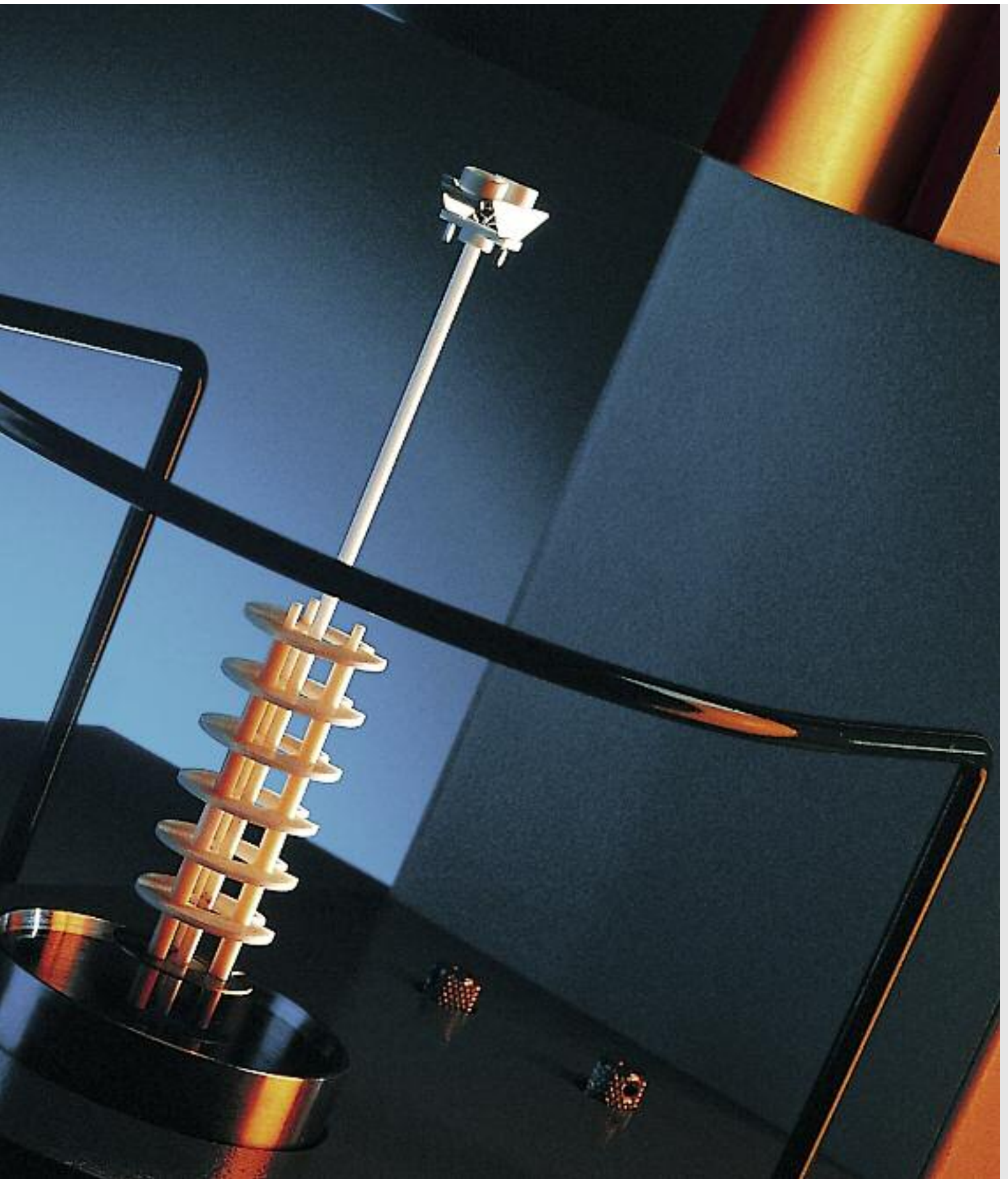
The DMA 242 C is used in the determination of storage and loss modulus and the damping factor of a sample as a function of temperature, time and the applied force, along with its oscillation frequency.

- Temperature range: -170°C to 600°C
- Frequency range: 0.01 Hz to 100 Hz
- Modulus range: 10⁻³ MPa to 10⁶ MPa
- Force up to 16 N
- Deformation modes: bending, tension, shearing, compression/penetration
- Special furnace: moisture, UV
- Special sample holders for liquids, stiff materials, foams, for DEA
- Immersion tests
- Fast Fourier Transformation (FFT)



DMA 242 C

Simultaneous Thermal Analysis (STA) - TG - DSC - DTA





STA 449 **F3 Jupiter**[®]

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Incorporating a robust monolithic weighing system and the well proven DSC and DTA sensors into a modern instrument design, the STA 449 **F3 Jupiter**[®] is the ideal workhorse for routine research and quality control applications. The specially developed control electronics and data acquisition system are also integrated and can be accessed simply by plugging the unit on to your PC. The vacuum-tight sample chamber makes it possible to work in well defined atmospheres on a variety of sample materials.

- Temperature range: -150°C to 2000°C
- Sample weights: up to 35 g
- Weighing range: 35 g
- TG resolution: 1 µg
- Vacuum: 10^{-2} mbar
- Atmosphere: static and dynamic, inert, reducing, oxidizing
- Perfect coupling with FTIR and/or MS

STA 409 CD

Classical benchtop, top-loading STA design for special extensions:

- Temperature range: -160°C to 2000°C
- Multiple furnace capability
- Skimmer coupling for MS, 1450°C or 2000°C
- Weighing ranges: 25 g / 15 g
- TG resolution: 5 µg / 2 µg

STA 429 CD

Stand alone STA model, top-loading, for special applications:

- 2400°C with tungsten furnace
- Multifurnace options (-160°C to 2400°C)
- High-vacuum capability, 10^{-5} mbar
- Vapor pressure determination (Knudsen cell)
- MS/FTIR coupling
- Weighing ranges: 25 g / 15 g
- TG resolution: 5 µg / 2 µg

STA 449 **F1 Jupiter**[®]

The STA system combines the DSC and TG methods and accomplishes the measurement of heat flow and mass change under completely identical conditions. The application fields of the STA 449 **F1 Jupiter**[®] include plastics, rubbers, resins, fibers, coatings, oils, ceramics, glass, cements, refractories, metals, fuels, drugs, foods, and so on.

- Temperature range: -150°C to 2000°C
- Sample weight: up to 5000 mg
- Weighing range: 5000 mg
- TG resolution: 0.025 µg
- Vacuum: 10^{-4} mbar
- Atmosphere: static and dynamic, inert, reducing, oxidizing
- High precision of c_p measurements
- Perfect coupling with FTIR and/or MS



STA 449 **F1 Jupiter**[®] with Automatic Sample Changer (ASC)

Dilatometry (DIL), High-Temperature DSC

DIL 402 C

Pushrod dilatometry allows measurement of the dimensional changes of a sample as a function of temperature or time.

The DIL 402 C allows this over a broad temperature range in well-defined atmospheres with very high resolution and accuracy.



DIL 402 C

- Temperature range: -180°C to 2000°C
- Resolution: 0.125 nm/digit
- Atmosphere: vacuum, oxidizing, inert or reducing gas
- Vacuum: 10⁻⁴ mbar
- Sample holder: graphite, alumina, fused silica
- Unique *c-DTA*[®] function

DIL 402 CD

The dual- and differential-dilatometer, DIL 402 CD, offers a higher sample throughput, direct comparison of samples and online calibration of expansion measurements.

- Temperature range: -180°C to 1600°C
- Resolution: 0.125 nm/digit
- Atmosphere: vacuum, oxidizing, inert or reducing gas
- Vacuum: 10⁻⁴ mbar
- Sample holder: alumina, fused silica
- Unique *c-DTA*[®] function



DIL 402 CD

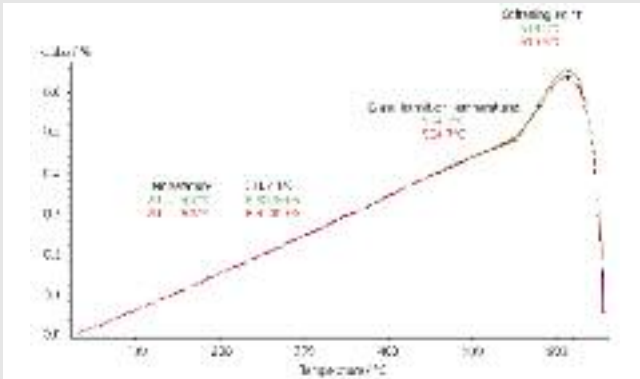
DIL 402 E

The DIL 402 E series instruments are designed for the highest temperature applications. Measurements can be carried out up to a maximum temperature of 2800°C, with pyrometer for temperature measurement and control.

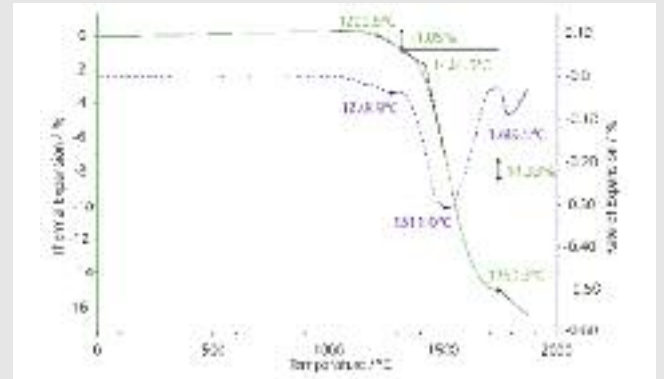
- Temperature range: RT to 2800°C
- Resolution: 0.125 nm/digit
- Atmosphere: vacuum, inert or reducing gas
- Vacuum: 10⁻⁴ mbar
- Sample holder: graphite, alumina
- Unique *c-DTA*[®] function (with thermocouple operation)



DIL 402 E



Coefficients of thermal expansion (CTE), glass transition temperatures and softening points are important parameters for the characterization of glass materials. Such properties can be easily measured using pushrod dilatometry.



Determination of the shrinkage during sintering of ceramic or powder-metal-lurgical products can be accurately measured with dilatometers. Presented here is the sintering range of the technical ceramic silicon nitride.



DIL 402 PC

DIL 402 PC

The DIL 402 PC is specially tailored for glass and ceramic applications. It is a cost-effective instrument for research, development and quality control.

- Temperature range: RT to 1600°C
- Resolution: 8 nm/digit
- Atmosphere: oxidizing, inert (static, dynamic)
- Sample holder: alumina, fused silica
- Unique *c-DTA*® function



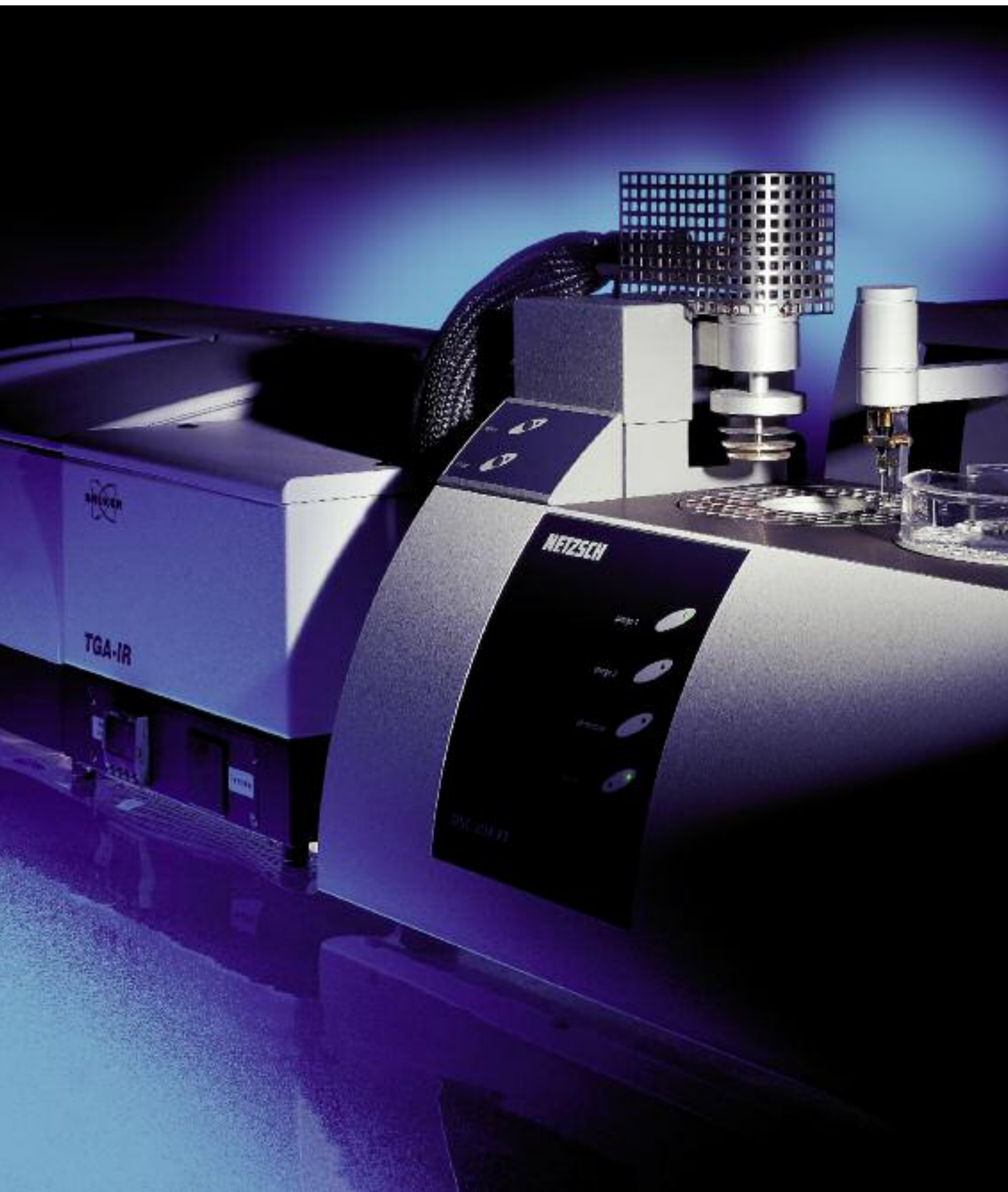
DSC 404 **F1** Pegasus®

DSC 404 **F1** Pegasus®

This unique high-temperature DSC system features easily interchangeable furnaces for different applications. Thanks to the design of the heating system and the automatic furnace lifting hoist, a stable baseline and high reproducibility can be achieved.

- Temperature range: -150°C to 2000°C
- c_p measurement: -120°C to 1500°C
- Atmosphere: static and dynamic, inert, reducing, oxidizing
- Vacuum: 10^{-4} mbar
- Sensor: DSC- c_p , DSC, DTA
- High precision for c_p measurement

Evolved Gas Analysis (EGA)
Coupling to Mass Spectrometer (MS)
and Infrared Spectrometer (FTIR)





DSC 204 **F1 Phoenix**[®]-FTIR Tensor™ 27

MS and FTIR coupling

Our Thermal Analysis equipment uses vertical gas flow systems in the furnaces. This leads to perfect gas transport in the natural upward flow direction and requires only low purge gas flow rates, resulting in low dilution of the evolved sample gases. Additionally all the gas paths have a precisely controlled heating, including the furnace exit, the transfer line, and the inlet to the gas analyzers. Integrated software solutions make the experiments and evaluations easy for daily use.

A sensitive and complete detection and analysis of the evolved gas species is the result of our many years of experience with coupling of gas analyzers.

- Optimized furnace design for capillary coupling
- MID scanning mode for more comprehensive MS analysis
- Trigger signal for simultaneous start/stop of TG/STA and MS/FTIR

TG 209 **F1 Iris**[®] + FTIR/MS

This vacuum-tight thermobalance with a micro furnace is the ideal basis for coupling, even when equipped with the automatic sample changer (ASC)

DSC 204 **F1 Phoenix**[®] + FTIR/MS

The gas-tight DSC offers a unique coupling possibility; small sample quantities and low flow rates ensure highest sensitivity and resolution in gas analysis.

- Unique coupling

STA 409/429/449 + FTIR/MS

Simultaneous information about the weight changes, enthalpy changes and evolved gases provide the optimum performance for a comprehensive material characterization. The vacuum-tight STA instruments guarantee a fast atmosphere adjustment especially with very pure and non-oxidizing sample atmospheres.

- Optimized gas cell and transfer line
- Fully controlled gas paths, no dead volume
- No cold spots
- No need for high gas flow rates
- Low dilution - high sensitivity



STA 449 **F1 Jupiter**[®]-QMS 403 C Aëolos[®]

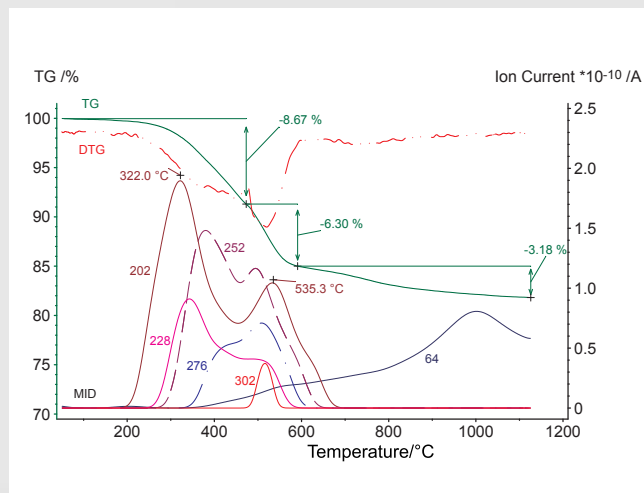
Advanced Coupling Techniques for Evolved Gas Analysis



TA-MS

The *SKIMMER* coupling is the shortest possible solution for the gas transfer from the sample to the QMS. An intense, highly parallel oriented molecular beam is collimated by the aerodynamic beam *SKIMMER* from the barrel-shaped jet expansion behind the divergent nozzle. The pressure reduction of the purge gas flow at atmospheric pressure down to the high vacuum behind the *SKIMMER* orifice is achieved in two steps along a distance of less than 20 mm. All components are heated to at least the sample temperature and therefore no chance for any condensation exists. Even metal vapors are detected by this unrivalled coupling system.

- Temperature range: RT to 2000°C
- Mass range: 1 amu to 512/1024 amu
- Resolution: 0,5 amu
- Electron impact ionization 25 eV to 100 eV adjustable
- 2 tungsten cathodes
- Operation modes: scan, scan-bargraph, MID
- Detection limit: > 100 ppb



Pitch carbon powder (55.2 mg) decomposes in nitrogen flow (50 ml/min) into high molecular weight aromatic compounds (mainly below 600°C). Only a selection is shown by MID curves for pyrenes (m/z 202), triphenylenes (m/z 228), benzo(a)pyrenes (m/z 252), benzo(ghi)perylene (m/z 276) and dibenzopyrenes (m/z 302).

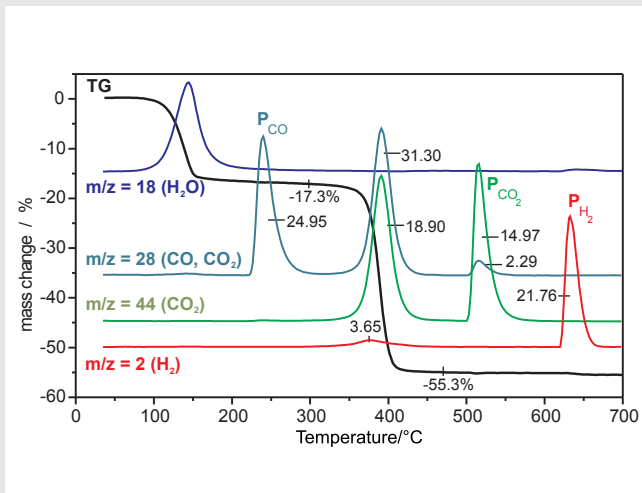
STA 409 CD – QMS 403/5 *SKIMMER* Coupling

PULSETA

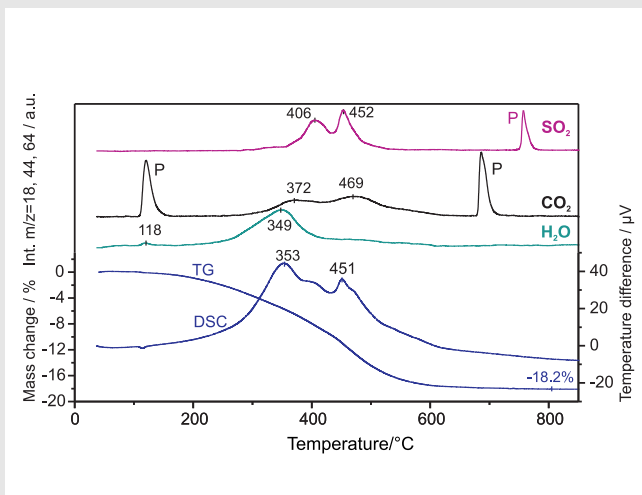
Quantification of the signals from gas analyzers requires a calibration of the whole coupled system with a known type and amount of gas or liquid in order to account for the temperature dependent gas flow properties. The unique pulse thermal analysis technique *PULSETA*® is the perfect tool for achieving quantitative gas detection in separate calibration runs or even online during a sample measurement.

A known amount of gas or liquid is simply injected into the sample gas stream. The resulting pulse signal is registered and evaluated.

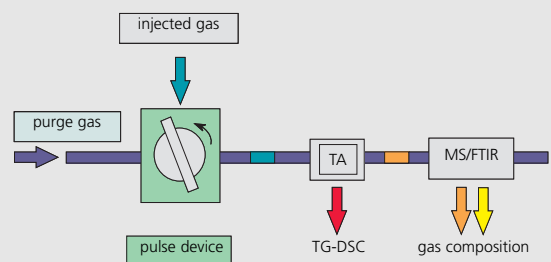
The application of *PULSETA*® also increases the sensitivity of thermoanalytical measurements, allows the studying of gas-solid reactions with step-wise control of the process by the pulsed supply of the reactive gas, and simplifies adsorption /desorption experiments.



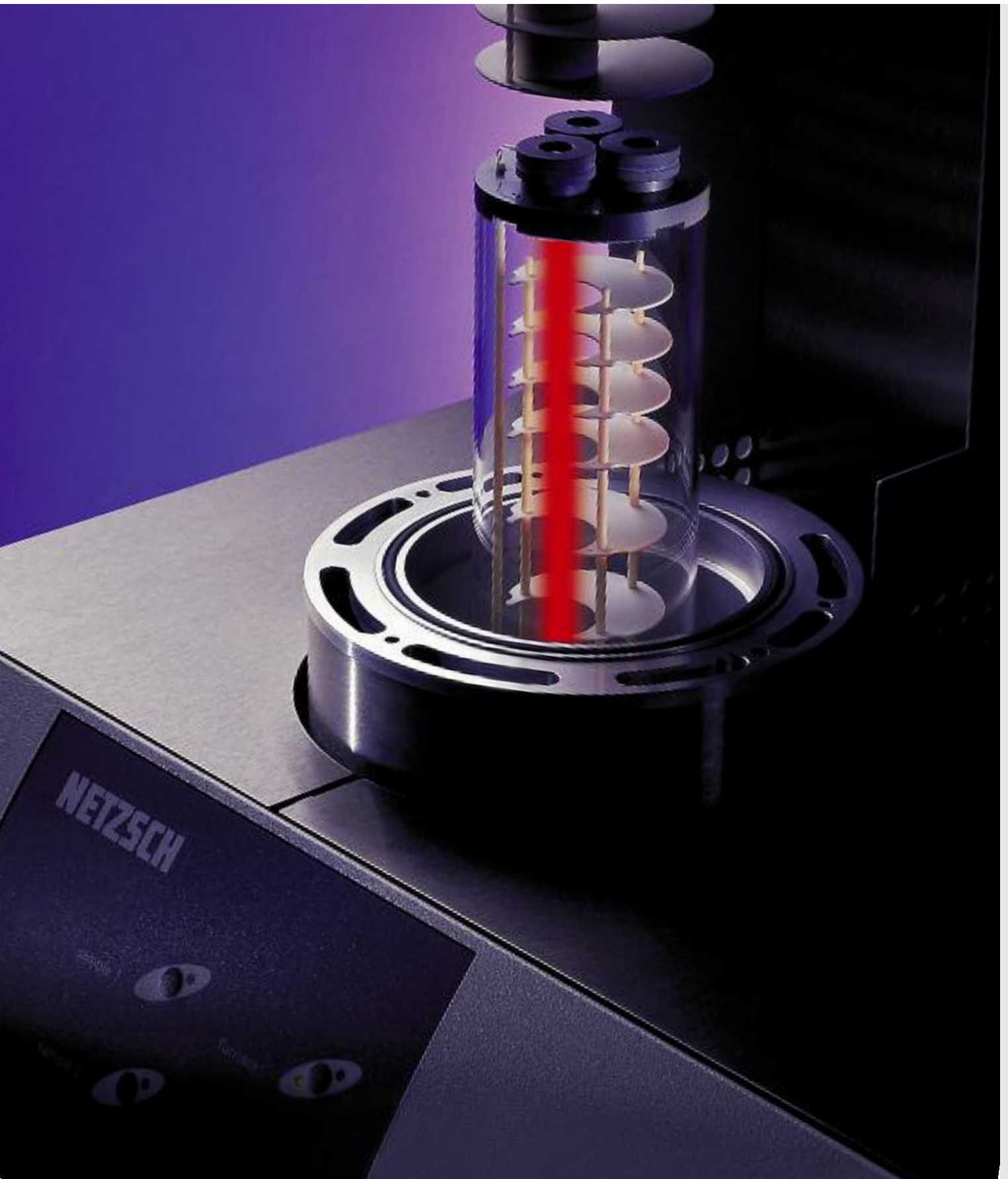
Thermal decomposition of $ZnC_2O_4 \cdot 2H_2O$ measured in a helium gas flow (50 ml/min). With corresponding pulses of CO and CO_2 , a quantification of the evolved gases is possible, even with the overlapping contributions to m/z 28 by CO and the fragmentation of CO_2 . The reaction between CO_2 and traces of water is shown by the H_2 signal and quantified by the H_2 pulse P.



Determination of carbon and sulfur content in a petrol rock. During calcination in air, the CO_2 and SO_2 signals can be exactly quantified through corresponding pulses.



Thermophysical Properties (TPP) Line
Thermal Diffusivity by Laser Flash Analyzers (LFA)





LFA 457 MicroFlash®

LFA 457 MicroFlash®

The laser flash technique is used to measure the thermal diffusivity and thermal conductivity of samples in solid, liquid and powder form. This non-contact and non-destructive method features many advantages such as easy sample preparation, small sample size, fast measurement and high precision.

- Temperature range: -125°C to 1100°C
- Thermal conductivity range: 0.1 W/(m*K) to 2000 W/(m*K)
- Vacuum: 10⁻² mbar
- Sample size: 8 mm x 8 mm, 10 mm x 10 mm, Ø 10 mm, Ø 12.7 mm, Ø 25.4 mm; thickness 0.02 mm to 6 mm
- ASC for up to 3 samples



LFA 447 NanoFlash®

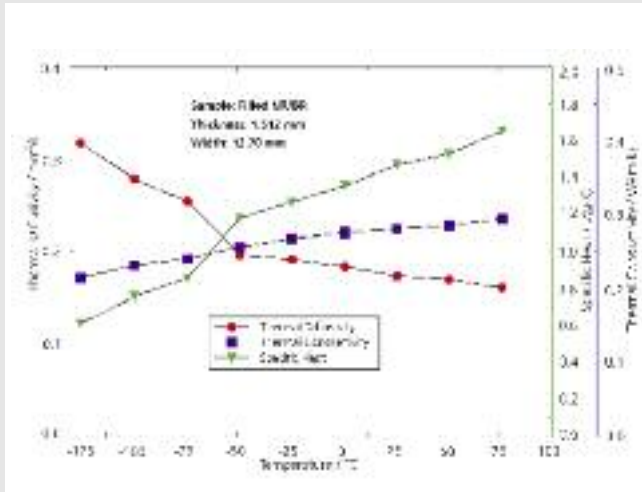
LFA 447 NanoFlash®

The LFA 447 NanoFlash® is a flash system based on a xenon-flash lamp capable of carrying out thermal diffusivity and thermal conductivity measurements with excellent accuracy up to 300°C.

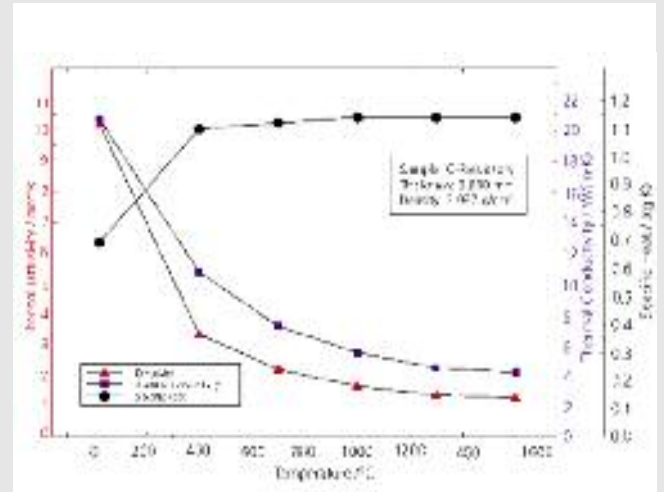
It offers advantages similar to standard laser flash systems but for a more attractive price.

- Temperature range: RT to 300°C
- Thermal conductivity range: 0.1 W/(m*K) to 2000 W/(m*K)
- Sample size: 8 mm x 8 mm, 10 mm x 10 mm, Ø 10 mm, Ø 12.7 mm, Ø 25.4 mm; thickness 0.02 mm to 6 mm
- ASC for up to 2 or 4 samples
- MTX scanning system for 50 mm x 50 mm samples, resolution: down to 100 µm

Laser Flash Analysis (LFA) Heat Flow Measurements (HFM) Dielectric Analysis (DEA)



Low temperature application - filled rubber. The specific heat and thermal diffusivity show steps due to the glass transition between -75°C and -50°C.



High temperature application - carbon refractory. Typical behavior of the thermophysical properties of carbon-containing refractories up to 1500°C.



LFA 427

LFA 427

The laser flash method can be employed up to very high temperatures. The LFA 427 allows thermal diffusivity and thermal conductivity tests up to 2000°C. This system is the most versatile instrument allowing tests on solids, powders, laminates, or even liquid metals and slags.

- Temperature range: -70°C to 2000°C
- Thermal conductivity range: 0.1 W/(m·K) to 2000 W/(m·K)
- Vacuum: 10⁻⁵ mbar
- Atmospheres: inert, oxidizing, reducing
- Sample size: 10 mm x 10 mm, Ø 6 mm, Ø 10 mm, Ø 12.7 mm; thickness 0.02 mm to 6 mm, Ø 20 mm (special version)



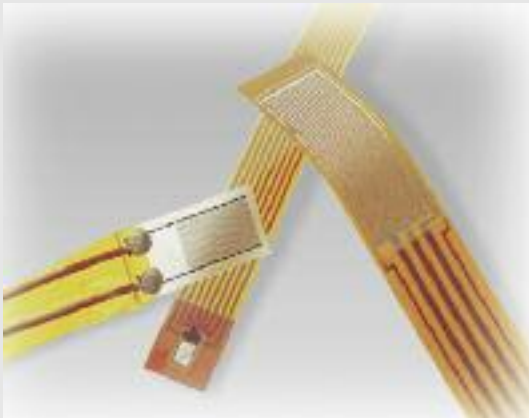
HFM 436 *Lambda*

HFM 436 *Lambda*

Heat flow meters are used to measure the thermal conductivity of insulation and building materials such as fiber boards, loose fill fiberglass, rock wool, synthetics, ceramic fiber boards, cellular plastics, powders, foams, evacuated panels, gypsum boards, wood, concrete, sand, and soil.

For advanced measurements from 160°C to 700°C, the Guarded Hot Plate **GHP 456 Titan®** (see special brochure) is recommended.

- Temperature range: -20°C to 100°C
- Thermal conductivity range: 0.005 W/(m*K) to 0.5 W/(m*K)
- Sample size:
300 mm x 300 mm x 100 mm
600 mm x 600 mm x 200 mm
- Repeatability: 0.5 %
- Precision: 3 %
- Unique dual sensor design
- Unmatched test speed
- In accordance with ASTM C 518, ISO 8301, JIS A1412, and EN 12667



DEA 230/231 *Epsilon* Series

This instrument series is used to investigate the curing of reactive resins by monitoring their dielectric properties during processing. The DEA 230 *Epsilon* series is used for most thermosets, adhesives, paints, and coatings, while the DEA 231/1 *Epsilon* is used for fast curing thermosets such as SMC/BMC and UV curing.

All of these can be used either in the lab or in-situ (sensors in oven, mould, autoclave, press, etc.).

- Frequency range: 0.001 Hz to 100 kHz
- Temperature range: -150°C to 400°C
- Data channels: up to 10
- Wide spectrum of implantable and reusable sensors
- Accessories: furnace and press



DEA 230/231 *Epsilon*

Accelerating Rate Calorimeter, Automatic Pressure Tracking Adiabatic Calorimeter (APTAC)

Adiabatic Reaction Calorimeters for Process Safety

Adiabatic Reaction Calorimeters help to secure safe and profitable operations in industry. As highly versatile, miniature chemical reactors, they measure thermal and pressure properties of exothermic



Accelerating Rate Calorimeter 244



Accelerating Rate Calorimeter 254



APTAC 264

chemical reactions. The resulting information helps engineers and scientists to identify potential hazards and address key elements of process safety design including emergency relief systems, process optimization, and thermal stability. The patented *VariPhi*[™] option enables

for all NETZSCH Accelerating Rate Calorimeter and Automatic Pressure Tracking Adiabatic Calorimeter systems DSC like performance in the scanning mode: exotherms, endotherms and heat capacity plus pressure data.

Accelerating Rate Calorimeter 244

The cost-effective 244 model is designed to safely measure the amount and rate of heat release associated with the processing or storage of chemicals. The key features are high performance, safety, usability, and flexibility with data integrity and robustness.

- Temperature range: RT to 500°C
- Max. pressure: 200 bar
- Max. tracking rate: 20 K/min
- Sample volume: 0.5 ml to 7 ml

Accelerating Rate Calorimeter 254

The new 254 model works from sub-ambient temperature (option) or from room temperature to 500°C and offers options for stirring, venting and injection of chemicals. User safety is the key objective: Fully computer-controlled and highly automated, the 254 model features a graphical interface that is easy to learn and use.

- Temperature range: sub-ambient (option) to 500°C
- Max. tracking rate: 200 K/min
- Max. pressure: 200 bar
- Sample volume: 0.5 ml to 7 ml

APTAC 264

The APTAC 264 with pressure control works from ambient to 500°C. As an accelerating rate calorimeter, the APTAC 264 can detect and track exothermic reactions up to 400 K/min in a pressure range up to 140 bar. The maximum pressure tracking rate is 680 bar/min. Stirring, venting and injection accessories are available. Due to the pressure compensation thin-walled vessels can be used in order to achieve a low ϕ factor for the thermal inertia.

- Temperature range: RT to 500°C
- Max. tracking rate: 400 K/min
- Max. pressure: 140 bar
- Pressure balancing
- Sample volume: 5 ml to 75 ml

Testing of Refractories, Refractoriness Under Load (RUL) Hot Modulus of Rupture (HMOR) Thermal Conductivity Testing (TCT)



RUL 421

RUL 421

Refractoriness under load (RUL) is a measure of the resistance of a refractory product to deform when it is subjected to the combined effects of load, rising temperature, and time. The range in which the softening occurs is not identical to the melting range of pure raw materials because it is influenced by the refractory composition and by the degree of distribution of low melting point fluxing agents.

- Temperature range: ambient to 1700°C
- Heating elements: 4 Super-Kanthal 1800
- Sample size: 50 mm diameter, 50 mm height
- Load range: 1 N to 1000 N in steps of 1 N and 100 N
- Test atmosphere: static air, optional inert gas purge
- Optional vacuum-tight version RUL 421 G



HMOR 422

HMOR 422

Measuring the modulus of rupture of refractories at elevated temperatures has become a widely-accepted method of evaluating materials at operating temperatures. Many companies base their specifications on this type of test. It is a very important parameter for quality control which, together with other thermophysical properties, gives information about the behavior of refractory materials used for furnace linings.

- Temperature range: ambient to 1500°C
- Heating elements: SiC
- Furnace: chamber furnace with preheating zone
- Thermocouples: type S
- Sample size: 150 mm x 25 mm x 25 mm
- Mode of operation: continuous
- Bending mode: three-point
- Load range: 0 N to 5000 N
- Load rate: 2 N/s to 12.5 N/s



TCT 426

TCT 426

The TCT 426 is a thermal conductivity tester which operates according to the well-known hot-wire technique. This transient method allows the determination of the thermal conductivity of ceramics, bricks, and other refractory materials up to high temperatures. The hot-wire technique is an absolute method; no standard samples are required.

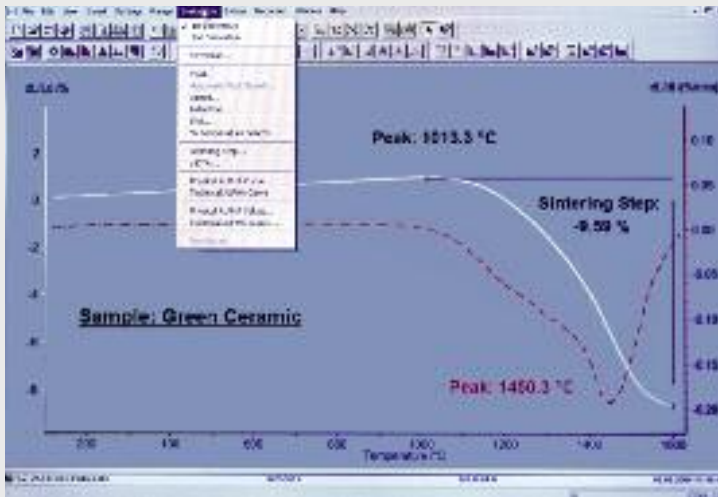
- Temperature range: ambient to 1400°C
- Cross- and parallel-wire arrangement
- T(R)-technique
- Large sample sizes: up to 250 mm x 125 mm x 75 mm
- DIN-, ISO- and ASTM-standardized

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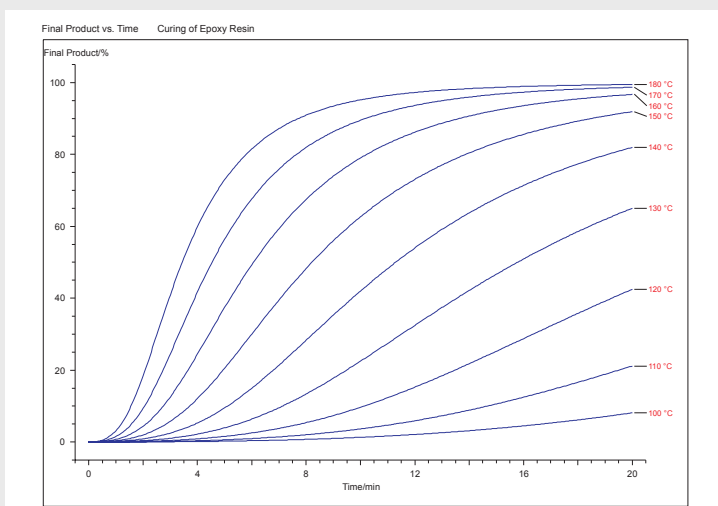




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Proteus® measurement and analysis system

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- Combined analysis of different methods
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- Specific heat
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- Rate controlled mass change *SuperRes®* (TG)
- Rate controlled sintering (DIL)

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