NETZSCH

Analyzing & Testing

Dynamic Mechanical Analysis – DMA 242 D

-170°C to 600°C

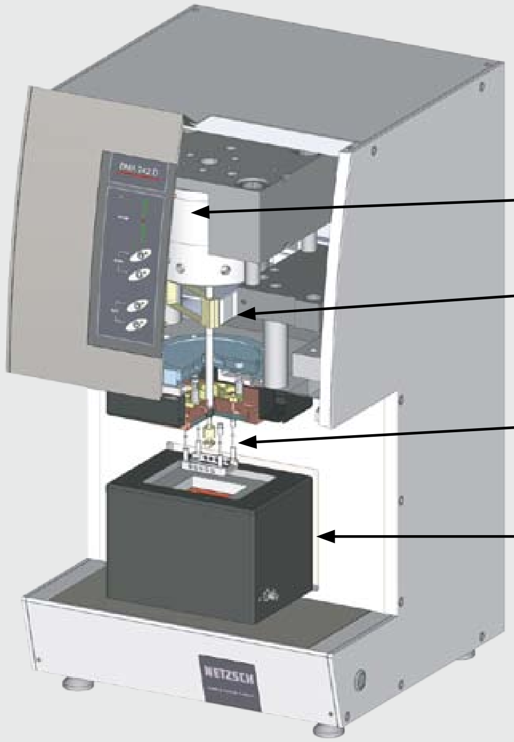
Leading Thermal Analysis

Dynamic Mechanical Analysis – DMA

Dynamic Mechanical Analysis (DMA) is a technique which provides quantitative information about the mechanical properties of a sample material under a low, primarily sinusoidal dynamic force as a function of temperature, time and/or frequency.

DMA generates important results about:

- Structural transitions (e.g., glass transitions)
- Modulus values
- Damping factor
- Relaxation performance
- Compatibility between polymer components
- Aging
- Curing / vulcanization



Sectional view of the DMA 242 D

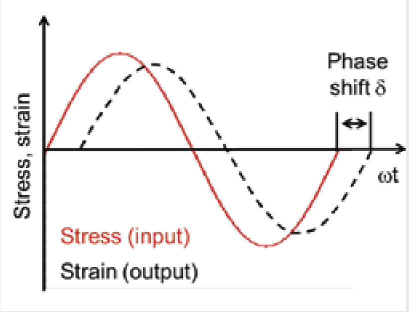
Functional Principle

During a dynamic-mechanical test a sinusoidal force (stress, σ) is applied to the sample. This also results in a sinusoidal response (deformation or strain, ε).

Most materials – but especially polymers – exhibit a "viscoelastic behavior". They posses both elastic (stiff like a spring) and viscous (damping effect) characteristics. Due to this viscoelastic behavior, the corresponding stress and strain curves are shifted. The deviation is the phase shift δ.

The response signal (strain, ε) is then split into an "in phase" and an "out of phase" part by means of Fourier Transformation. The results of this mathematical operation are the storage modulus E' (related to the reversible, "in phase" response) and the loss modulus E" (related to the irreversible, "out of phase" deformation part). The loss factor or damping factor tanδ is the ratio between the loss modulus and the storage modulus (tanδ = E"/E').

In general the storage modulus (E´) represents the material´s stiffness whereas the loss modulus (E´´) is a measure of the oscillation energy transformed into heat. The tanδ characterizes the mechanical damping or internal friction of a viscoelastic system.



DMA – measurement principle

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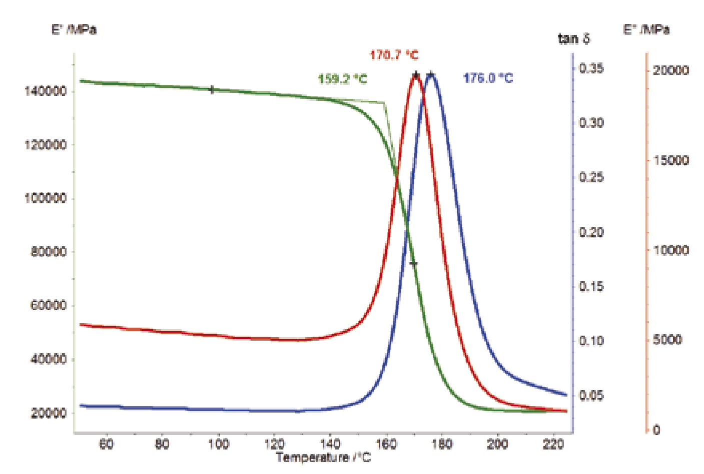
Carbon-Fiber-Reinforced Epoxy

The plot shows a DMA measurement result on a carbon-fiber-reinforced polymer (CFRP), carried out in the bending mode at a frequency of 10 Hz and a heating rate of 3 K/min.

The initial storage modulus (E´) of approx. 145,000 MPa indicates that this material is even stiffer than metallic titanium. The drop in the storage modulus (E′) curve at temperatures above 120°C, as well as the peaks in the loss modulus (E´´) and the loss factor (tanδ) curves, are related to the glass transition temperature of the epoxy matrix.

Especially for materials with a low polymer content, DMA is more sensitive for determination of the glass transition temperature than DSC (Differential Scanning Calorimetry).



DMA measurement on a CFRP material

Special sample holder for bending of composites

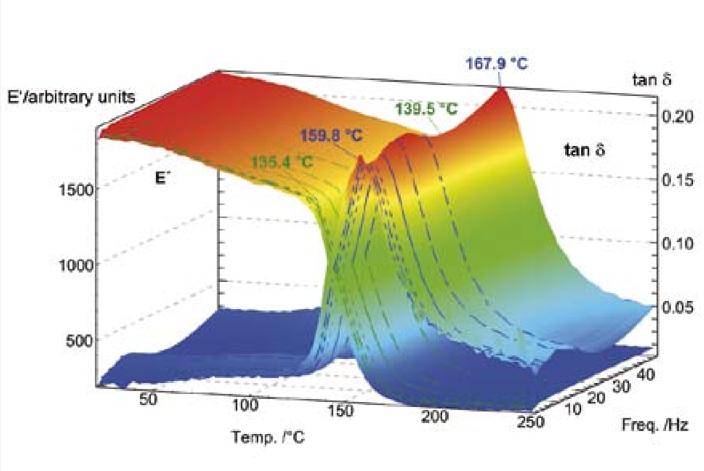
The modified single cantilever bending sample holder with a free pushrod is ideal for measuring composite materials. It guarantees quantitatively high storage modulus values (E´) at low damping values (E´´, tanδ). Here, the sample is tightly fixed at one end and a free pushrod oscillates at the other end with a superimposed static force.

DMA 242 D

PEEK (Polyether Ether Ketone)

The 3-dimensional presentation in the *Proteus*® evaluation software allows the user to view the viscoelastic properties of a material at a glance and is able to evaluate the performance of a multi-frequency measurement easily. This allows for a non-linear or non-proportional behavior to be visualized quickly.

This plot depicts the storage modulus (E') and the loss factor (tanδ) of a multi-frequency measurement on PEEK. The step in the E' curves as well as the tanδ peaks represent the glass transition of the PEEK sample. The extrapolated onset temperatures of the E´ curves and the peak temperatures of the tanδ curves, both at 0.5 Hz and 50 Hz, reveal a significant shift towards a higher temperature with increasing frequency.



Multi-frequency measurement on PEEK in the single-cantilever mode 5 mm (7 frequencies between 0.5 Hz and 50 Hz); heating rate: 1 K/min; max. dynamic force: 6 N; amplitude: 40 µm

The NETZSCH Group is an owner-managed, internationally operating technology company headquartered in Germany.

The three Business Units – Analyzing & Testing, Grinding & Dispersing and Pumps & Systems – provide tailored solutions for highest-level needs. Over 2,500 employees at 130 sales and production centers in 23 countries across the globe guarantee that expert service is never far from our customers.

When it comes to Thermal Analysis, Adiabatic Reaction Calorimetry and the determination of Thermophysical Properties, NETZSCH has it covered. Our 50 years of applications experience, broad state-of-the-art product line and comprehensive service offerings ensure that our solutions will not only meet your every requirement but also exceed your every expectation.

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42
95100 Selb
Germany
Tel.: +49 9287 881-0
Fax: +49 9287 881 505
at@netzsch.com

www.netzsch.com

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