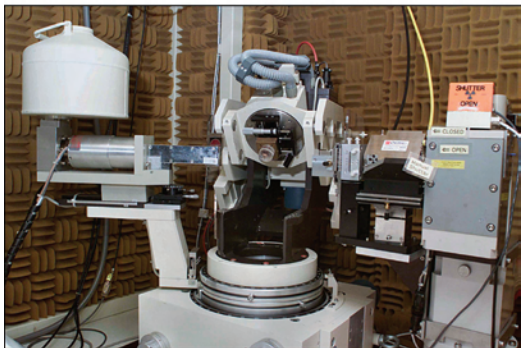
Residual Stress User Center

RSUC

The Residual Stress User Center (RSUC) is one of six user centers at 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 RSUC provides world-class facilities and a staff of technical experts for characterizing both surface and through-thickness stresses with state-of-the-art x-ray, synchrotron, and neutron diffraction facilities.

Residual stresses affect important properties such as fatigue life, fracture strength, onset of yield, and microcracking. X-ray and neutron diffraction methods are available in the RSUC to measure macro- and micro-residual stresses in polycrystalline and single crystal materials ranging from small specimens (thin films) to large industrial components.

Four-Circle Goniometers with18-kW Rotating Anode X-Ray or 2-kW X-Ray Tube Sources



X-ray diffraction permits measurement of texture and either biaxial or triaxial residual strains in ceramic and metal alloy surfaces. These instruments are designed to permit mapping of the residual stress state across the surface of a specimen and as a function of depth with electropolishing.

Common Features

- Scintag PTS four-axis goniometer for stress and texture analysis with unrestricted 2θ range (from –2 to +162°)
- Highly automated, flexible data-collection options (Ψ tilt or Ω tilt and multiple pole figure
- Solid-state detection of x-rays yields high peak-to-background ratios and excellent sensitivity
- Specimen dimensions up to 140 mm in diameter, 40 mm in thickness, and 5 kg in mass
- Software includes biaxial and triaxial stress analysis, pole figures, and orientation distribution function calculations from texture data
- Load frames for determination of diffraction elastic constants and hot
- Grazing incidence x-ray diffraction for depth profiling of stress and phases
- Parallel-beam optics for characterization of curved or irregular surfaces

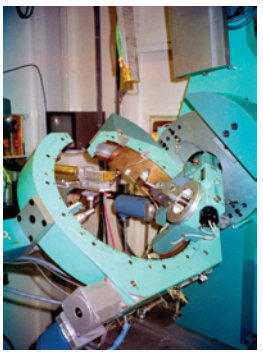
Cu Rotating Anode

- High-flux, high-brilliance rotating anode source
- Copper target
- Incident parabolic mirror and radial-divergence-limiting slits for true parallel beam optics

Tube Source

- Interchangeable 2-kW x-ray tubes
- Divergent-beam and near-parallel-beam optics

X-14A Synchrotron Beamline at the National Synchrotron Light Source

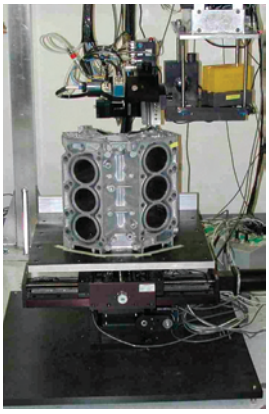


This high-flux beamline instrument is designed to permit the measurement of residual stress in a variety of ways, including grazing incidence at high temperature.

Features

- High-flux, high-brilliance source (9×10^{11} photon/s at 8 keV, 223 mA, 2.5 GeV)
- Tunable x-ray source (energy range 3.5–18 keV; energy resolution $\Delta E/E = 2 \times 10^{-4}$)
- Parallel x-ray source (total horizontal angular acceptance: 5 mradians)
- Six-circle Huber diffractometer with split chi-ring; crystal analyzers (Si,Ge, LiF, graphite)
- Pinholes > 10 μm diam
- Displex cryostat
- Buehler high-temperature stage
- Hemispherical Be dome furnace

Large Specimen X-Ray Diffractometer



This instrument allows x-ray examination of large specimens. Measurement of residual strain in ceramics and metal alloys and determination of retained austenite in ferrous alloys can be performed.

Features

- Cu, Co, and Cr x-ray targets
- Computer-controlled XY mapping of surface
- $\sin^2\Psi$ residual stress and retained austenite analyses
- Sample fixturing able to be custom-designed to accommodate needs
- 120-ft^2 x-ray enclosure
- Gantry system providing overhead translation of x-ray source and goniometer
- Two automated XY sample translation stages for large and small specimens

Web: http://html.ornl.gov

html HIGH TEMPERATURE MATERIALS LABORATORY

Neutron Diffraction Residual Stress Mapping Facility

Neutron diffraction permits measurement of triaxial residual strains within the bulk of alloys and ceramics. Diffraction elastic constants are used to convert strains to stresses. The high flux at HFIR permits mapping through many millimeters thickness of most materials.

Features

- Highest flux thermal neutron source in United States
- Selectable wavelength with multiwafer doubly focusing monochromators
- Position-sensitive 7-detector array
- Specimen-positioning equipment
  - X, Y, and Z translations
  - Specimen rotations
  - Large capacity (1000 lbs)
- Peak position measurement to ±0.003° 2θ
- 3-D strain mapping
  - Gage volume of <1 to 40 mm^3
  - Automated data acquisition
  - Real-time data analysis
- Triaxial strain measurement and stress analysis
- Load frame for uniaxial loading to 15 kN
  - Fracture mechanics strain mapping under load
  - Diffraction elastic constants
  - Anisotropic intergranular response
  - Multiphase response to load of composites

Micro Residual Stress Neutron Powder Diffraction Facility

This high-flux instrument permits the determination of the grain-to-grain residual stresses in multiphase samples.

Current Features

- Phase sensitive
- Monochromatic beam
- 32 ^{3}He detectors with Soller slits
- Pattern from 10 to 130° 2θ
- High resolution ($\Delta d/d = 2 \times 10^{-3}$)
- Room for sample enclosures and attachments
  - High-temperature furnace (1600°C in vacuum)
  - Controlled atmosphere furnace
- Rietveld analysis codes
- Powder diffraction analysis codes

Scan Arm and Laser Tracker

Metrology and reverse engineering of samples can be achieved with the Laser Tracker and Scan Arm. With associated software packages (CAM2 and GeoMagic Studio) the instruments can be used to generate "as-is" engineering drawings for comparison with the design drawings and identification of locations of distortion. The instruments are also used to pre-align specimens and pan neutron diffraction strain mapping experiments using the SScanSS visualization software.

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