Thermography and Thermophysical Properties User Center

TTPUC

The Thermography and Thermophysical Properties User Center (TTPUC) is one of six user centers in the High Temperature Materials Laboratory (HTML), which is a DOE User Facility dedicated to solving materials problems that limit the efficiency and reliability of systems for power generation and energy conversion, distribution, storage and use. The TTPUC provides world-class facilities and a staff of technical experts for both determining thermophysical properties such as thermal conductivity, diffusivity, expansion, or specific heat; and also characterizing thermal stability, high-temperature reactions and compatibility, and high temperature oxidation and corrosion properties.

Materials studied at the TTPUC include metals, ceramics, superalloys, glasses, sand, paper, thermal barrier coatings, carbon materials, carbon composites, ceramic composites, metal matrix composites, and thick and thin films. In addition, high-performance infrared (IR) cameras are used in various thermography applications, including mapping temperatures and properties, monitoring processes, and nondestructively evaluating materials and structures. The thermography capability is portable and may be used for offsite user projects.

Thermal Analysis Facilities

Simultaneous Thermal Analysis (STA)

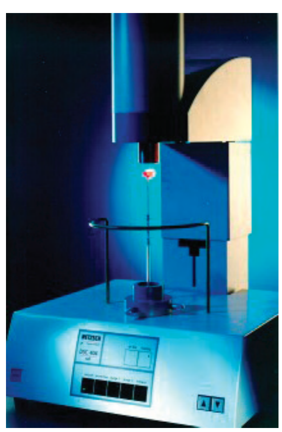
The STA technique is comprised of both differential thermal analysis (DTA) and thermogravimetry (TG). STA can be used to follow the course of chemical reactions, thermal decompositions, or phase changes as a function of temperature, heating rate, and atmosphere.

Features

- DTA and TGA measurements from 25 to 1450°C
- All systems fully computer controlled

Differential Scanning Calorimetry

The operation of a differential scanning calorimeter (DSC) is based on measurement of the thermal response of an unknown specimen as compared with a standard when the two are heated uniformly at a constant rate. A DSC is used to measure specific heat capacity and heats of transition, and to detect phase changes and melting points.



Features

- Operation of instrument completely automated and computer controlled
- Small sample volumes required (~1 to 50 mm^3)
- Widely accepted method for determining specific heat capacity

Netzsch DSC 404C

- Specific heat measurements to 1200°C
- Operation in air, inert gas, or vacuum to 1650°C

TA Instruments Q2000 DSC

- Operation in inert gas from - 180°C to 400°C
- Automatic sample changer
- Moduated DSC
- Pressure cell for pressures to 7MPa (1000 PSI)

High-Temperature, High-Mass Thermogravimetric Analyzer

This instrument is used to examine the time-temperature-environment relationships for high-temperature materials. The ability to accommodate large samples allows the testing of real components in aggressive environments, simulating actual processing or operating conditions.

Features

- 20–1700°C operation
- TG balance capacity up to 100 g with sample diameters up to 30 mm
- Mass change determinations to ±1 µg
- Heating rates up to 100°C/min
- Controlled environments, including vacuum, inert, and corrosive gases
- All systems fully computer controlled

Dual-Push-Rod Dilatometer

A differential dual-push-rod dilatometer measures the linear thermal expansion from 20 to 1600°C and can be used to detect various physical or chemical changes such as phase transitions in a specimen.

Features

- Measurements from 20 to 1600°C
- Differential length changes measured to ±1.5%
- Measurements in both inert gas and vacuum oxidizing environments
- Dedicated computer control of time-temperature programs for the samples
- Length change data automatically acquired, analyzed, and plotted

Quench Dilatometer

A quench dilatometer measures the change in length of a specimen as it is heated or cooled at programmed rates or held isothermally for a programmed time. It can be used to detect various phase transitions in a specimen such as equilibrium and metastable transitions in steels (development of CCT and ITT curves), and precipitation in age-hardenable aluminum and magnesium alloys.

Features

- Rapid heating at controlled rates in vacuum using RF induction coil
- Rapid cooling at controlled rates in vacuum or by forced helium assisted quenching
- Quench rates in excess of 150°C/s obtainable
- Option of deformation of specimen prior to cooling

Web: http://html.ornl.gov

html HIGH TEMPERATURE MATERIALS LABORATORY

Thermography: IR Cameras

High performance IR cameras are used in the following areas:

- Generating thermal diffusivity maps of bulk materials, especially composites
- Temperature mapping of devices, components, human, and biological objects
- Nondestructive evaluation of materials and components
- Process monitoring, high-speed imaging, and machine-vision application

Near-IR (0.9–1.7 μm) Camera features

- Snapshot mode
- 320 x 256 pixel InGaAs focal plane array (FPA)
- Frame rate up to 346 Hz (full frame) and 38 kHz (line)

Mid-IR (1.5–5 μm) Camera features

- Snapshot mode
- 320 x 256 pixel InSb focal plane array (FPA)
- 0.012 K temperature resolution
- Frame rate up to 346 Hz (full frame) and 38 kHz (line)
- IR microscope lens: 1.4 x 1.4 mm field of view, 5.4 μm per pixel
- Hyperspectral lens (3–5 μm)

Long IR (7–14 μm) Camera features

- Compact size (4.3 cm x 4.3 cm x 10.7 cm)
- 160 x 128 pixel FPA microbolometer
- Frame rate: 30 Hz
- 0.1 K temperature resolution

Thermal Transport Facilities

The TTPUC offers several techniques for the measurement of thermal transport properties numerous classes of materials over a wide temperature range. In addition, electrical resistivity and Seebeck coefficient are measured up to 1000°C.

All instruments have been used in the study of factors affecting the thermal transport properties of materials.

Flash Thermal Diffusivity System

Flash thermal diffusivity systems provide for studies at a wide range of test conditions. The three systems are a multiple-station laser flash system, a xenon flash system, and an IR-camera-based diffusivity mapping system.

Multiple-Station Laser Flash Diffusivity System

- Temperature range: cryogenic to 2500°C
- Bulk and layer sample measurements
- Vacuum or inert atmospheres
- Six samples per run measurement capability
- Thermal contact resistance between two layers
- Finite pulse-width and heat-loss corrections

Xenon Flash Diffusivity System

- Optimized for rapid room-temperature thermal diffusivity measurements
- Measures bulk and layer samples
- Accepts a wide range of specimen sizes and shapes

Hot Disk System

This technique measures thermal conductivity. The hot disk sensor is usually sandwiched between two pieces of sample during measurement. The sensor consists of an electrical conductor in the shape of a double spiral laminated between two thin sheets of insulating material (Kapton or mica). The sensor is used both as a heat source and as a dynamic temperature sensor.

LaserPIT System

This technique measures in-plane thermal diffusivity of a wide range of materials, including CVD diamond, metals, ceramics, glasses, plastics and thin film coatings on a substrate. Typical sample size is 30 mm long, 2.5 to 5.0 mm wide, and 3-500 μm thick. Measurements are made at room temperature.

Seebeck Coefficient and Electrical Resistivity System

This technique measures Seebeck coefficient (thermopower) and electrical resistivity of bulk and thin films from room temperature to 800°C. For bulk samples, typical samples are 3 mm x 3 mm x 15 mm. Thin film samples should be on insulating substrates, and the substrate needs to be at least 1 mm thick and 3 mm wide.

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