MATERIALS CENTER LEOBEN
FORSCHUNG GMBH

We innovate Materials

preparation, metallography, lightoptical microscopy

structure and phase analysis, X-ray diffraction

scanning electron microscopy

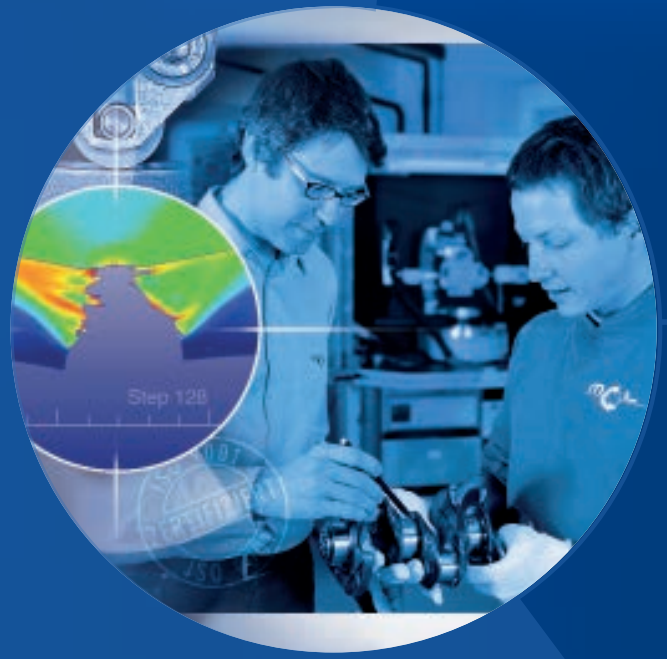
mechanical materials testing

thermal analysis and heat treatment

microelectronic test methods

MCL Services

labs and equipment



ISO 9001 CERTIFIED ISO 9001

COMPETENCE & RELIABILITY

Accredited testing laboratory acc. to EN ISO 17025

MATERIALS CENTER LEOBEN
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sample preparation

lightoptical microscopy - structure characterization

hardness testing

surface structures and topography

preparation, metallography & lightoptical microscopy

ISO 9001 CERTIFIED ISO 9001

Akkreditierung Austria A 0421 ISO/IEC 17025 T

Accredited testing laboratory acc. to EN ISO 17025

COMPETENCE & RELIABILITY

sample preparation

coarse cutting, fine cutting, mechanical specimen preparation
and preparation of metallographic sections

our focus / competences

- preparation of metallic materials, ceramics, composite materials, special materials, microelectronic components
- coarse cutting of components
- fine cutting of specimen material
- mechanical production of specimens (milling, turning, grinding, eroding (*))
- production of microsections in the size range from <0.1 mm to >1 dm for microscopic documentation

(*) in cooperation with our long-term partners/suppliers

contact

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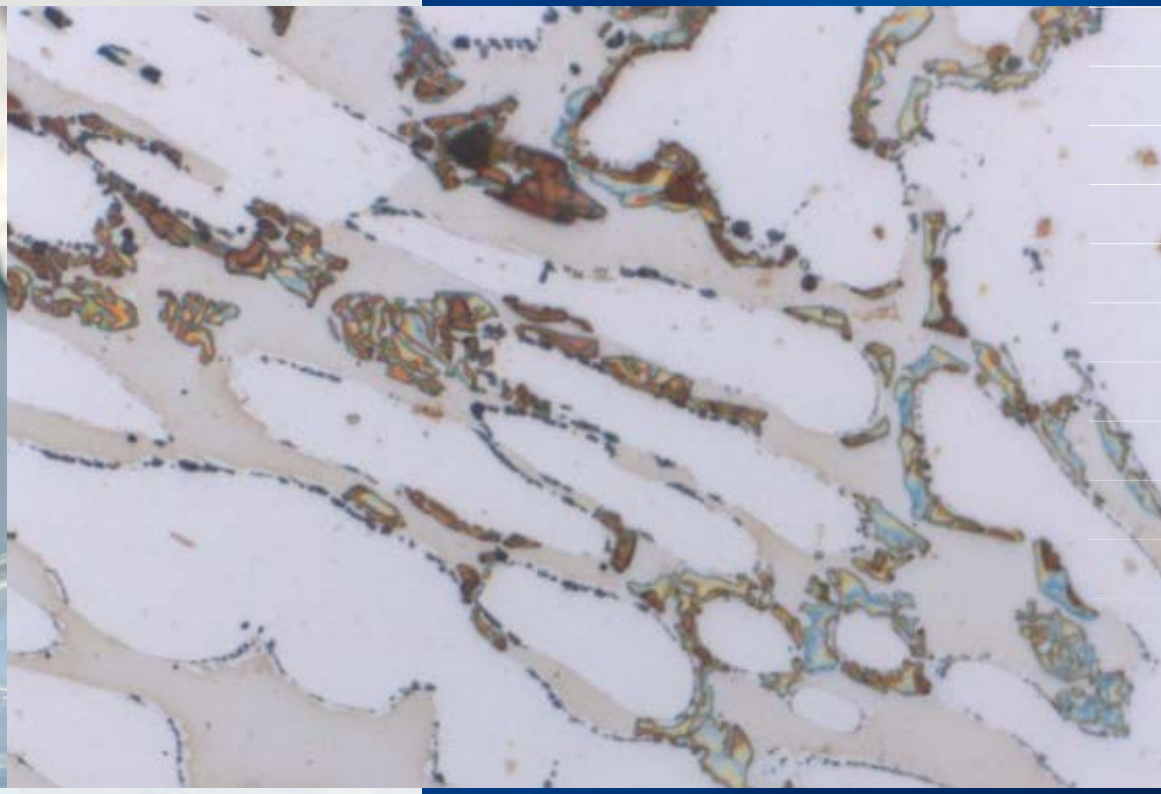
lightoptical microscopy - structure characterization



Characterization of the microstructure of structural parts and functional components

our focus / competences

- microstructure documentation and analysis
- comprehensive range of etching methods (chemical and electrochemical) for steels, non-ferrous metals, hard metals, ...
- assessment according to various standards
  - content of non-metallic inclusions acc. to DIN 50602, ASTM E45, DIN EN 10247, ISO4967
  - carbide structure in steels acc. to SEP 1520
  - apparent grain size acc. to DIN EN ISO 643 und ASTM E112
  - depth of decarburisation acc. to DIN EN ISO 3887

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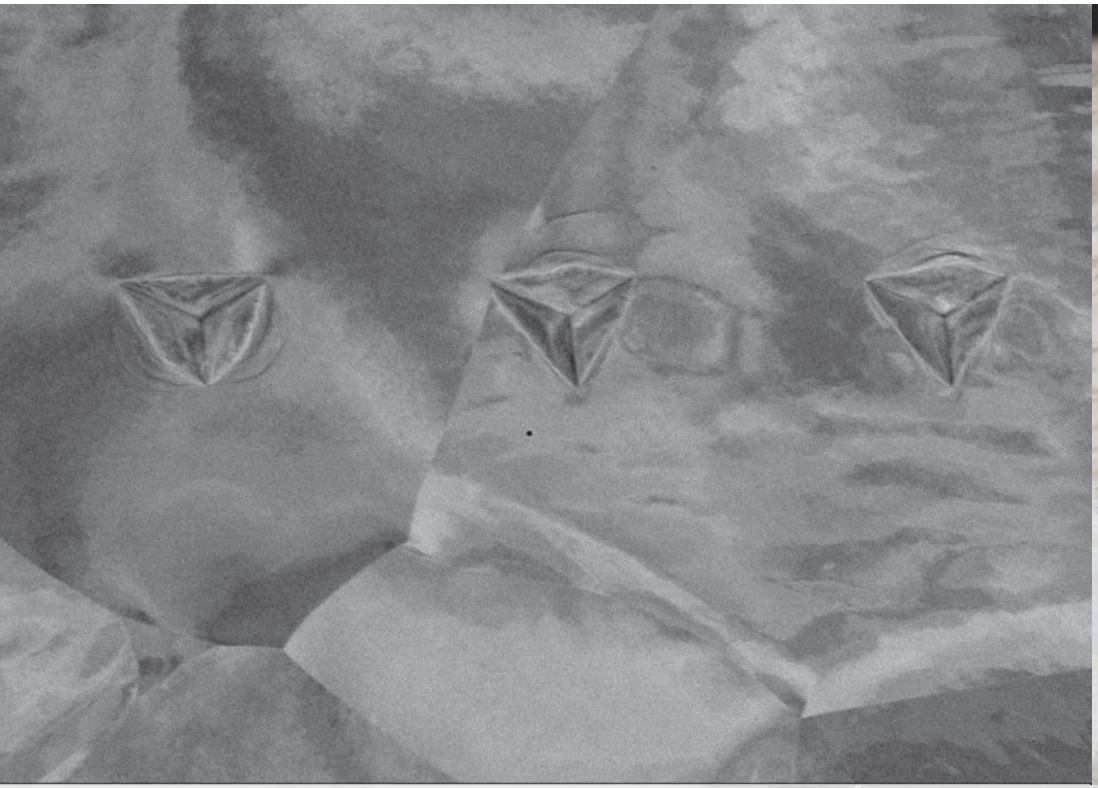
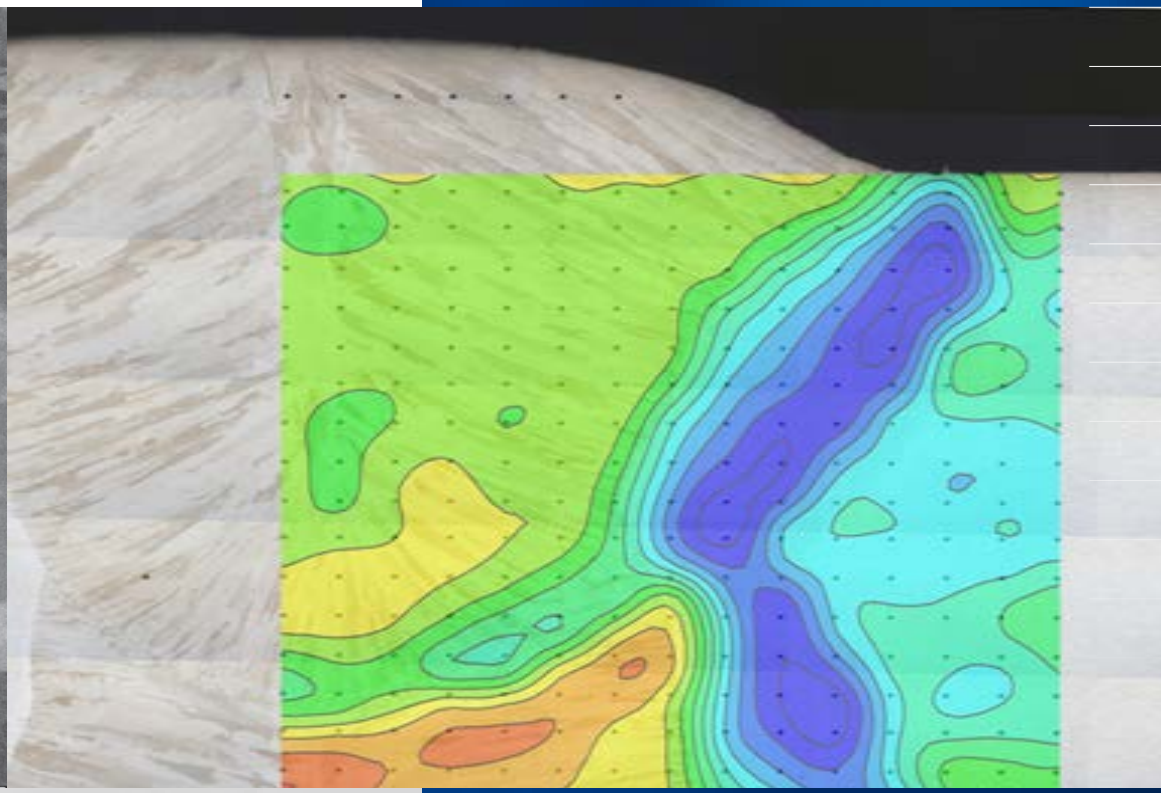
hardness testing





Performance of hardness tests from instrumented nano hardness testing to macro hardness testing *(partly within the scope of accreditation according to EN ISO 17025).*

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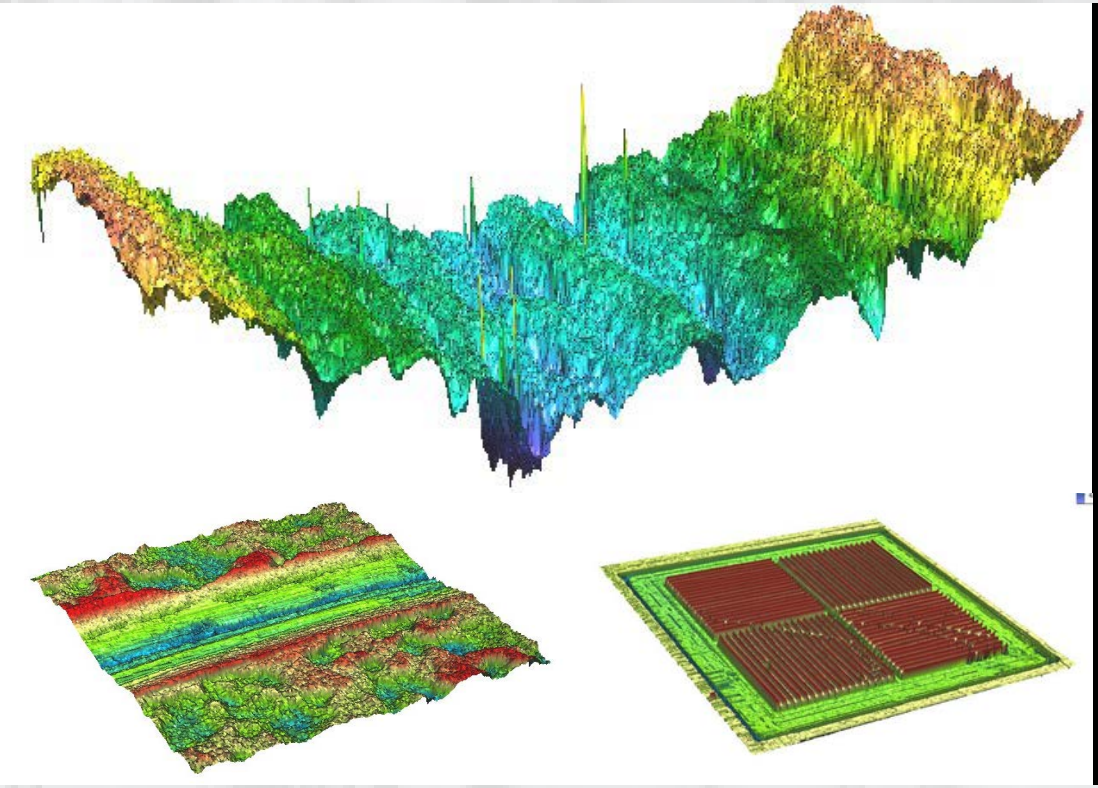
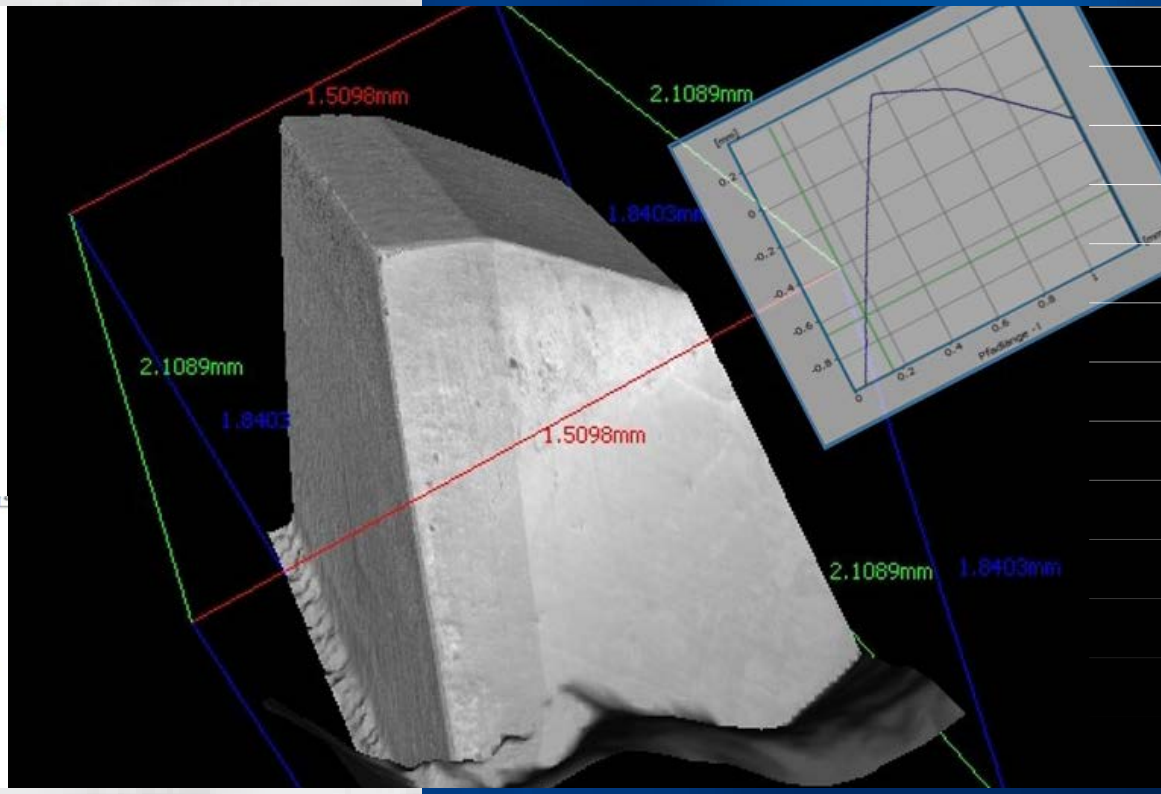
our focus / competences

- determination of the core hardness HV, HRC, HB in the accredited testing lab acc. to EN ISO 6506-1 (HB), EN ISO 6507-1 (HV), EN ISO 6508-1 (HRC)
- measurement of hardness profiles and hardness mappings
- instrumented small load hardness measurement
- instrumented nanoindentation (*)
- insitu nanoindentation in SEM

(*) in cooperation with the Department Materials Science of the University of Leoben

surface structures and topography





2D and 3D - imaging of contours and surfaces from several millimeters to a few nanometers.

our focus / competences

- imaging of surfaces, contours or components by means of stereomicroscopy, profilometry and scanning electron microscopy
- Roughness measurements (Ra, Rt, Rz)
- Wear characterization on samples, components and tools
- 3D topography of contours, damage, etc. incl. measurement in the mm to sub-µm range in SEM.
- Analysis of local deposits, ablations incl. local chemical analysis (EDX).

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COMPETENCE & RELIABILITY

Service offer

- coarse/fine cutting,mechanical production of specimen material
- preparation of metallographic sections (metallic materials, metal-ceramic composite, electronic components)
- light microscopic examinations (microstructure documentation, microstructure assessment)
  - content of non-metallic inclusions acc. to DIN 50602, ASTM E45, DIN EN 10247, ISO4967
  - carbide structure in steels acc. to SEP 1520
  - apparent grain size acc. to DIN EN ISO 643 and ASTM E112
  - depth of decarburisation acc. to DIN EN ISO 3887
- stereomicroscopic examinations (surface and fractography)
- roughness measurement (Ra, Rt, Rz) by confocal microscopy
- creation of topography images, qualitative and quantitative evaluation in 2D or 3D, also on small to medium-sized components, cutting edges, friction marks, wear surfaces, etc.
- ambulant metallography (on-site-testing)
- one to several days on-site-trainings in the field of metallographic preparation and microstructure evaluation

equipment

- coarse and fine cutting machines for sample preparation
- CNC milling and turning machines for sample production
- equipment for hot and cold embedding of microsections
- automated and manual grinding and polishing equipment
- lightoptical microscopy incl. digital image recording and automatic x-y table for analysis of large microsection surfaces
- stereomicroscopy with 3D recording technology
- quantitative image analysis system
- nanofocus µsurf confocal microscope (profilometer) with automatic x-y stage (analysis of large areas)
- various scanning electron microscopes (see SEM folder)

MATERIALS CENTER LEOBEN
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qualitative and quantitative phase analysis

high temperature properties and phase transformations

(X-ray) residual stress measurements

structure and phase analysis

X-ray diffraction

COMPETENCE & RELIABILITY

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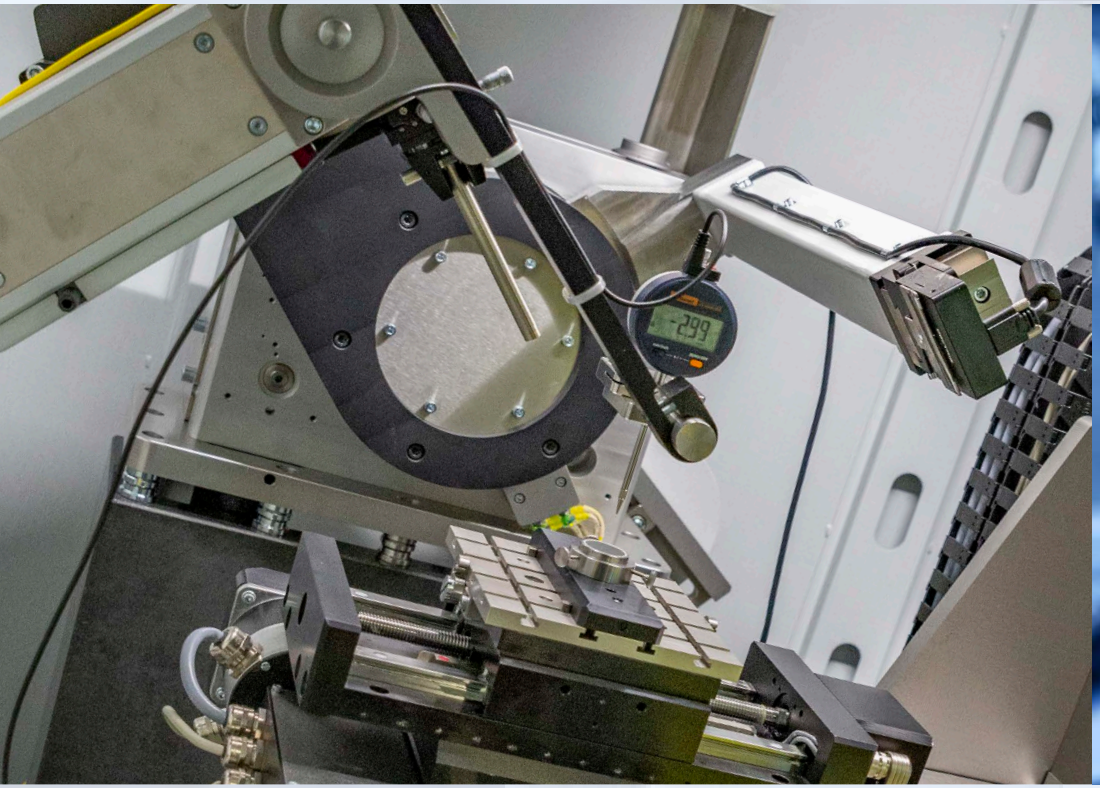
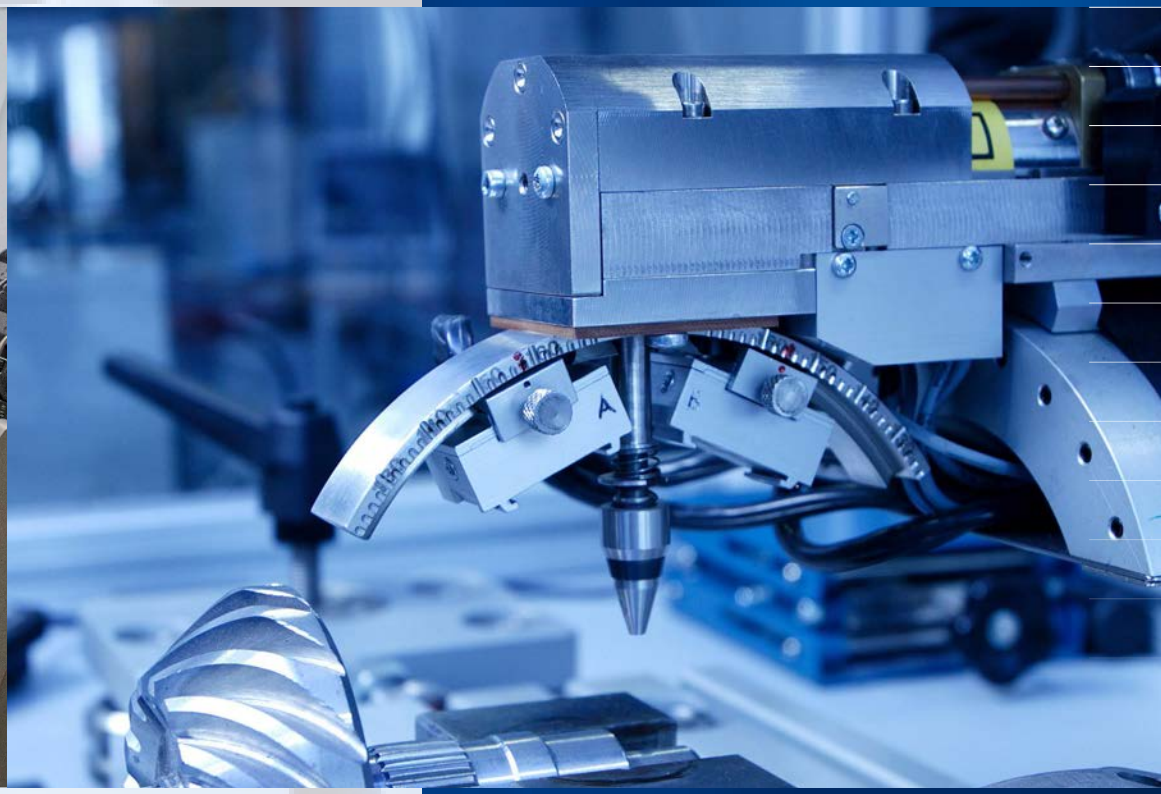
Accredited testing laboratory acc. to EN ISO 17025

qualitative and quantitative phase analysis





X-ray determination of phase structure and structural parameters at room temperature

(partly within the scope of accreditation according to EN ISO 17025)

our focus / competences

- qualitative and quantitative phase analysis (incl. Rietveld method)
- determination of lattice parameters (lattice constants, defect density, crystallite size)
- determination of the retained austenite content according to ASTM E 975 (within the scope of the accreditation) or by means of the Rietveld method (laboratory and on-site)
- analysis of ripples, reflectometry e.g. on microelectronic components
- examination of metals, ceramics, coatings

contact

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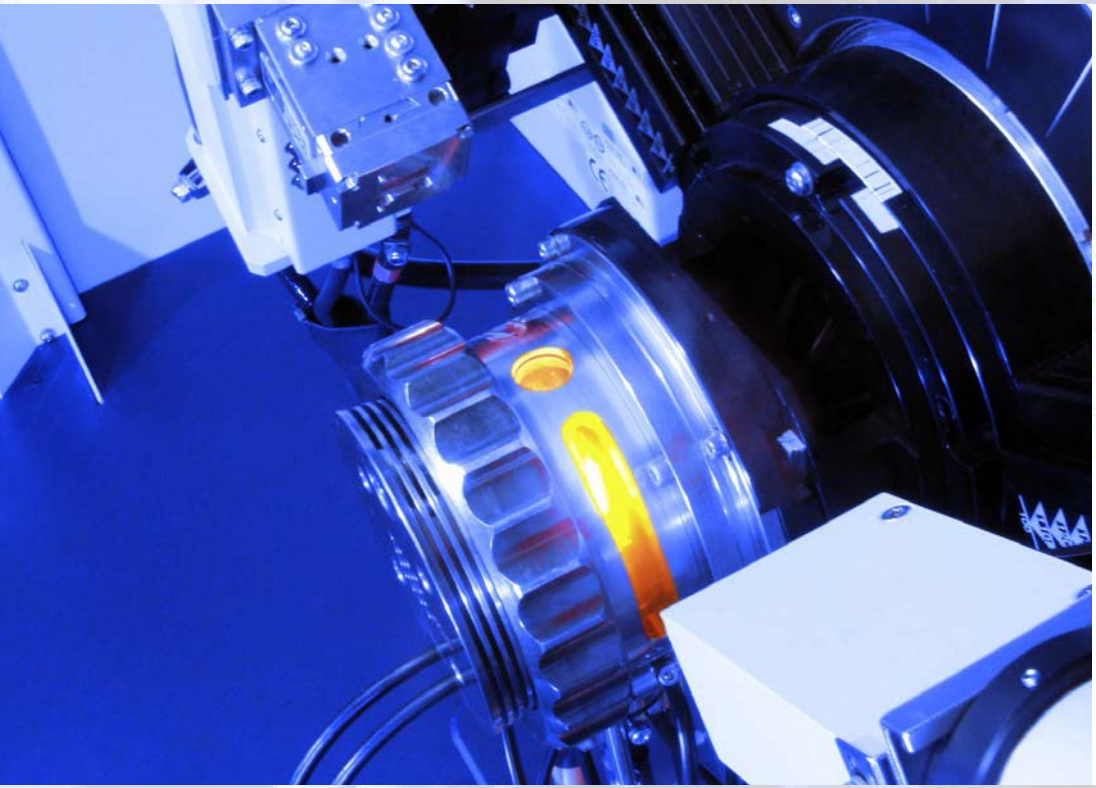
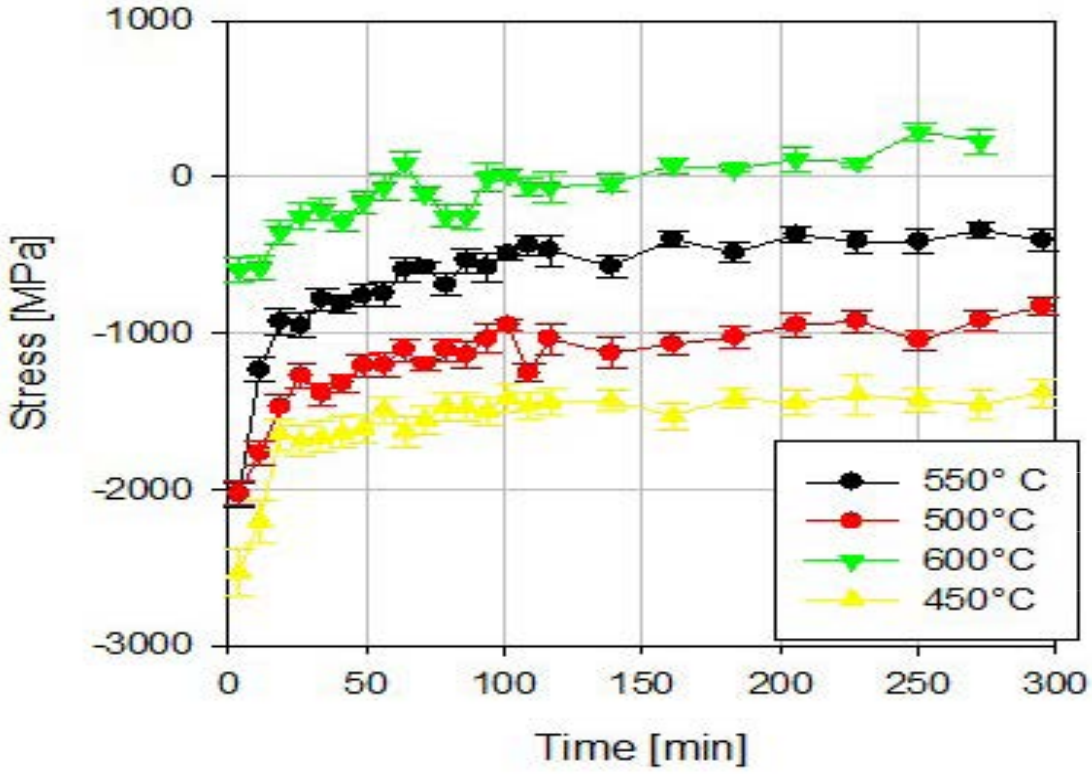
We innovate Materials

high temperature properties and phase transformations





Determination of phases, phase transformations, structural parameters and residual stresses at elevated temperatures as well as under different atmospheres.

our focus / competences

- Determination of crystallographic structure parameters as a function of temperature
- Determination of phase transformations such as magnetic and lattice transformations, melting, glass transition temperatures
- Tracking of phase changes due to annealing processes
- Detection of phase reactions (e.g. oxidation, decomposition)

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(X-ray) residual stress measurements

X-ray determination of residual stresses

(partly within the scope of accreditation according to EN ISO 17025)

our focus / competences

- X-Ray determination of residual stresses, residual stress distributions and residual stress depth profiles on components in the laboratory or at the customer's site (according to EN 15305 within the scope of accreditation)
- Residual stress development in layer/ substrate composites at temperature-change
- Determination of relaxation of residual stresses at elevated temperatures up to 900°C
- Determination of residual stresses using the cut compliance method

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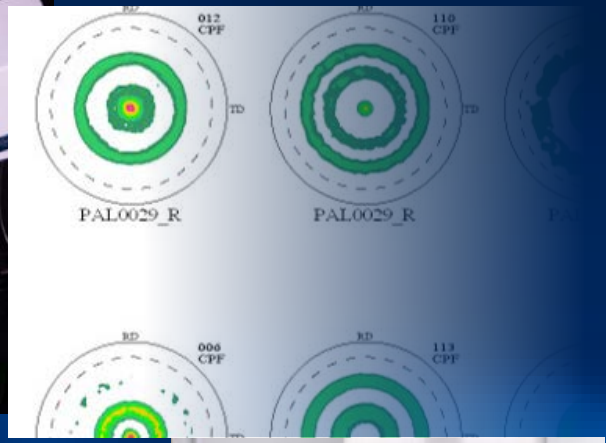


Service offer

- qualitative and quantitative radiographic phase analysis (room temperature up to 1400°C)
- determination of lattice parameters (lattice constants, defect density, crystallite size) as f(T)
- determination of phase transformation temperatures
- X-ray phase and structure analysis of thin surface layers
- determination of fiber textures in layer systems
- determination of ripples, refletometry on microelectronic components

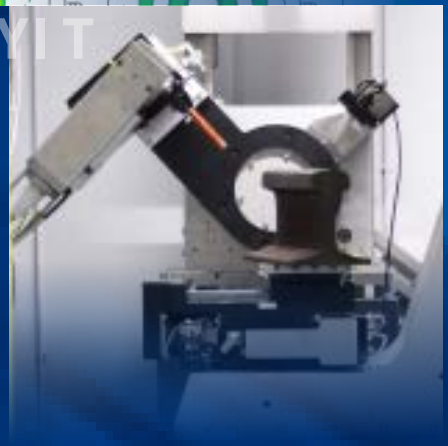
- Determination of the retained austenite content according to ASTM E975 resp. Rietveld method (accredited)
- X-ray determination of process-related residual stresses according to EN 15305 (accredited)

- Determination of residual stress depth profiles on specimens and components
- Chemical analysis by XRF
- Measurements in the laboratory or on-site on large parts, components or materials

COMPETENCE & RELIABILITY

equipment

- X-Ray defractometer Bruker D8 Discover with ultra-precise Atlas goniometer and a wide range of anode materials, detectors and setups for various applications (e.g. high temperature chamber HTK2000 from Paar for detection of fast phase transformations in inert and oxidic atmospheres (25 to 1400°C))
- X-ray diffractometer Bruker D8 Discover with Euler cradle for texture, residual stress and phase analysis
- X-ray diffractometer Seifert Charon SXL (XRD Eigenmann GmbH): diffractometer for large components for high-precision measurements with a spot size of up to 50µm
- mobile X-ray diffractometer Stresstech Xstress 3000 (G2/G3) with integrated depth measurement and automatic inspection table. Also suitable for measurement of internal surfaces and insitu measurement on testing machines.
- mobile X-ray fluorescence analyzer S1TurboLE from Bruker (Handheld)



MATERIALS CENTER LEOBEN
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scanning electron microscopy

material- and damage investigation

3D microstructure and contour analysis

high resolution scanning electron spectroscopy

precise chemical and structural analysis

Focus Ion Beam micromachining

Insitu - micromechanical investigations

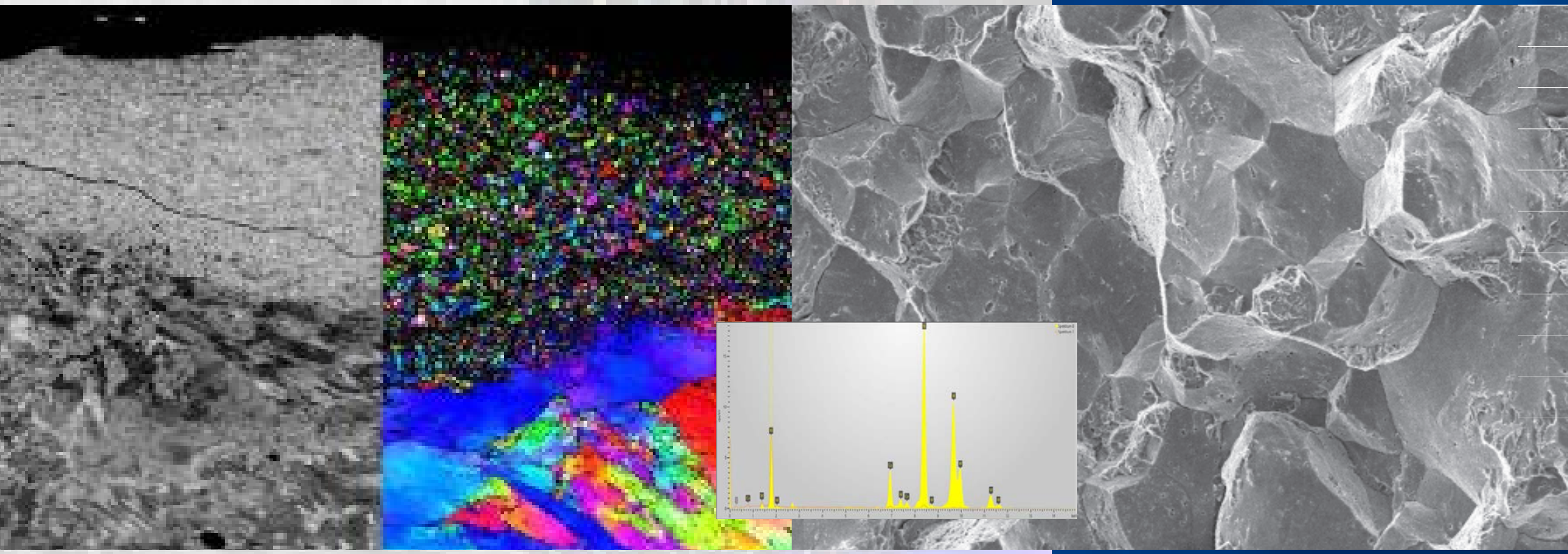
Insitu - temperatur transformation analytics

Ex-/Insitu - AFM-measurements

ISO 9001 CERTIFIED ISO 9001

COMPETENCE & RELIABILITY

material- and damage investigation



high-resolution examination of material sections, surfaces or fracture surfaces incl. local chemical and crystallographic analysis

our focus / competences

- surface analyses, fracture surface analyses, damage analyses
- analysis of large or difficult-to-clean components (up to 3kg), from microsections up to microelectronic components
- SEM analysis of non-conductive components without additional vapor deposition (e.g. ceramic components, metal/plastic composites)
- local chemical and crystallographic analyses

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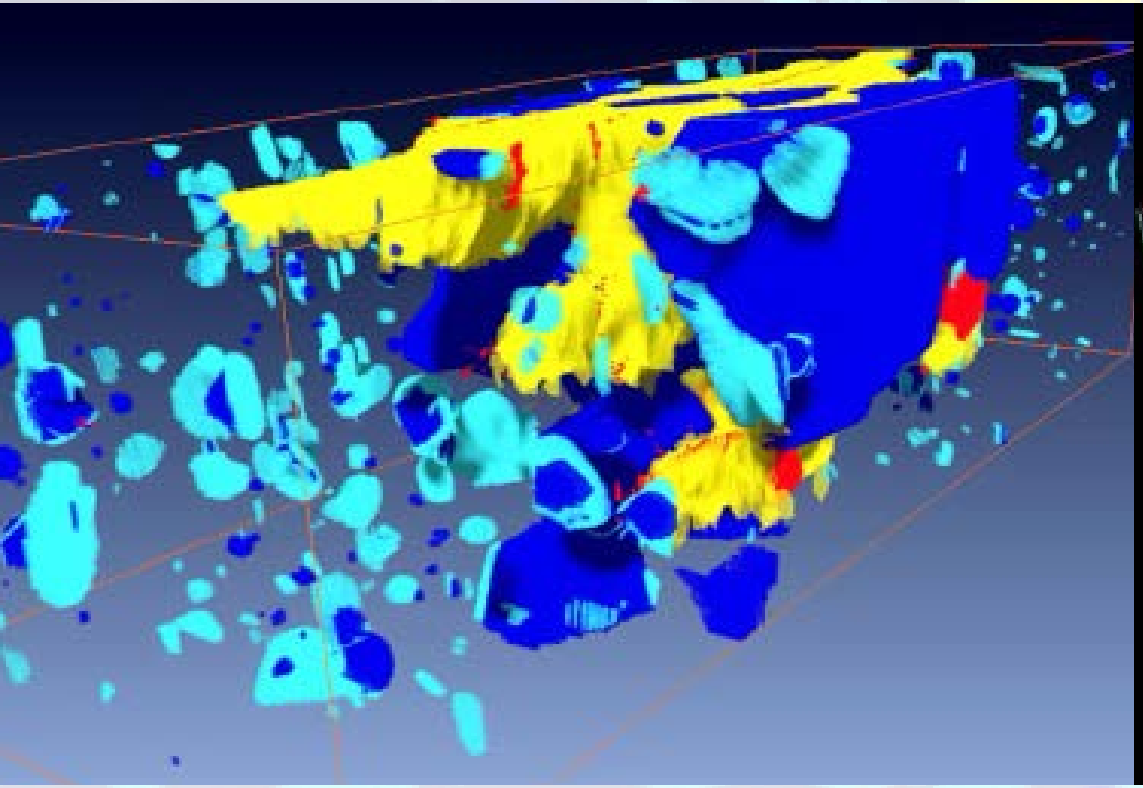
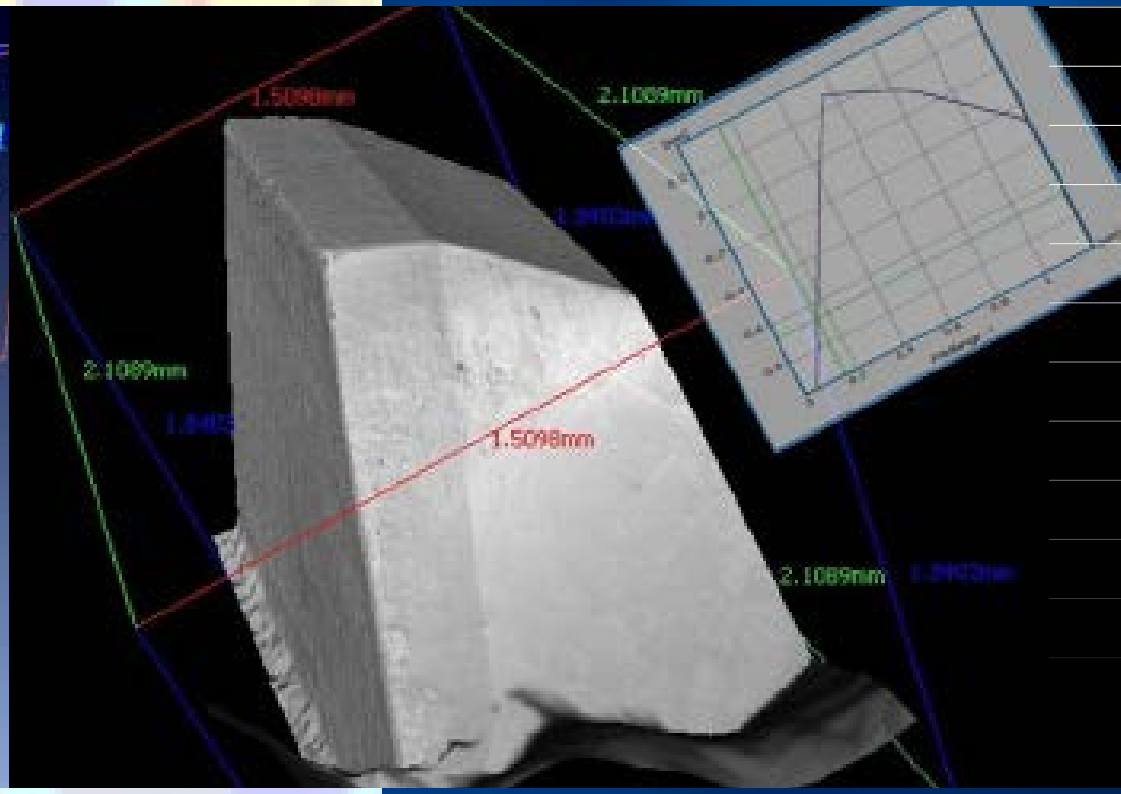
3D microstructure and contour analysis





high-resolution 3-dimensional examination and measurement of contours or structural components

our focus / competences

- 3D topography of contours, damage, etc. incl. measurement in the mm to sub-µm range
- 3D tomography of microstructural components by the Slive&View method incl. measurement of local chemistry and structure
- different electron constrasts, EBSD orientation measurement, local chemical composition over the measurable spectrum from lithium to uranium (EDX, WDX, XRF)

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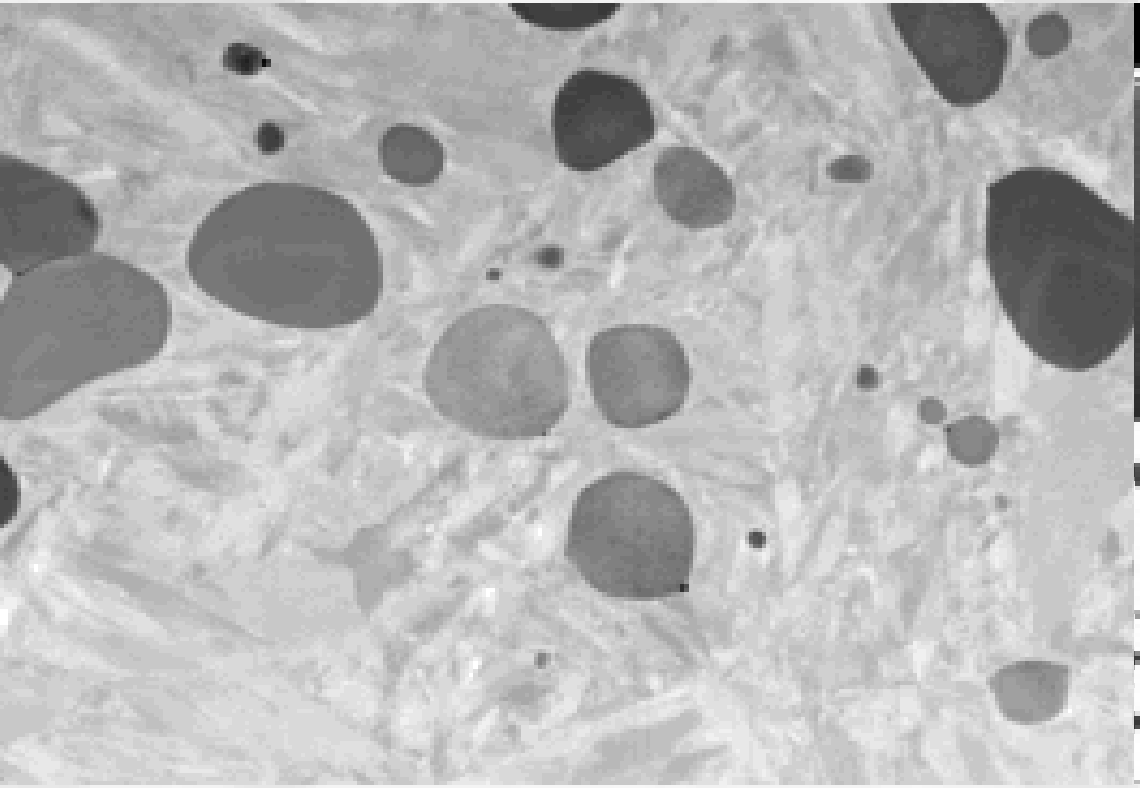
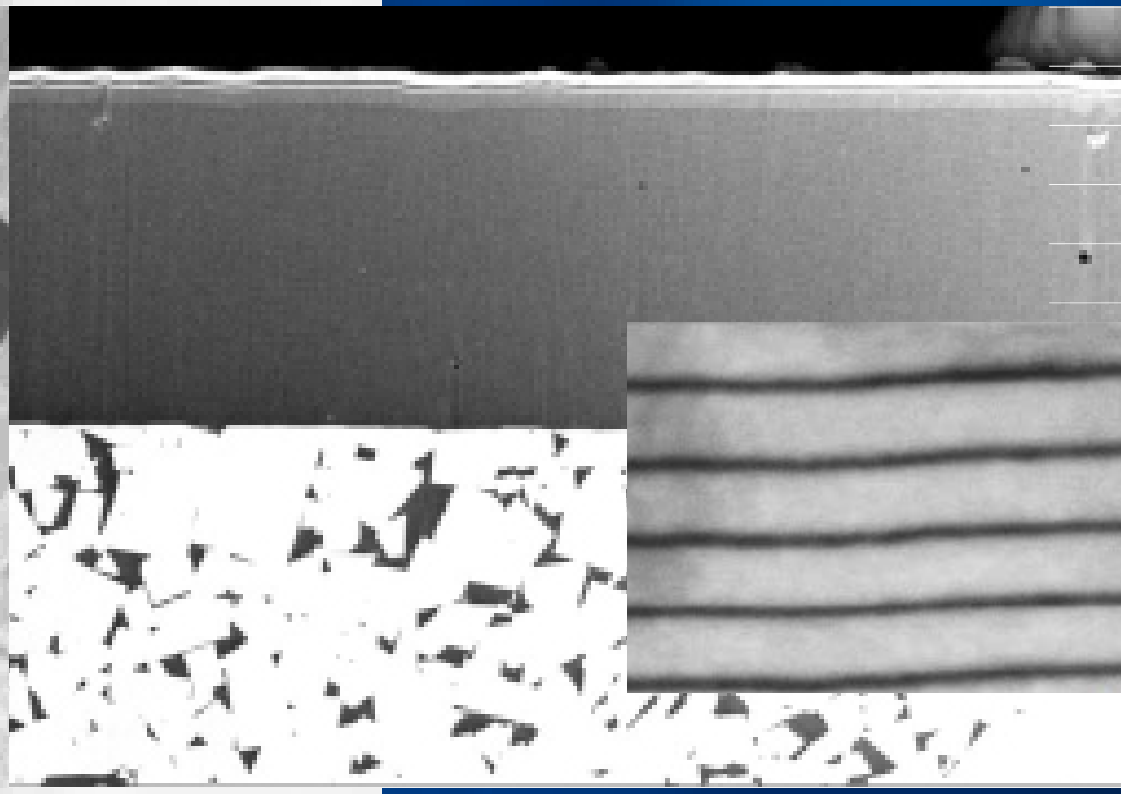
high resolution scanning electron spectroscopy





high resolution microstructure characterization

contact

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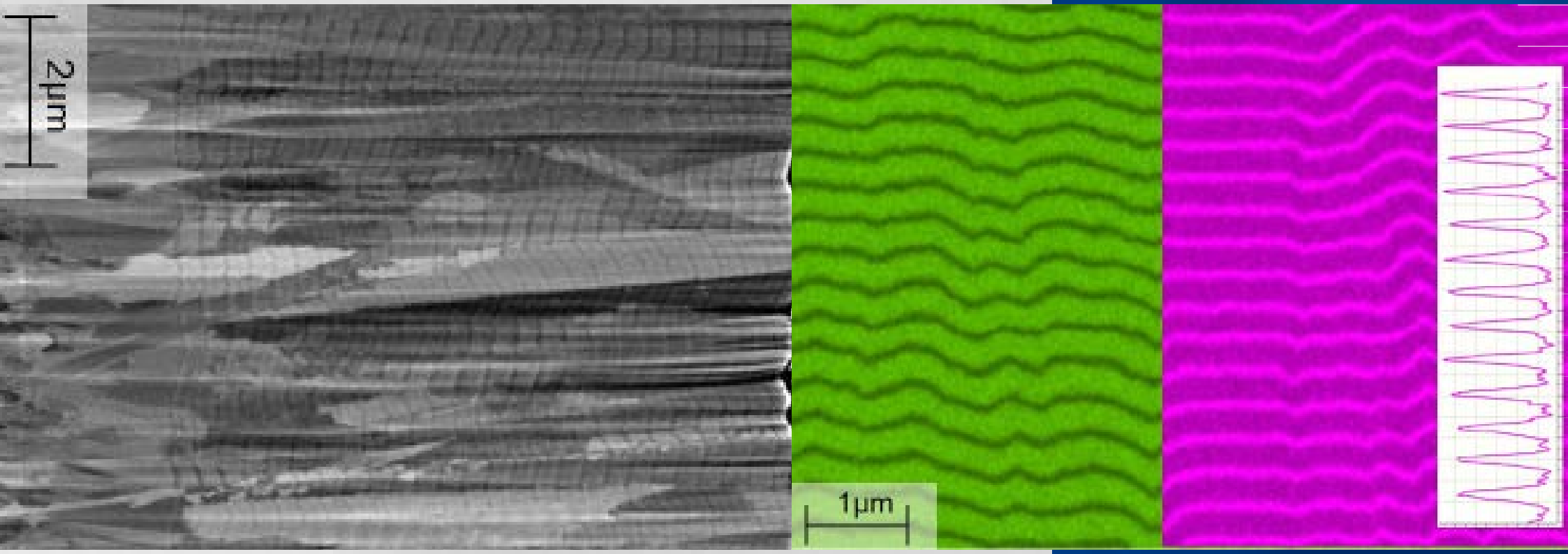
our focus / competences

- high resolution microstructure characterization with resolutions up to 1,000,000x
- different electron and ion constrasts, EBSD orientation measurement.
- measurement of the crystal structure by EBSD from the cm range down to 20-30nm small structures
- measurement of the local chemical composition over the measurable spectrum from lithium to uranium (EDX, WDX, XRF)

precise chemical and structural analysis



precise chemical and structural analysis of finest structural elements down to a few 10nm in size

our focus / competences

- precise chemical analysis using EDX, WDX and XRF
- high energy resolution with detection limits of 50-100 ppm
- trace element analyses down to detection limits of 10ppm
- EBSD measurements of grains less than 10nm in size for identification of microstructure or crystal structure

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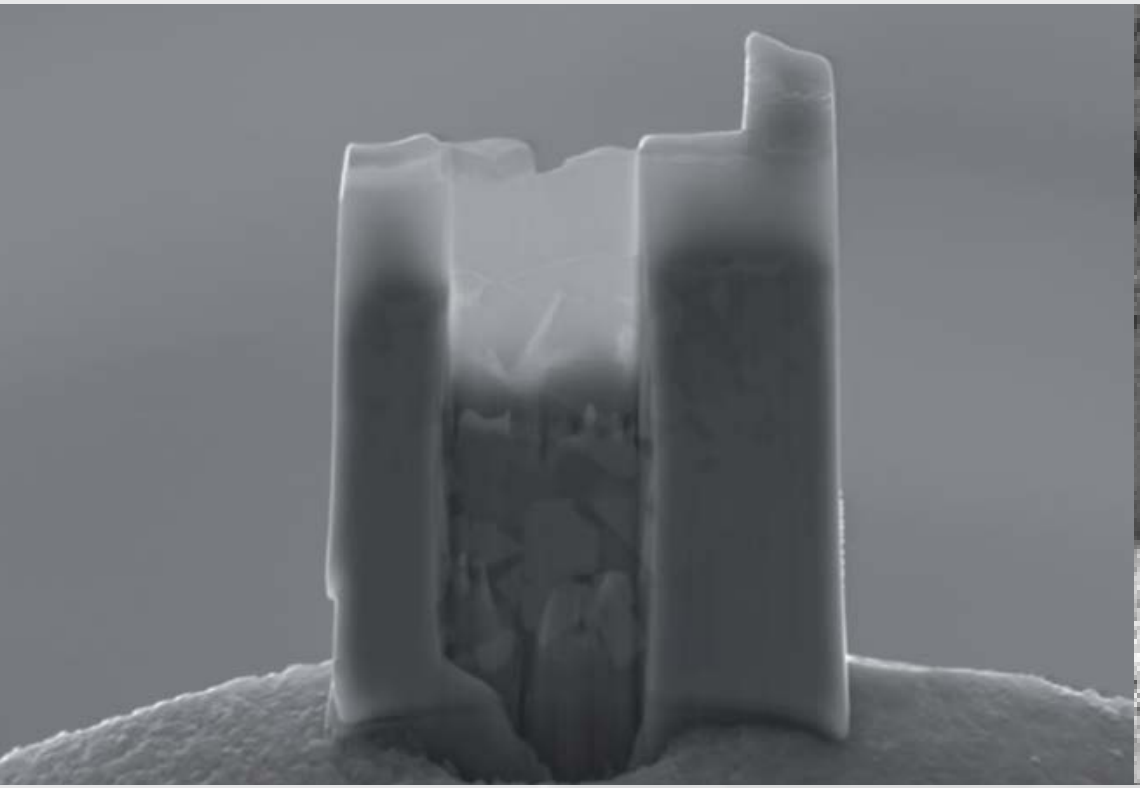
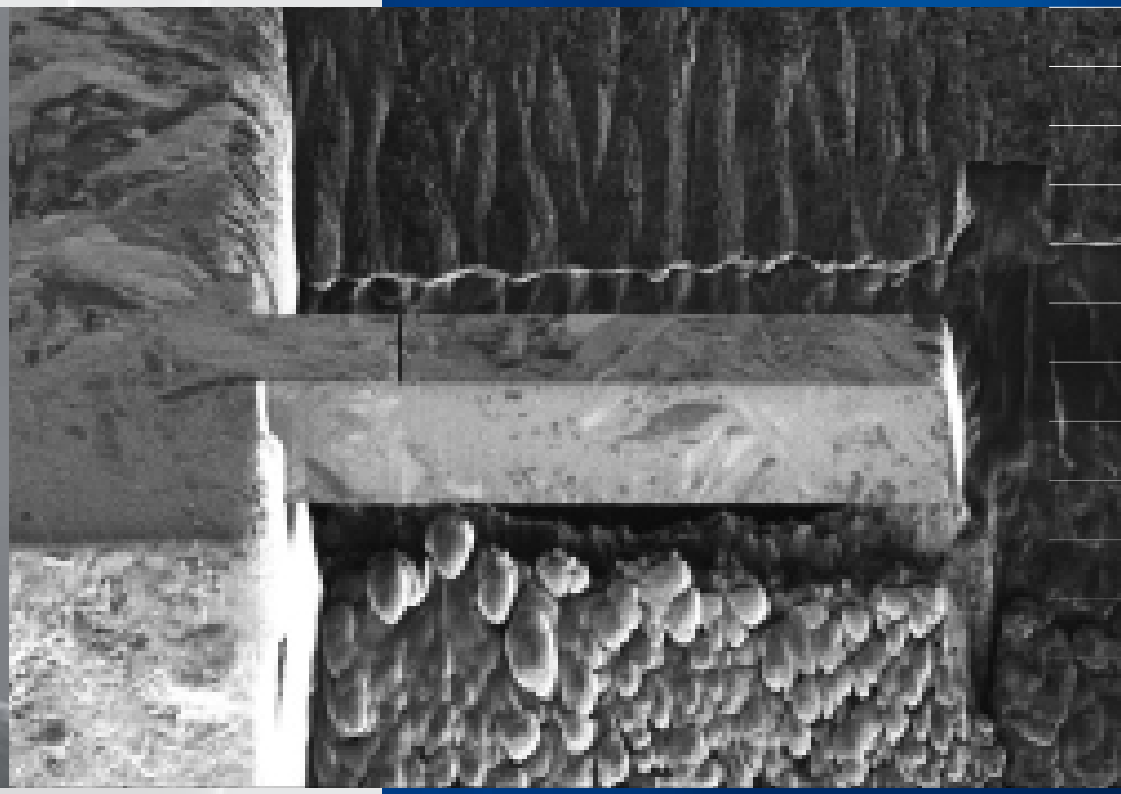
Focused Ion Beam micromachining





specimen preparation for micromechanical and microstructural investigations

our focus / competences

- target preparation of thin foils for subsequent electron microscopy and transmission electron microscopy examinations (*)
- target preparation of atom probe tips for subsequent atom probe examinations
- preparation of specimens for micromechanical testing of materials (e.g. thin films or microstructural components)

**advanced TEM, APFIM analyses are performed in cooperation with research partners of the MCL*

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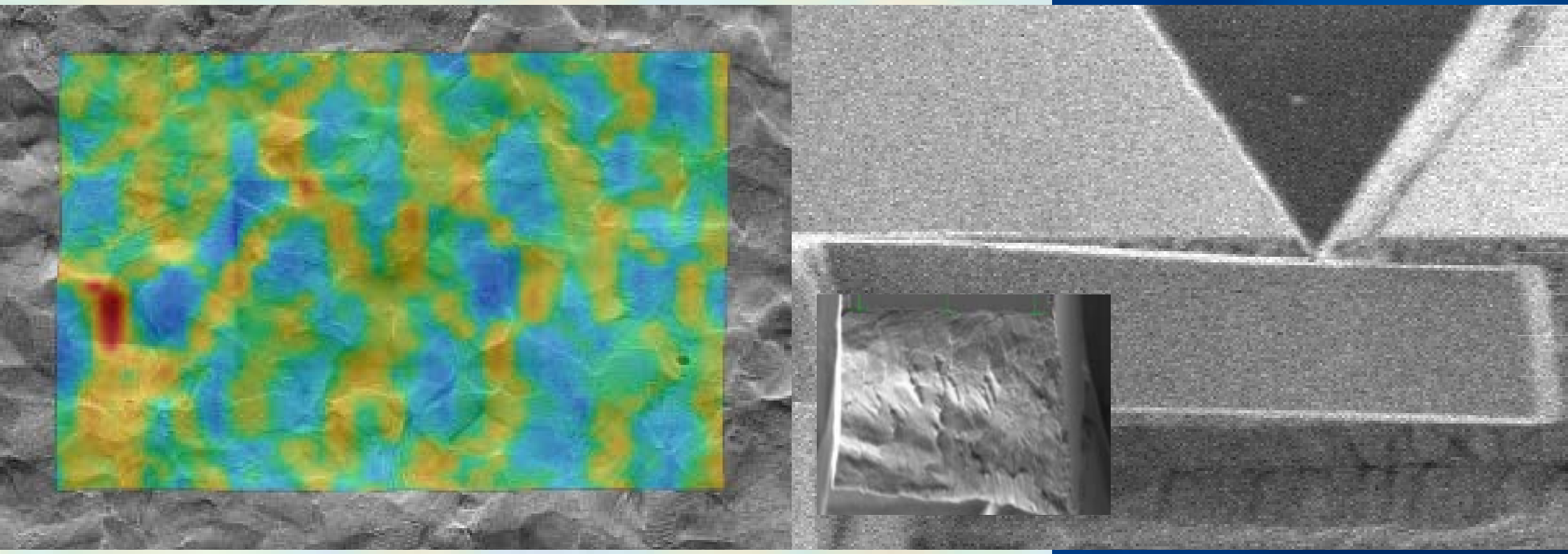
Insitu - micromechanical investigations



determination of micromechanical properties of microstructural components or layers

our focus / competences

- hardness testing of individual microstructural fractions
- Insitu tensile test to observe local strain changes
- Insitu hardness testing using nanoindentor, recording flow curves and determination of Young's modulus
- Insitu static and cyclic material testing using the nanoindentor, determination of fracture and fatigue properties
- testing of shear resistances at interfaces (e.g. interface of a coating)

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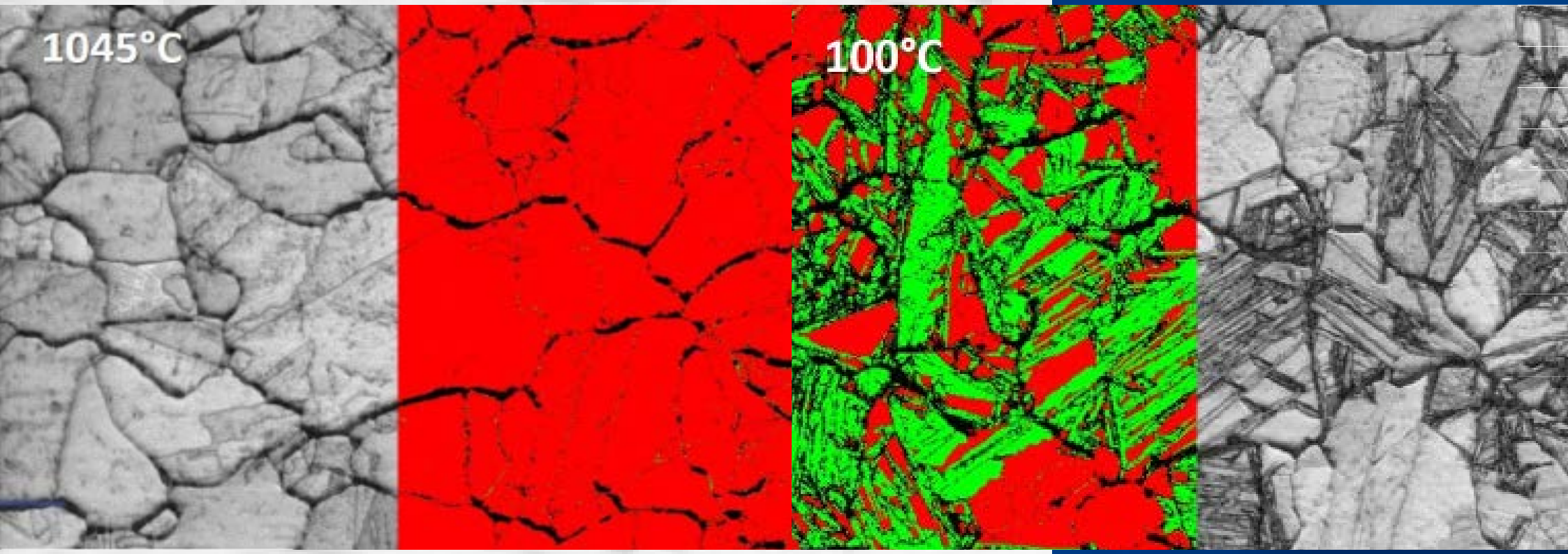
Insitu - temperatur transformation analytics



High-resolution documentation of the transformation kinetics of individual phase fractions

our focus / competences

- Insitu heating and cooling experiments in the scanning electron microscope
- temperature range -180°C to 1045°C
- heating rates:-180°C to 400°C max. 20°C/min
  250°C to 1045°C max. 250°/min
- temperature-dependent residual stress measurement on coatings
- analysis with various detectors (including EBSD)

contact

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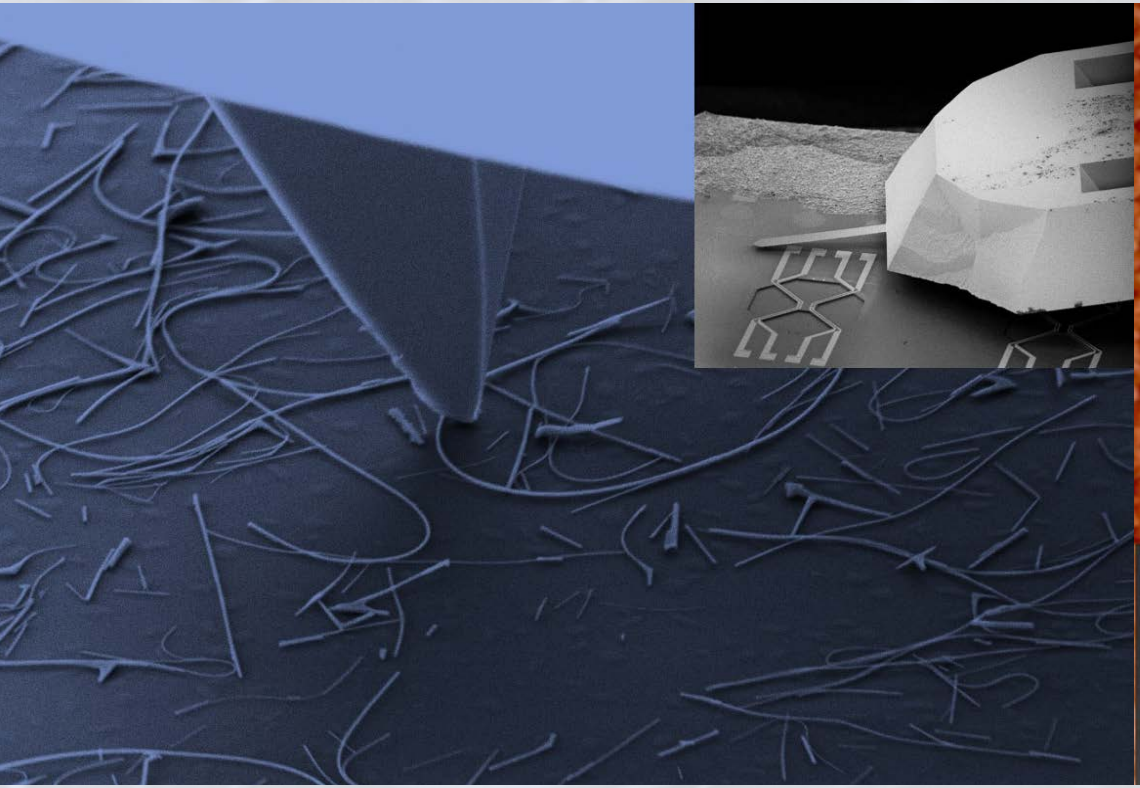
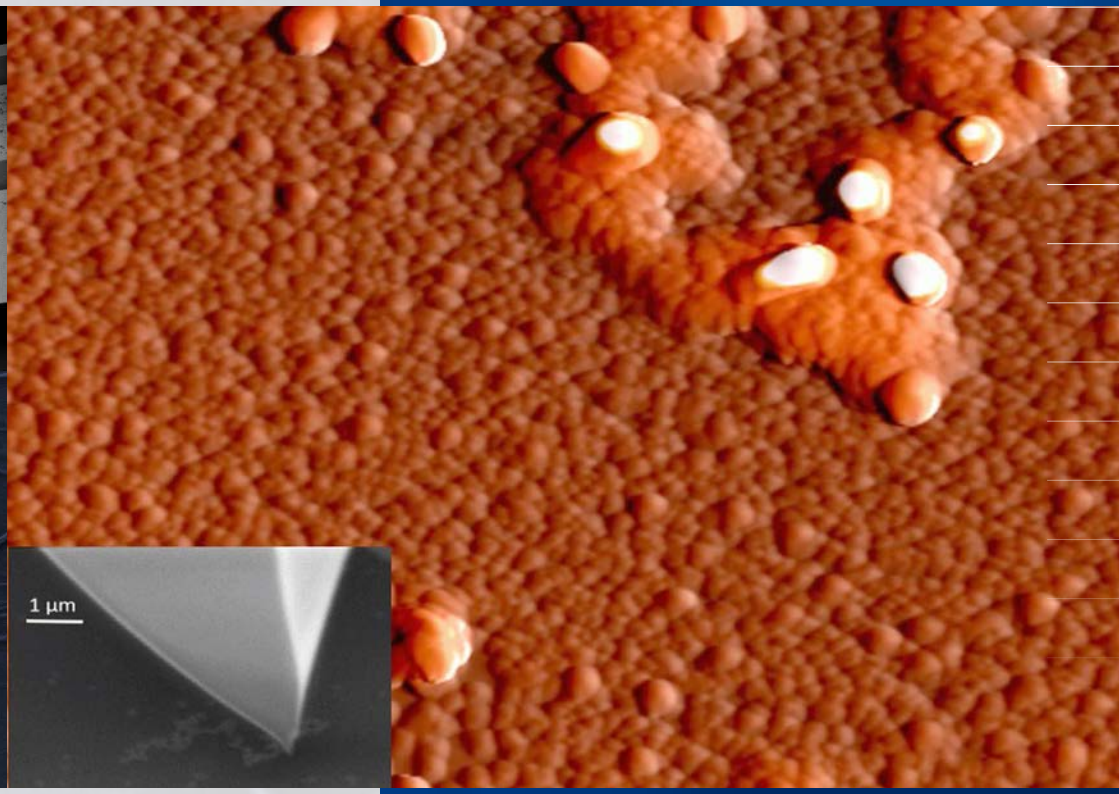
Ex-/Insitu-AFM measurements





determination of local electrical, thermal and magnetic properties and surface topographies

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We innovate Materials

our focus / competences

- topography / roughness
- KPFM for the determination of local electrical properties of grains or microstructural components
- SThM for determination of thermal conductivity of grains or microstructure components
- EBIC for determination of local electrical properties and short circuits/interruptions
- MFM for determination of local magnetic properties (e.g.: retained austenite)
- STM for visualization of atoms or atomic lattice
- C-SPM for measuring electrical properties such as resistance or conductivity

COMPETENCE & RELIABILITY

Service offer

- SEM characterization of surfaces, fracture surfaces, damage and microsections incl. local chemical composition
- material investigations up to 3D microstructures, topography and tomography using SEM-FIB technology
- target preparation of TEM thin films, atom probe tips for further high-resolution investigations
- preparation of microsamples for mechanical in-situ experiments with different geometries (e.g. cuboids, cylinders or micro tensile specimens and cantilever)
- investigation of TEM samples in transmission mode (STEM) incl. chemical and crystallographic analysis
- insertion of small crack-like defects (in the sub-µm to µm range) to study the behavior of short cracks
- local and depth-resolved residual stress measurements
- high temperature investigations in combination with EBSD
- determination of physical parameters in combination with modules and analytics
- SPM-SEM in combination of different modules
- one to several days on-site training in preparation & microstructure evaluation

equipment

- scanning electron microscope with large sample chamber of Zeiss type EVO MA25® for the analysis of non-conductive and contaminated samples.
- dual-beam FE-SEM (Zeiss AURIGA®-CrossBeam®) incl. Focused Ion Beam System (FIB)
- high-resolution FE-SEM (Zeiss Gemini®-SEM 450) for imaging structures with a few nm and precise chemical analysis
- modular SEM (Zeiss CrossBeam®-SEM 340) with
  - tensile/compression/bending module
  - nanoindenter
  - heating/cryogenic module
  - AFM
- Acquisition techniques and analytics: SE, BSD, STEM, secondary ion, InLens and EBSD detector, EDX, WDX, ED-XRF, WD-XRF, EBSD, STEM, TKD (Transmission EBSD)
- ionslicer for sample preparation (flatmilling, cross sectioning)
- vapor deposition with different substances (graphite, platinum,...) for charge compensation and analysis of non-suffering samples

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mechanical materials testing

- hardness testing
- static materials testing - tension/compression/bending
- cyclic materials testing -Low Cycle Fatigue (LCF)
- cyclic materials testing -High Cycle Fatigue (HCF)
- fracture mechanics

COMPETENCE & RELIABILITY

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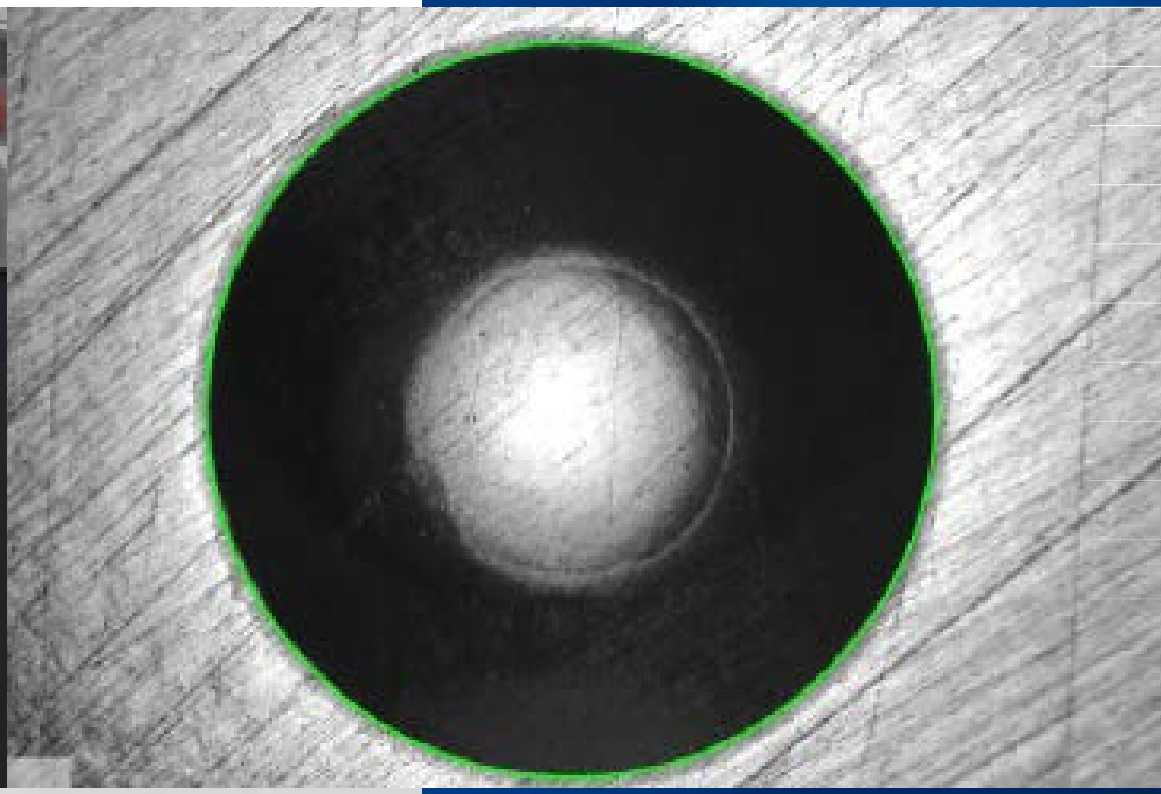
Accredited testing laboratory acc. to EN ISO 17025

hardness testing



performance of hardness tests (Vickers HV, Brinell HB, Rockwell HRC) within the scope of accreditation according to EN ISO 17025.

our focus / competences

- determination of core hardness HV, HRC, HB in the accredited lab
  - EN ISO 6506-1 (HB)
  - EN ISO 6507-1 (HV)
  - EN ISO 6508-1 (HRC)
- measurement of hardness profiles
- hardness measurement of metallic and ceramic materials

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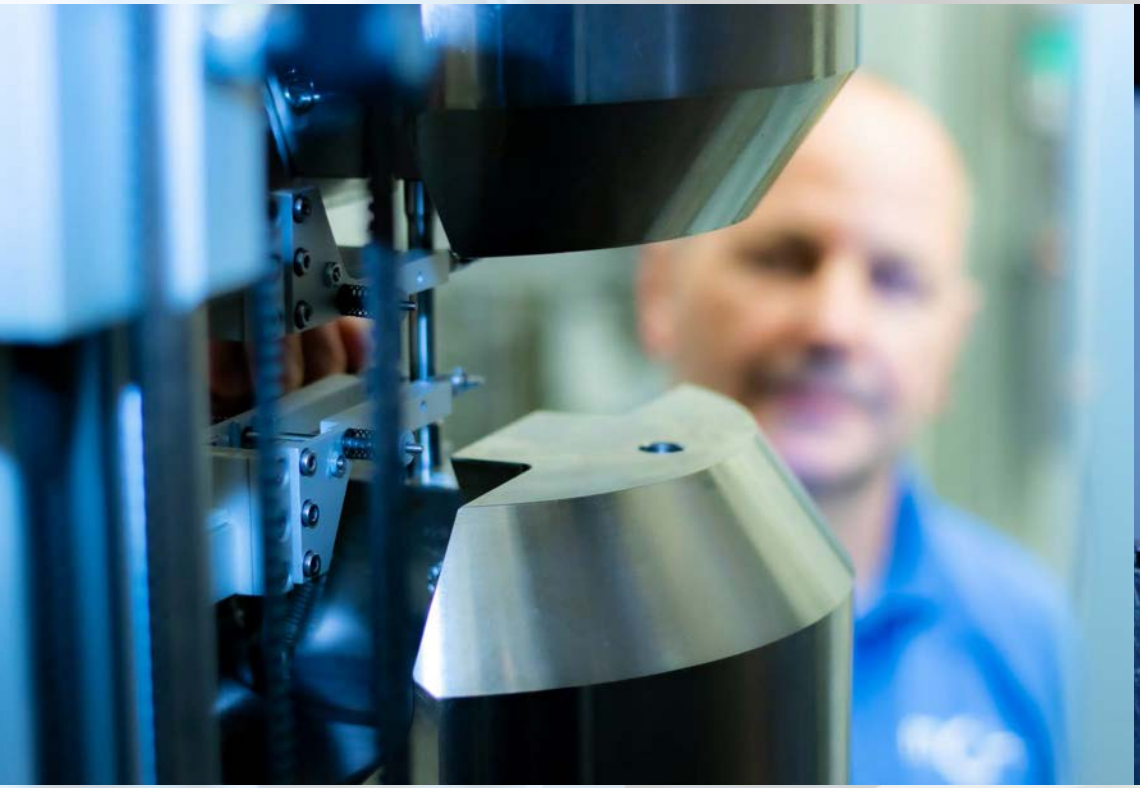
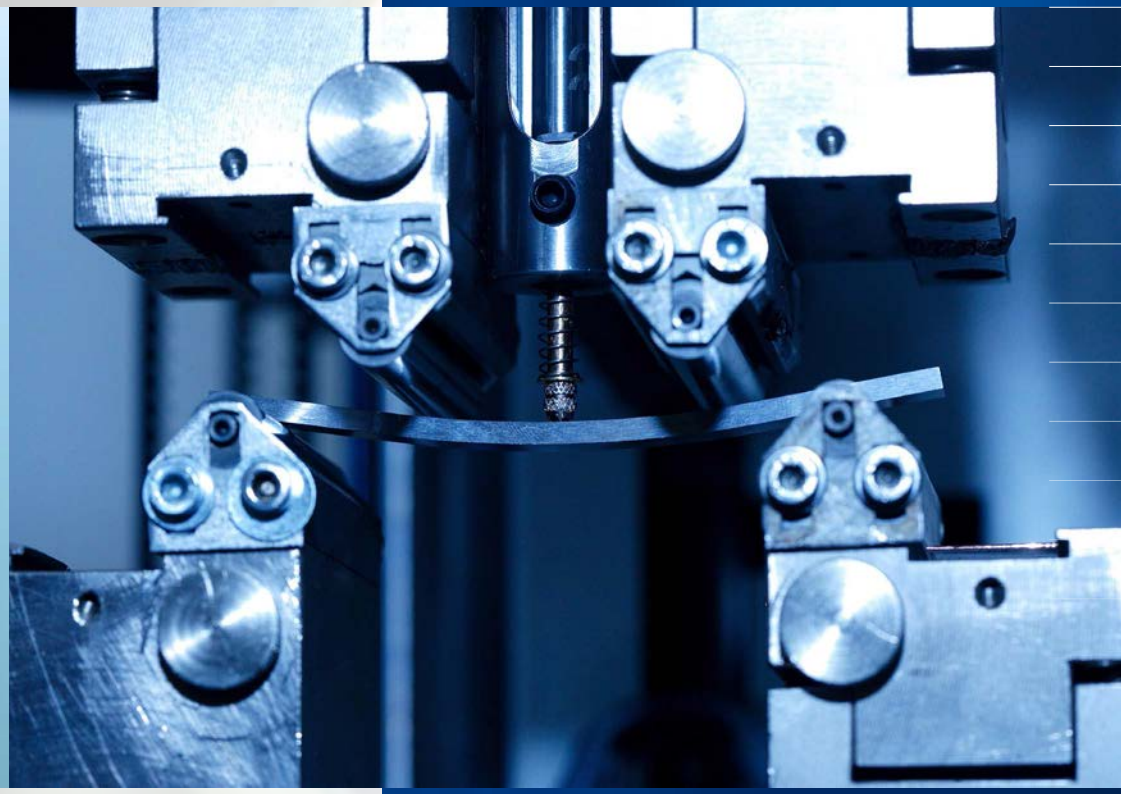
static materials testing - tension/compression/bending





determination of mechanical material parameters for low- to high-strength materials under tension, compression and bending

(partly within the scope of accreditation according to EN ISO 17025)

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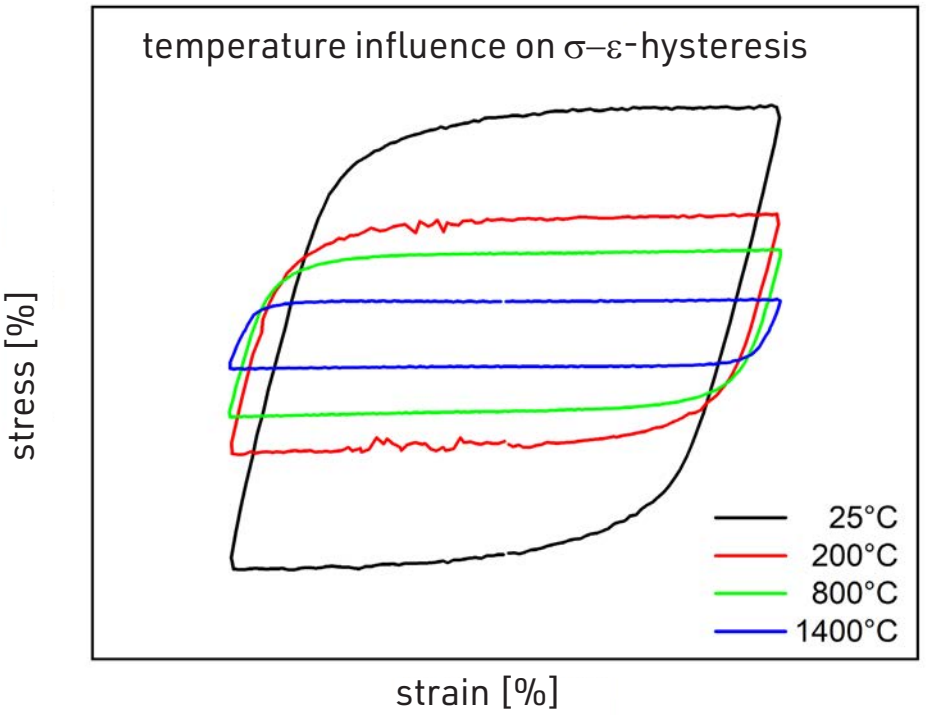
our focus / competences

- tensile test acc. to EN ISO and ASTM standards (partly within the scope of accreditation)
- compression test acc. to ASTM E9 and DIN 50106
- 3-point and 4-point bending test
- temperature range from -150°C to 1400°C
- combination with local deformation analysis (Aramis)
- specimen fabrication and testing of various specimen geometries and dimensions

cyclic materials testing - Low Cycle Fatigue (LCF)



determination of cyclic material properties (strain creep curves, cyclic creep,...)

our focus / competences

- strain camber curves (ASTM E606, ISO 12106)
- cyclic flow curves
- cyclic creep
- tension/compression ± 250 kN from -150°C to 1400°C
- high precision laser strain measurement
- vacuum / air / inert gas
- Individual load block programs
- Special tests: coupling heating / cooling with mech. loading (e.g. properties of metastable phases)

contact

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cyclic materials testing - High Cycle Fatigue (HCF)

determination of cyclic material properties (Wöhler curve, fatigue strength) at room temperature and elevated temperatures

(partly within the scope of accreditation according to EN ISO 17025)

our focus / competences

- High Cycle Fatigue tests (HCF) within the scope of accreditation acc. to EN ISO 17025 (DIN 50100, ASTM E466, ISO 1099)
- test frequency up to 180 Hz
- temperature: -150°C (N_2) to 900°C (air)
- statistical evaluation temporal strength / fatigue strength
- tensile-compression, torsion, bending (3PB, 4PB, 8PB)
- different atmospheres (air/protective gas/vacuum)

contact

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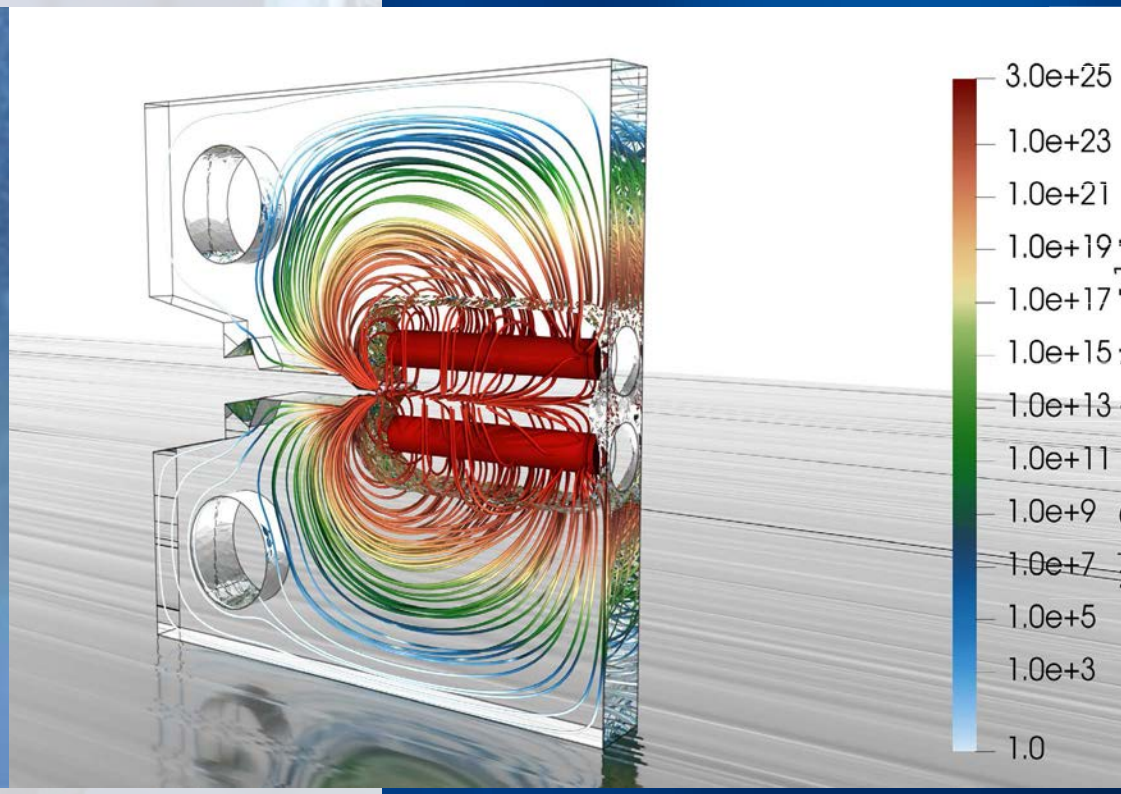
fracture mechanics



performance of static and cyclic fracture mechanics tests

(partly within the scope of accreditation according to EN ISO 17025)

our focus / competences

- static fracture mechanics:
  - KIC, JIC, JΔa-curve, CTOD
- cyclic fracture mechanics:
  - da/dN-curves
  - threshold value determination
  - crack resistance curves
- different test arrangements
  - CT, SE(B), SE(T)
- temperatures between -150°C and 800°C

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Service offer

hardness testing

- Determination of core hardness and hardness profiles HV, HRC, HB

Static material testing

- Uniaxial tensile test (-150°C to 1400°C)
- Uniaxial compression test or cylinder crush test according to ASTM E9 or DIN 50106 (-150°C to 1400°C)
- 3-point and 4-point bending test
- further technological tests with special setups acc. to customer requirements

cyclic material testing

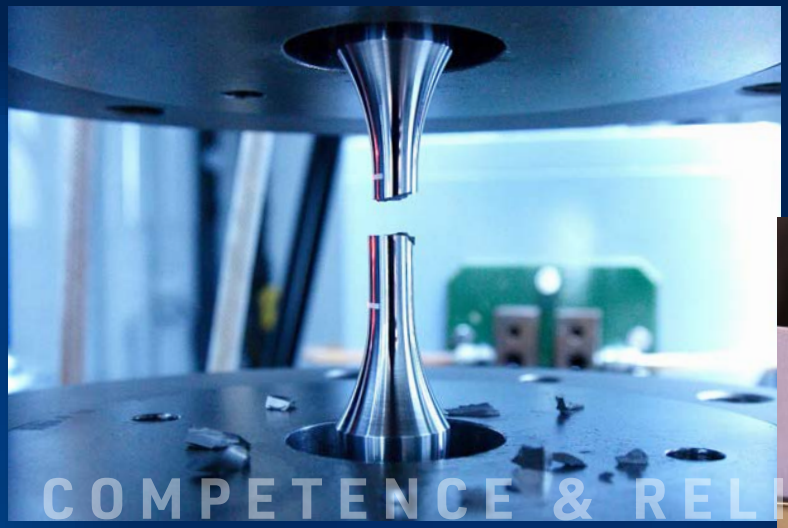
- LCF Low Cycle Fatigue tests (-150°C to 1400° C) (strain camber curves, cycl. stress-strain curve, ratchetting, strep-incemental-test, ...). (ASTM E 606, ISO 12106)
- Multiaxial tension-compression-torsion test (RT up to 900°C)
- HCF high cylce fatigue tests (-150°C to 850°C) (stress creep curves statistically validated, tension-compression, bending, torsion)

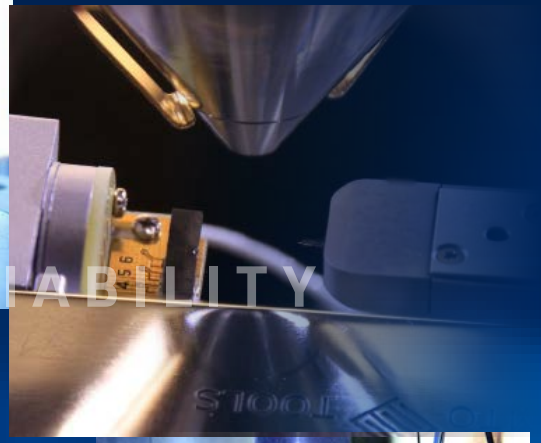
fracture mechanic investigation

- Static fracture toughness test (KIC, JIC, JDa, CTOD) (-150°C to 800°C) acc. to ASTM E 1820, ISO 12135, EN ISO 15563
- cyclic fracture toughness test (da/dN curves, DKth, Paris range, ...) acc. to ASTM E 647, ISO 12108

Test procedures within the scope of accreditation acc. to ISO IEC 17025

- determination of core hardness HV, HRC, HB acc. to EN ISO 6506-1 (HB), EN ISO 6507-1 (HV), EN ISO 6508-1 (HRC)
- tensile tests on metallic materials at room temperature acc. to EN ISO 6892-1, ASTM E8 / E8M, ASTM 370
- tensile tests on metallic materials at low temperatures acc. to EN ISO 6892-3
- hot tensile tests on metallic materials acc. to EN ISO 6892-2, ASTM E21
- cyclic tests on specimens acc. to DIN50100, ASTM E466, ISO 1099
- cyclic tests on fasteners acc. to DIN969
- fracture toughness test KIC according to ASTM E 399





equipment

- hardness tester Emco Test DV30G5 and QNess Q10A+
- Zwick universal testing machine Z250 (max. 250 kN)
- Zwick universal testing machine Z150 (max. 150 kN) with high temperature furnace up to 900°C
- Instron Hydropulser 8803 (max. 250 kN) mit vacuum chamber, inductive heating and high precise Laserextensometer Fiedler P50
- Instron tension-compression torsion pulsator 8854 (max. 250kN / 2000Nm) with inductive heating / compressed air cooling and high-precision Laserextensometer Fiedler P50
- Instron Hydropulser 8802 (max. 250kN) with temperature chamber (-150°C to 600°C) and high precise Laserextensometer Fiedler P50
- Schenk Hydropulser PS100 (with modernized Instron-elektronic) (max. 100kN)
- 4 x Russenberger-resonance testing machines Testronic 100 / 150 with HT-oven (up to 900°C) and temperature chamber (up to 300°C) and various setups
- 1x Russenberger resonance testing machine Mikrotron-20
- 4x DCPD-potential probes and 1x ACPD-Potential probe from Matelect and 2x high presice DCPD-measurement system (self-made) (for in-situ crack length measurement)
- variable measurement system for optical 3D displacement and deformation measurement by Aramis

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thermal analysis and heat treatment

- recording ZTU / ZTA charts
- determination of thermophysical properties
- vacuum and inert gas heat treatment
- inductive heat treatment
- recording of BxH curves
- FE simulation of hea treatment processes
- consulting and process development

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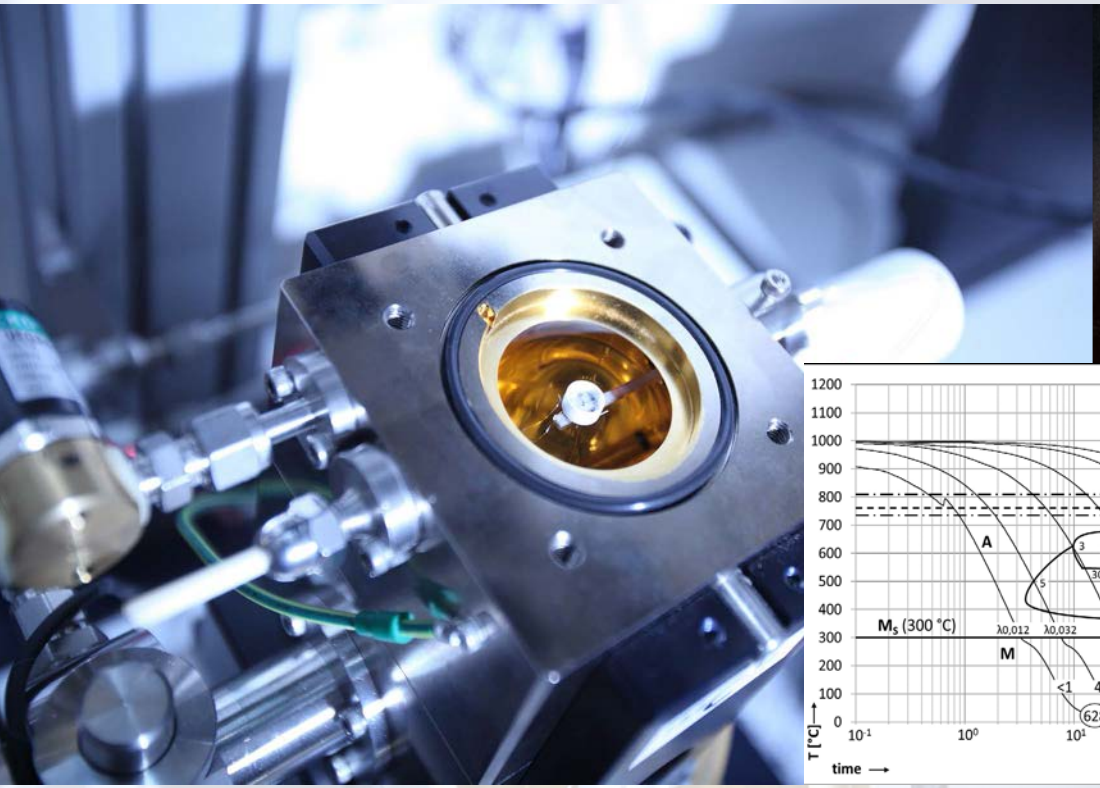
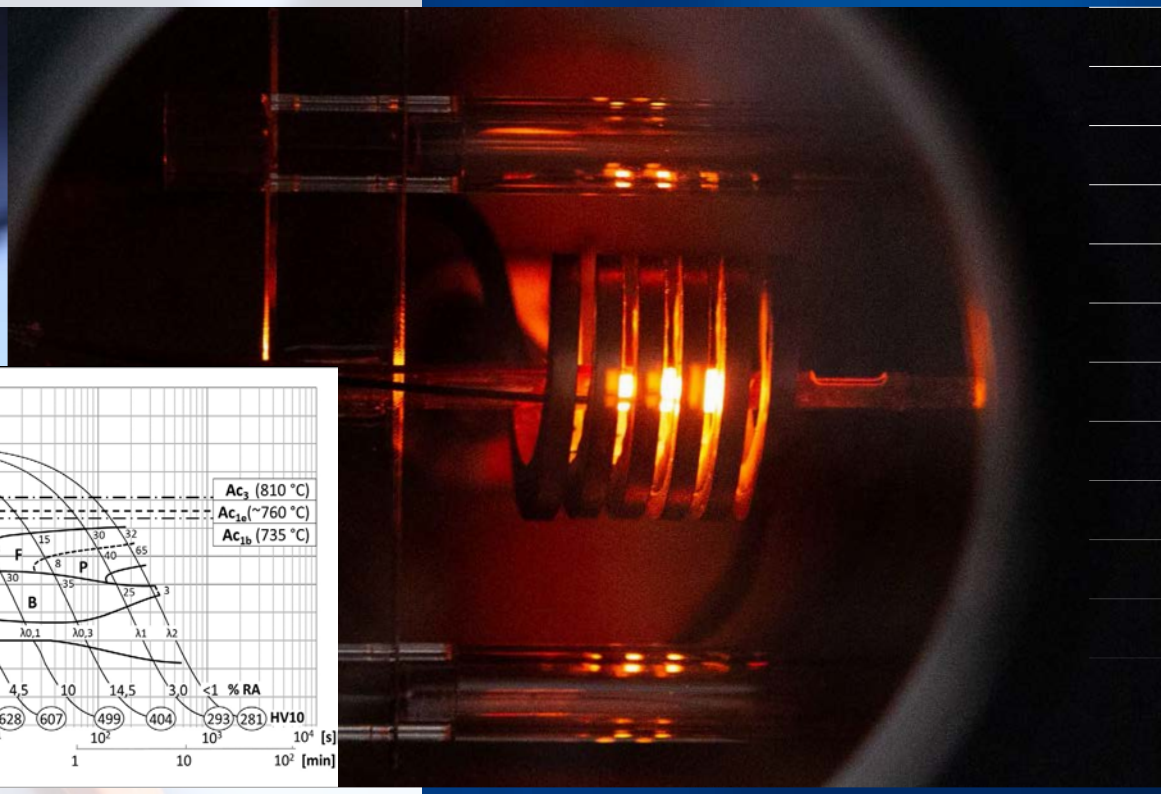
COMPETENCE & RELIABILITY

recording ZTU / ZTA charts





customized recording of transformation diagrams of steels

our focus / competences

- investigation of steels, in particular high-alloy, multiphase stainless steels
- Physical simulation of heat treatment processes by means of quench dilatometer
- Determination of time-temperature transformation diagrams as well as time-temperature austenitization diagrams

contact

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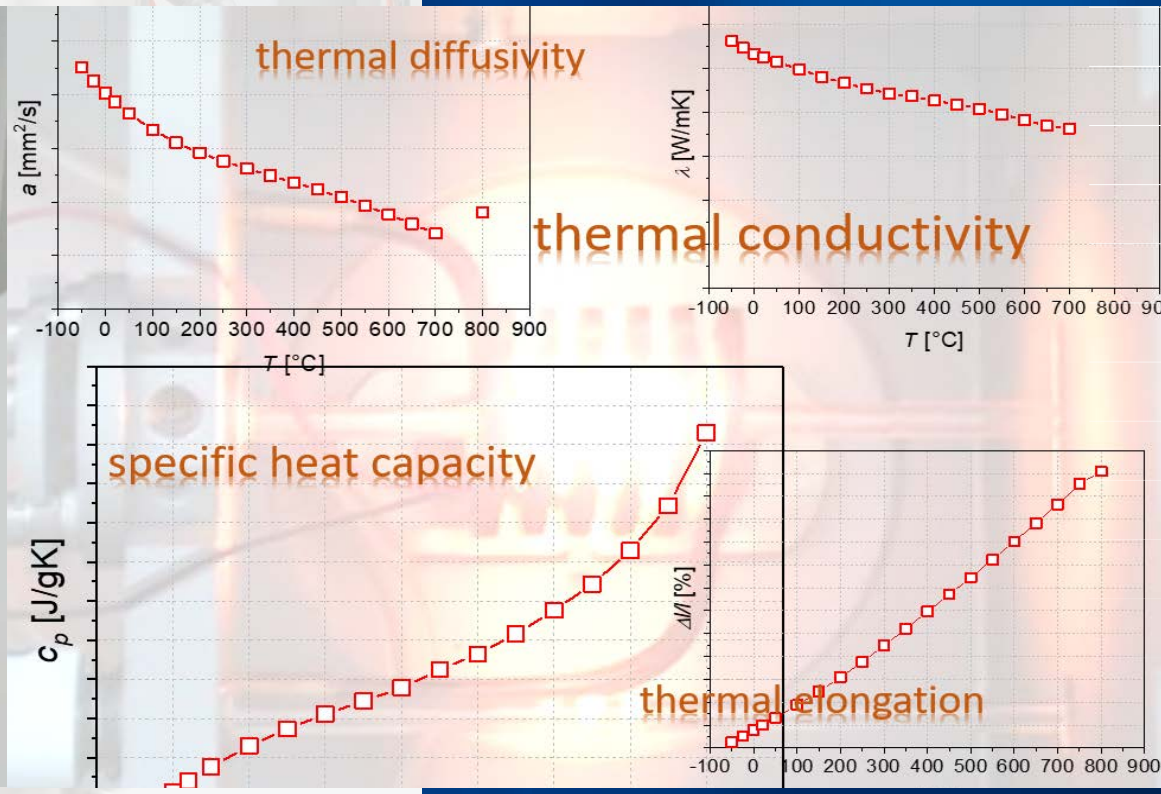
determination of thermophysical properties



determination of the basic thermophysical properties of metallic and ceramic materials or their composites

our focus / competences

- determination of thermal diffusivity (-60°C to 1200°C) acc. to EN 821-2
- measurement of the thermal length change of solid bodies (-150°C to 1200°C) acc. to DIN 51 045-1
- measurement of the specific heat capacity (-150°C to 1100°C) acc. to EN 821-3 (*)
- measurement of the dynamic modulus of elasticity (20°C to 900°C) acc. to EN 820-5 (*)
- calculation of the temperature-dependent thermal conductivity
- measurement of electrical resistance/conductivity (20°C to melting point of metallic samples) (*)

**in coorporation with the Österreichisches Gießerei-Institut (ÖGI)*

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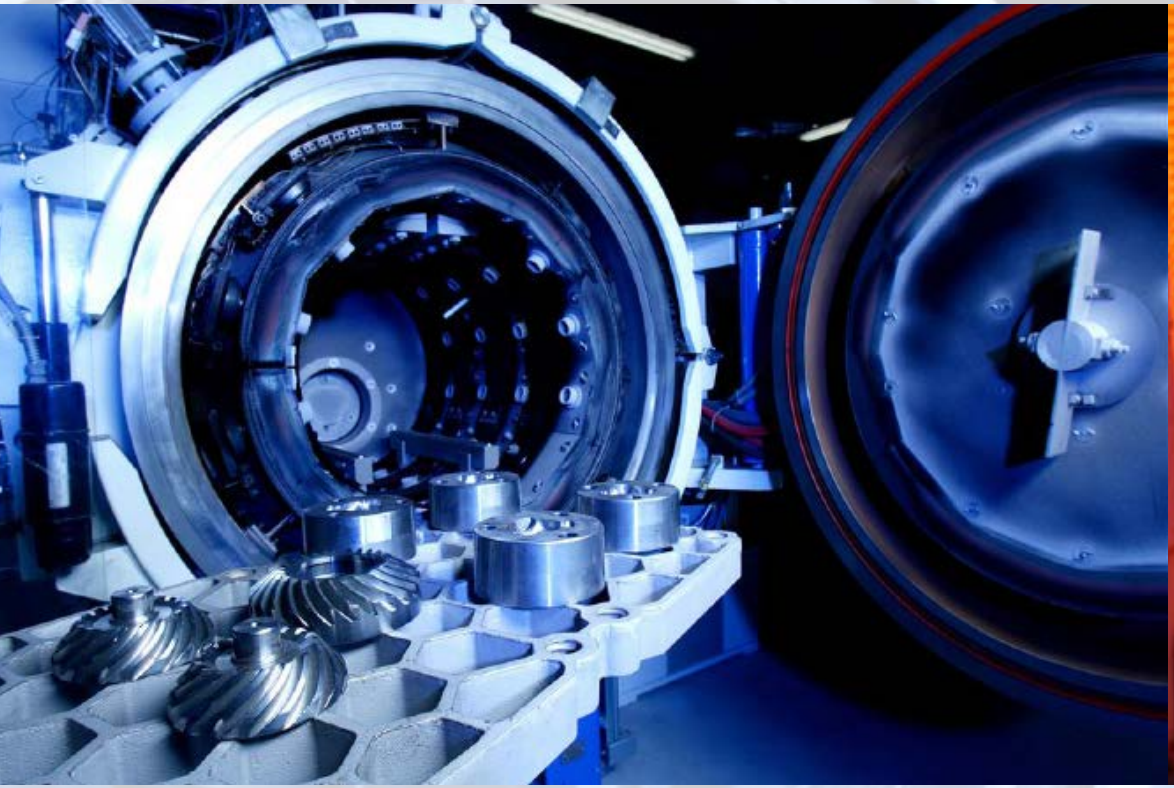
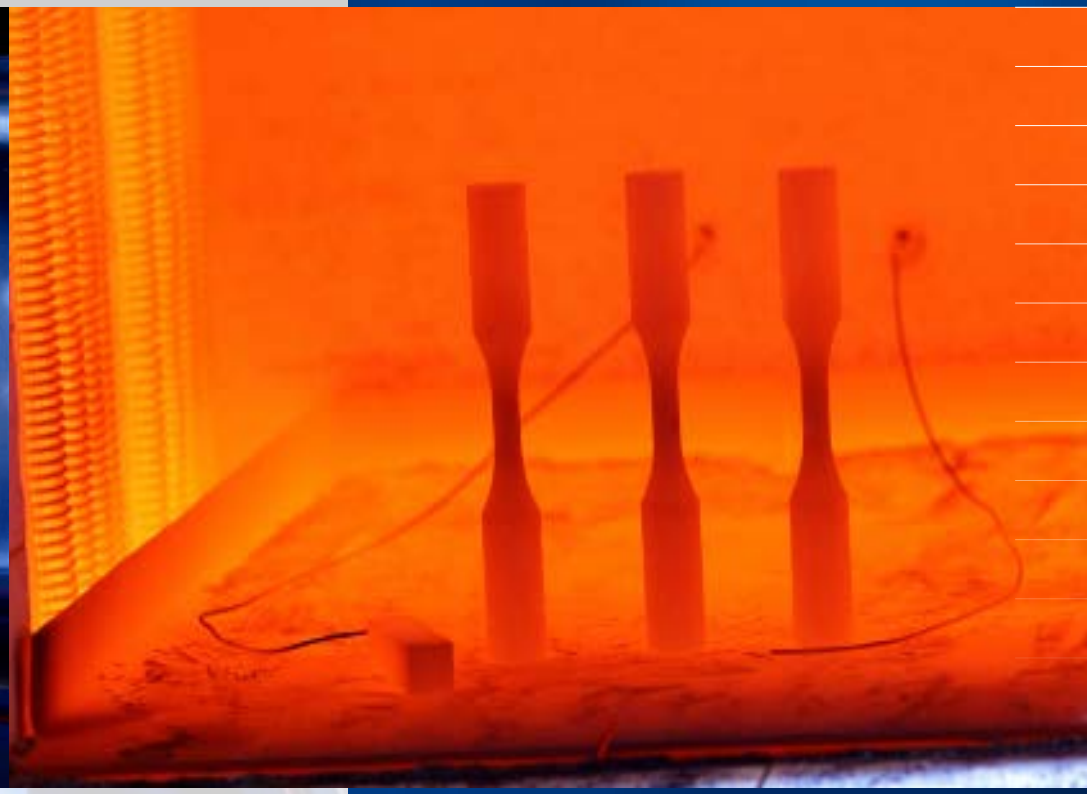
vacuum and inert gas heat treatment





standard and special vacuum heat treatments (hardening, annealing, tempering, ...) on specimens, components, small series or samples

our focus / competences

- individual, instrumented heat treatment processes under (convective) vacuum
- temperature-controlled heat treatment of samples and components incl. controlled quenching (lmin = 0.2)
- tempering or annealing under (convective) vacuum, inert gas (Ar, N_2) or atmospheric conditions

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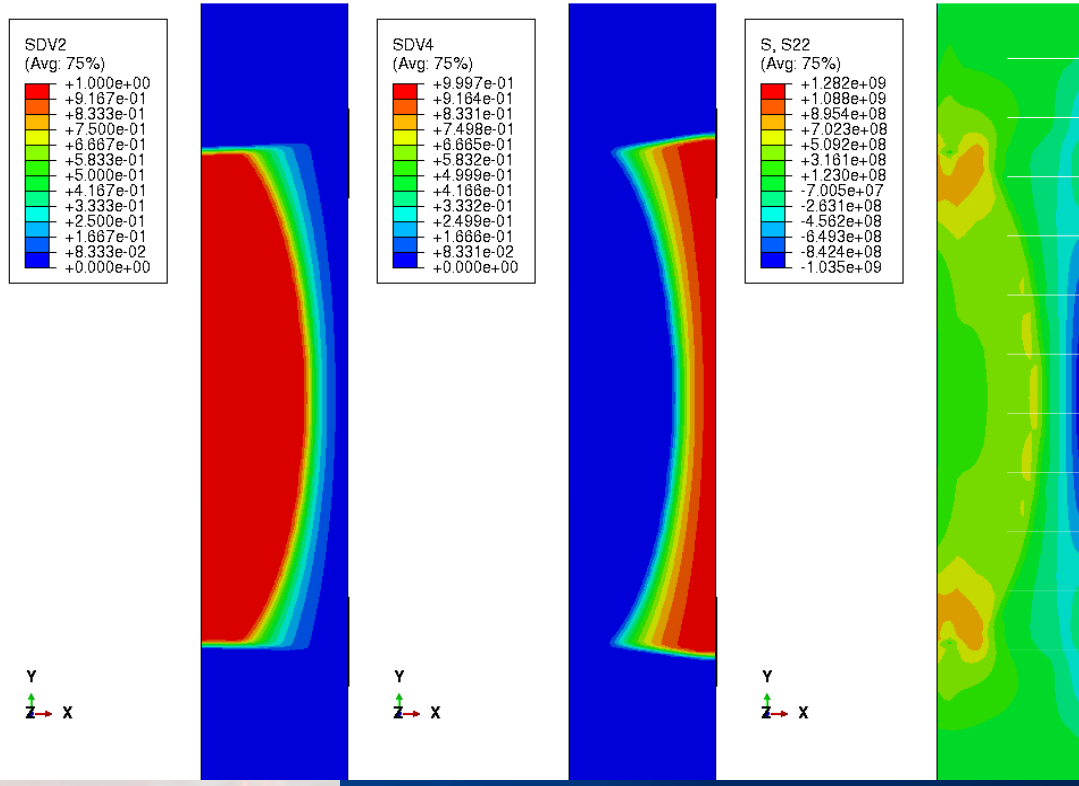
inductive heat treatment



development of inductive heat treatment processes on bar material

our focus / competences

- instrumented, inductive heat treatment with water or gas quenching for the development of heat treatment processes
- simulation of temperature, microstructure and residual stress distribution and development during inductive heat treatment
- recording of temperature-dependent B-H curves as input parameters for finite element simulation

contact

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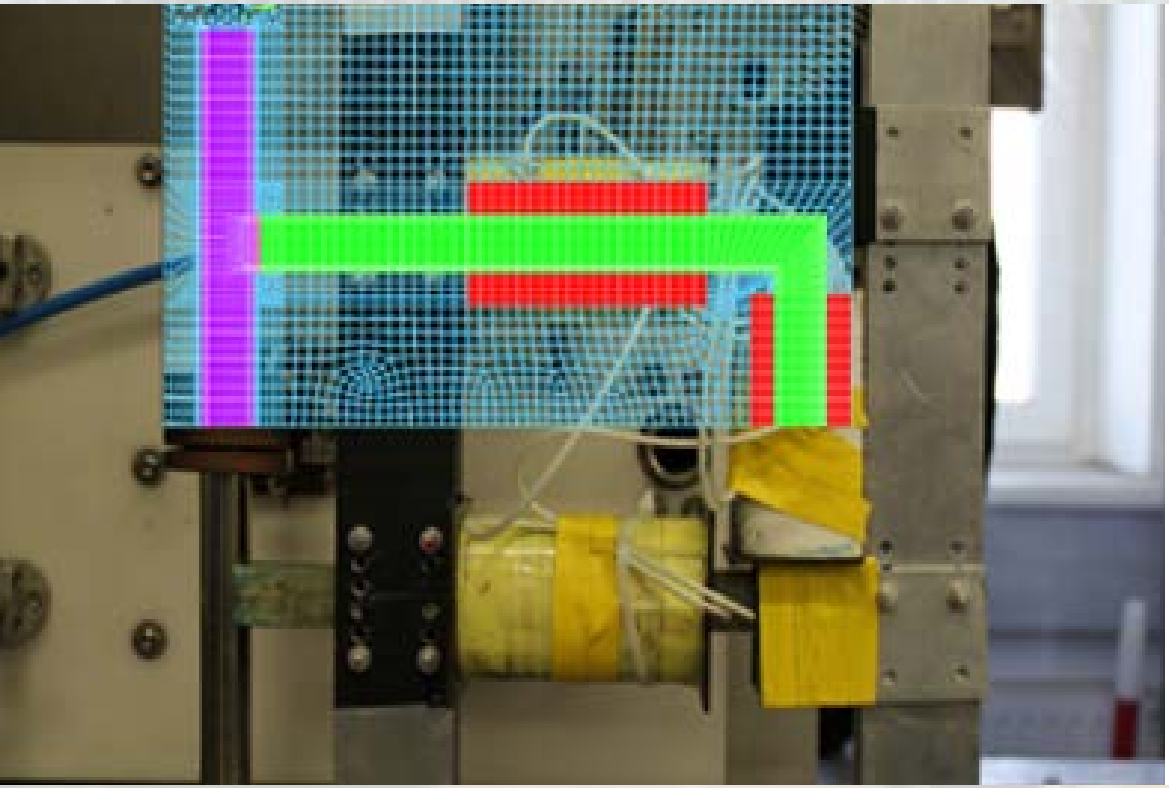
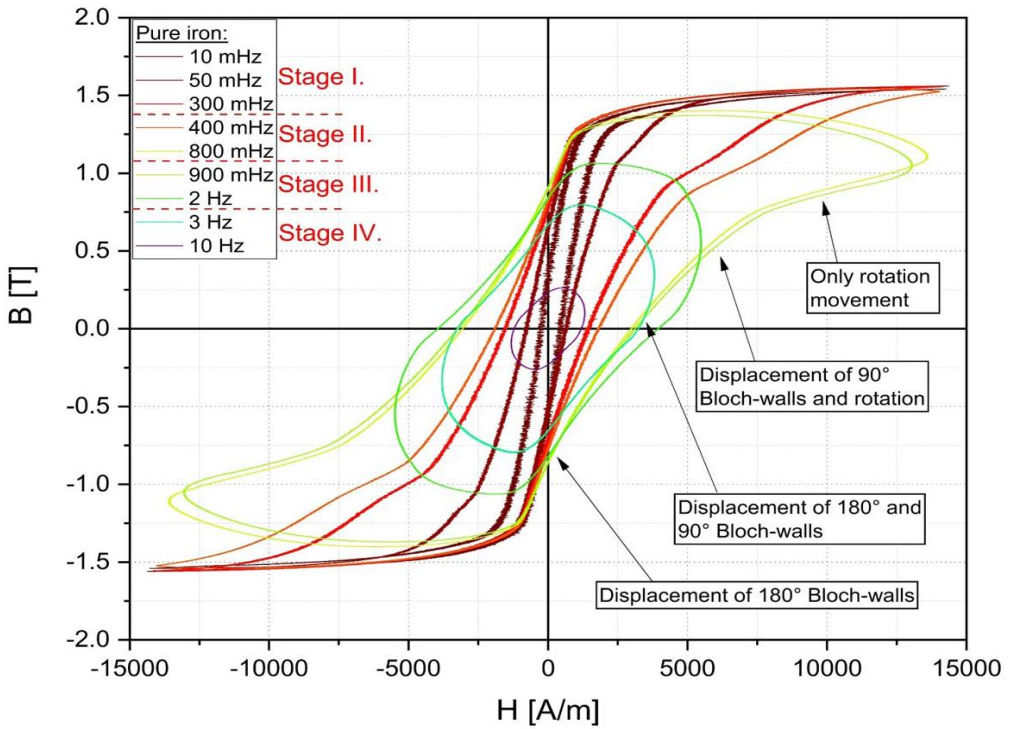
recording of BxH curves





recording of temperature-dependent B-H curves for the finite element simulation of inductive heat treatment processes

our focus / competences

- frequency- and amplitude-dependent recording of material-specific B-H curves (U-yoke).
- application to macroscopic, easy-to-produce industrially suitable specimens (rod DM 22 mm).
- recording of B-H curves at room temperature and elevated temperatures up to 1200°C.

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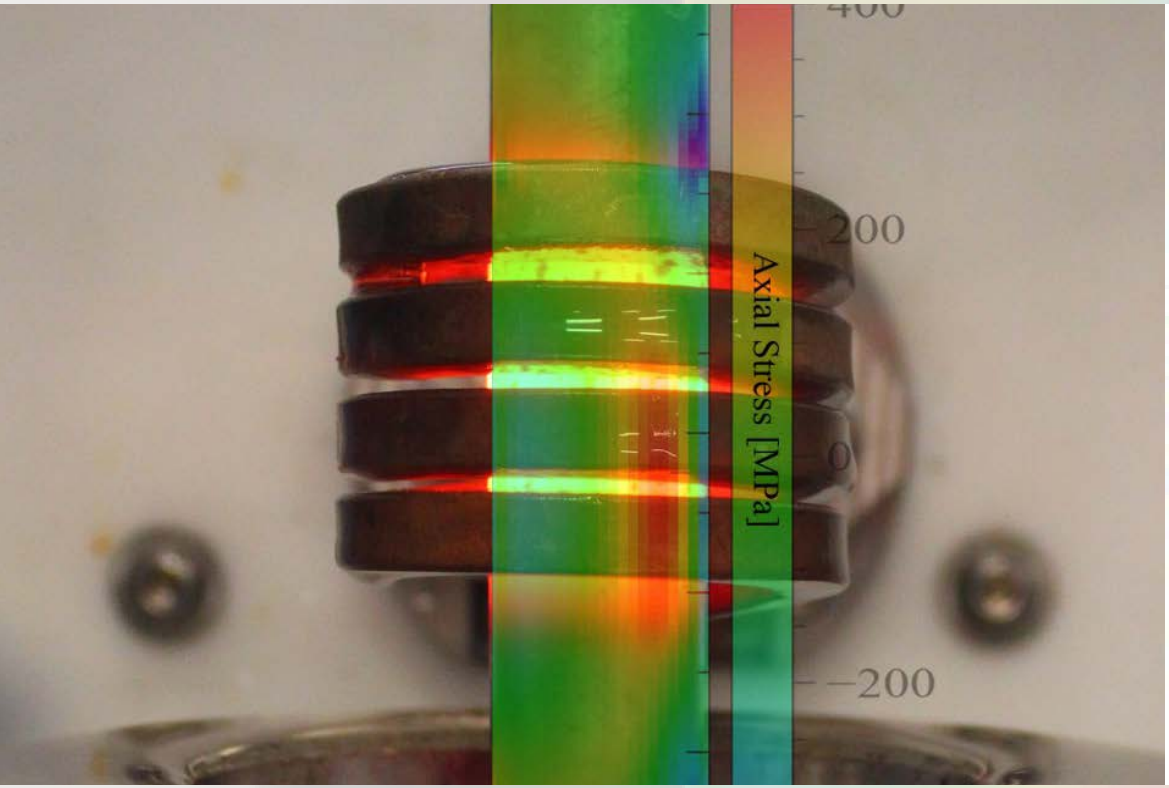
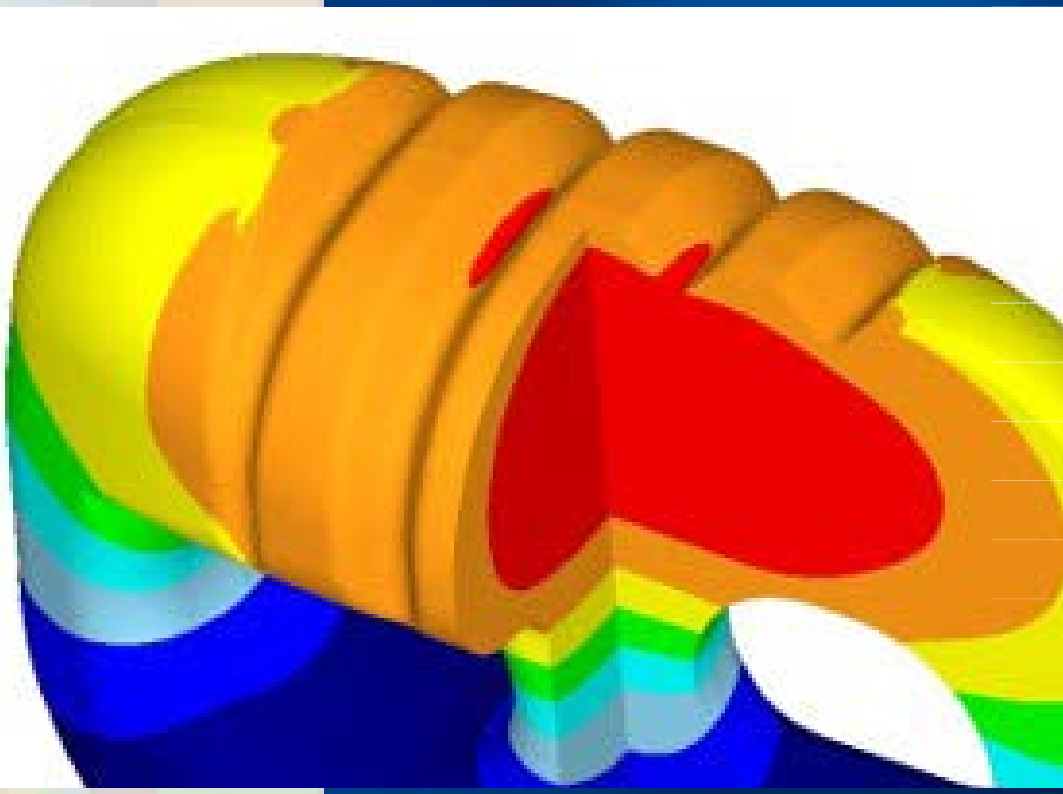
FE simulation of heat treatment processes





customized heat treatment simulation considering the influence of shrinkage, creep effects, phase transformation and TRIP strain

our focus / competences

- Analysis of (industrial) heat treatment processes with finite element simulation (e.g. crack-prone component positions, critical quenching conditions)
- Simulation of the temporal development of stress distributions and stress peaks (e.g. due to shrinkage, phase transformation, TRIP effect)
- Determination of the thermophysical data of the materials concerned required for the FE simulation, including the B-H curves for inductive heat treatment

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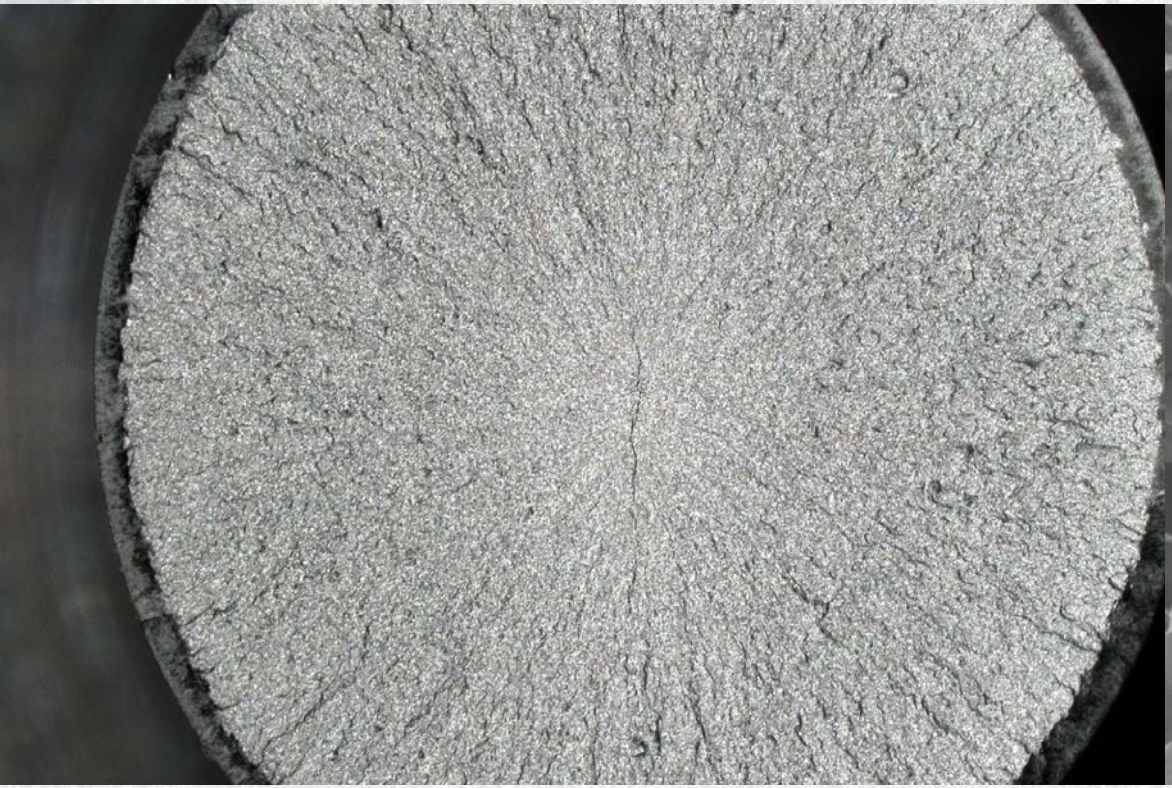
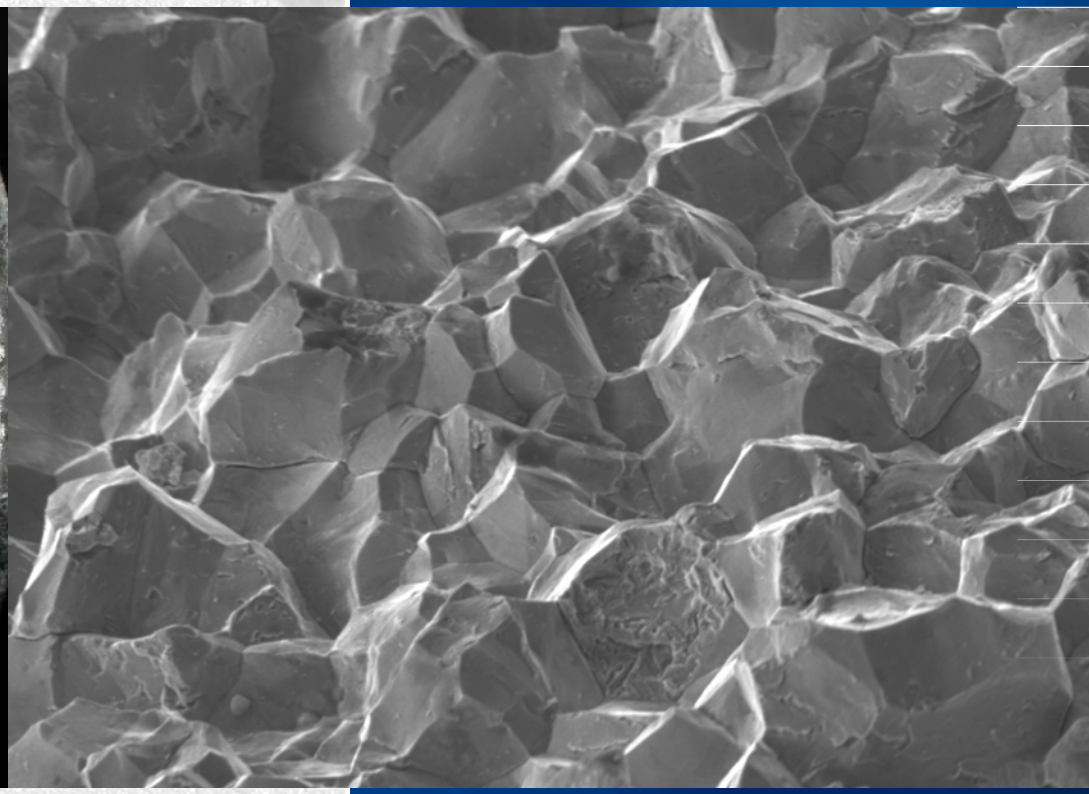
consulting and process development





consultation on the technical heat treatment of steels and performance of damage investigations on heat-treated components

our focus / competences

- damage investigations on improperly heat-treated components
- improvement and advice on the technical heat treatment of steels
- heat treatment of steels, tool steels (cold, hot and high-speed steels), aluminum, titanium and nickel-based alloys
- sample heat treatments incl. characterization

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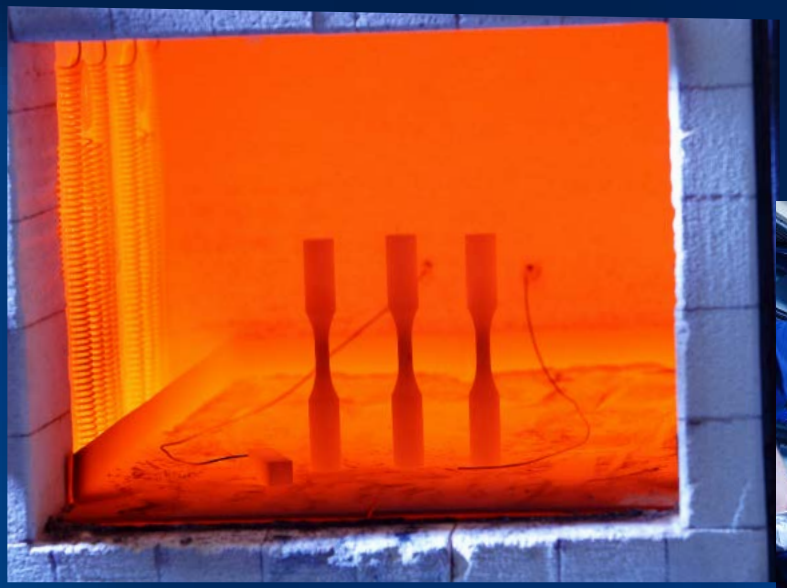

COMPETENCE & RELIABILITY

Service offer

- recording of continuous and isothermal transformation diagrams (ZTU / ZTA)
- experimental heat treatments (vacuum, inert gas, inductive) for sampling of components incl. metallographic microstructure analysis and verification of mechanical properties such as hardness, strength, impact energy or fracture toughness
- Finite Element (FE) simulation of heat treatment processes (temporal microstructure, hardness and residual stress development)
- consulting in the field of heat treatment
- damage analysis of improperly heat treated parts, tools and components and development of remedial measures

equipment

- quenching dilatometer DLI 805L from Bähr with inductive heating system (25-1300°C) and integrated gas cooling (N_2 or He)
- Systherms single-chamber vacuum furnace with integrated high-pressure gas quenching system (max. 14 bar), oven chamber: 400 x 400 x 600 mm (B x H x L)
- protective gas furnace (N_2 or Ar) up to 1200°C (oven chamber: 400 x 300 x 600 mm)
- Various air circulation chamber furnaces (tempering furnaces) up to 700°C (oven chamber: 220x200x495 mm) and up to 850°C (oven chamber: 350x400x500mm)
- Industrial induction hardness equipment ITP for inductive hardening/tempering of test specimens (l_{max} = 300 mm, $Ø_{max}$ = 30 mm) incl. water-, air- or inert gas quenching; vertical and horizontal operation; instrumentation by thermocouples
- Laserflash system LFA 427 from Netzsch (temperature range from -60°C to 1200°C)
- pushrod dilatometer from Netzsch DIL 402 CD (temperature range from -150°C to 1200°C)

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microelectronic test methods

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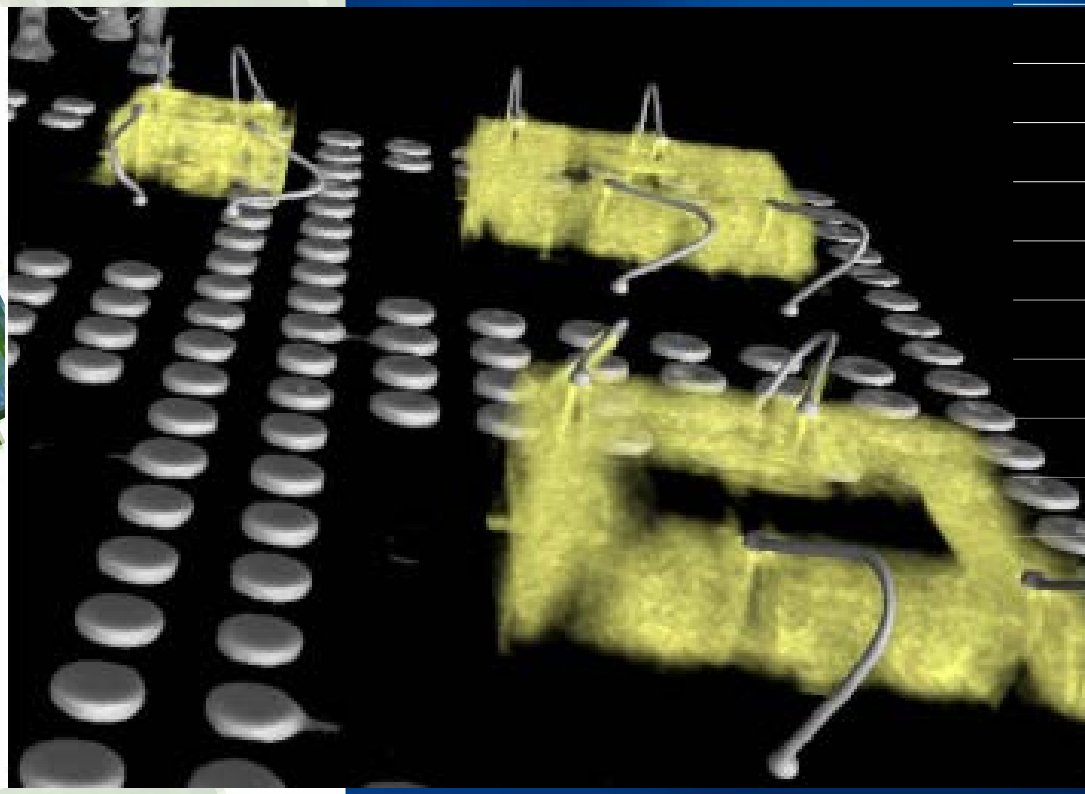
- Non-destructive Analytics
- Destructive Physical Analysis
- Thermal Management
- Environmental Simulation Laboratory
- Thin Film Analysis
- Raman Characterization
- Electronic Laboratory
- Phase, Morphology and Residual Stress Analysis
- Seminars @ MCL

COMPETENCE & RELIABILITY

Non-destructive Analytics



Non-destructive quality assurance and failure analysis for microelectronic devices

Our focus / competences

- Defect analysis - localization and evaluation of defects
- 2D and 3D porosity analysis
- Acquisition of geometry data
- Nominal/actual comparison
- Texture analysis - phase segmentation
- In-situ testing with mechanical / thermal / electrical loading

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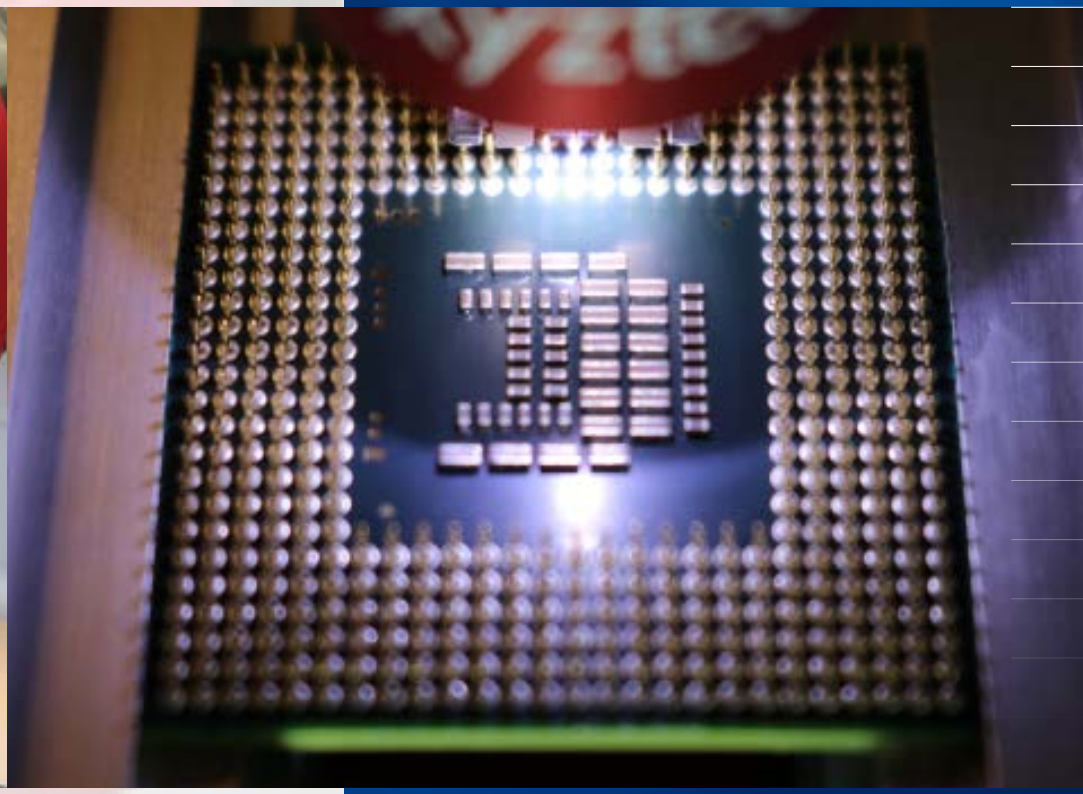
Destructive Physical Analysis



Reliability of structure and integrated circuit packaging

Contact

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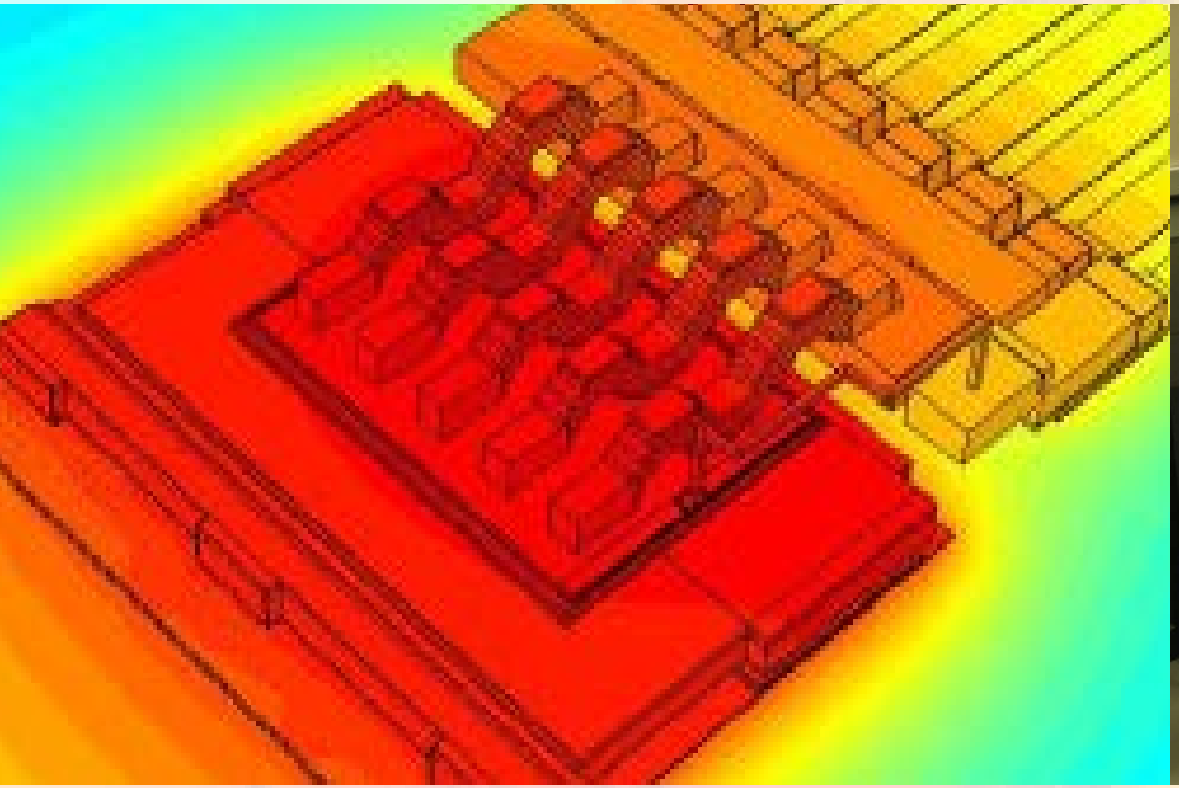
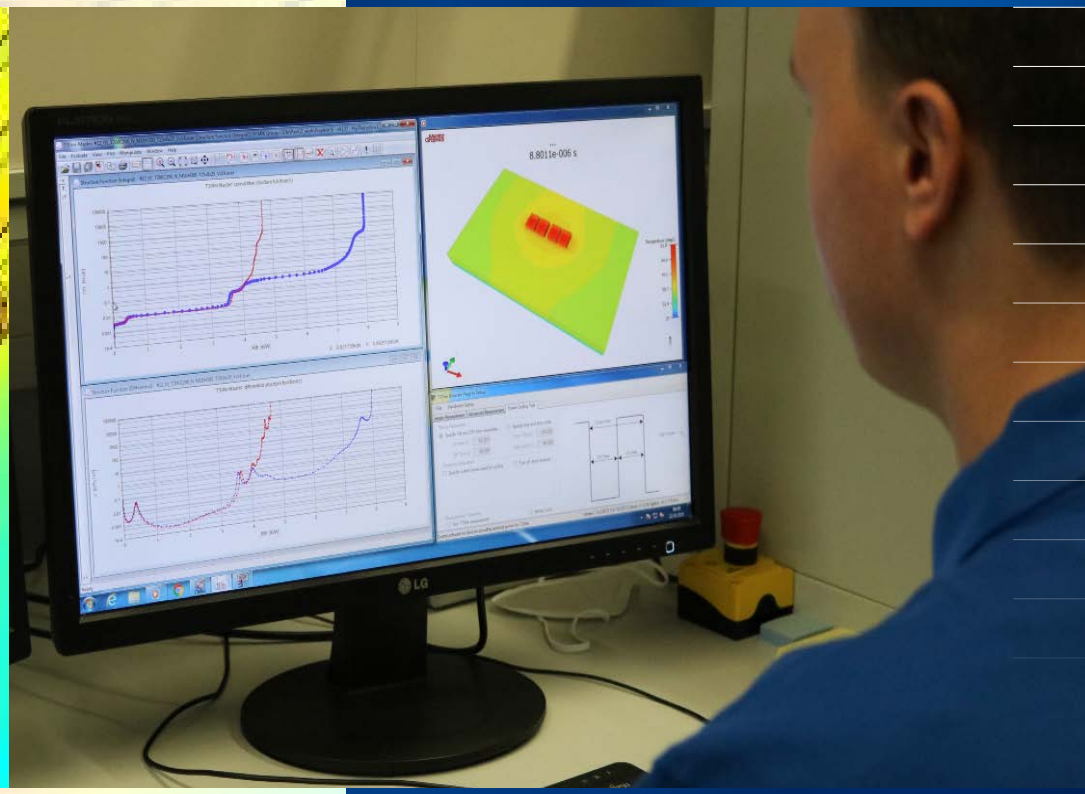
Our focus / competences

- Visualization of surface structures
- Detection of geometry and microstructure
- Failure and root-cause analysis of electronic components (inclusions, cracks, aging processes)
- Determination of deformation, damage and fracture behavior of different assembly and interconnection technologies
- Evaluation of mechanical peel, shear and tensile stresses
- 3-point and 4-point bending test
- Digital Image Correlation (DIC)

Thermal Management





Thermal analysis from material to electronic systems

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Contact

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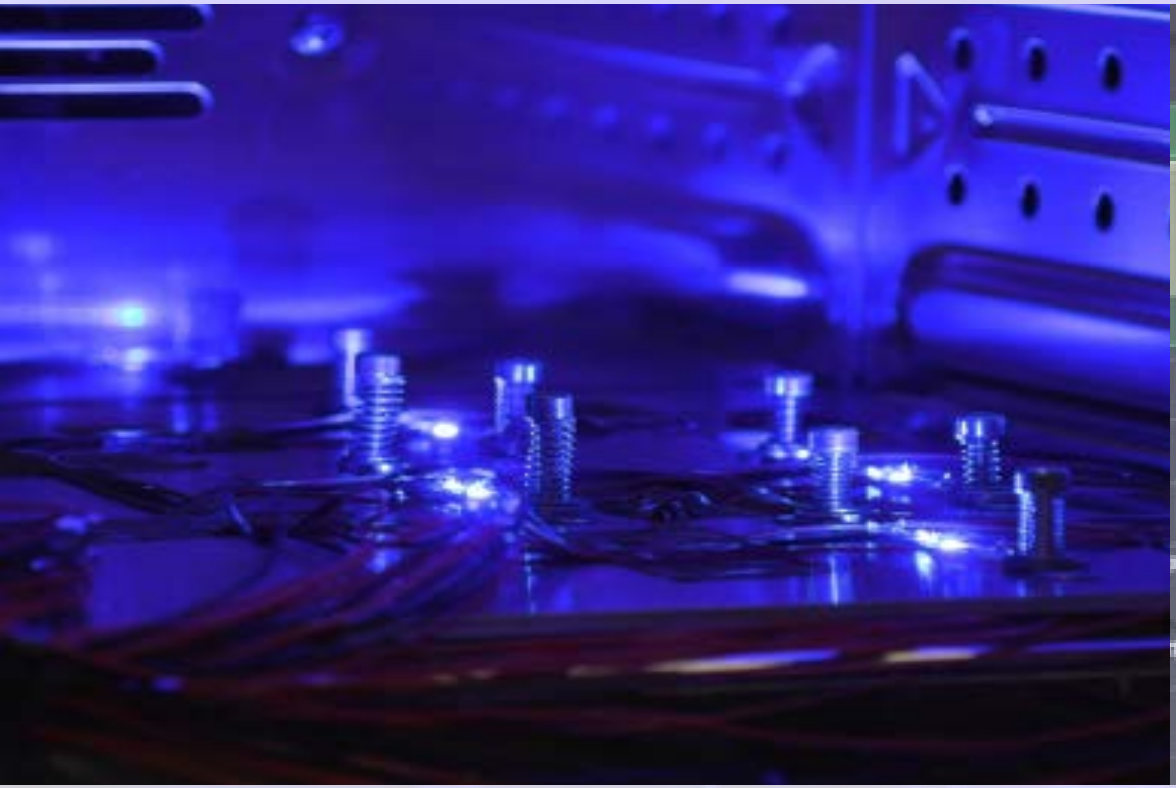
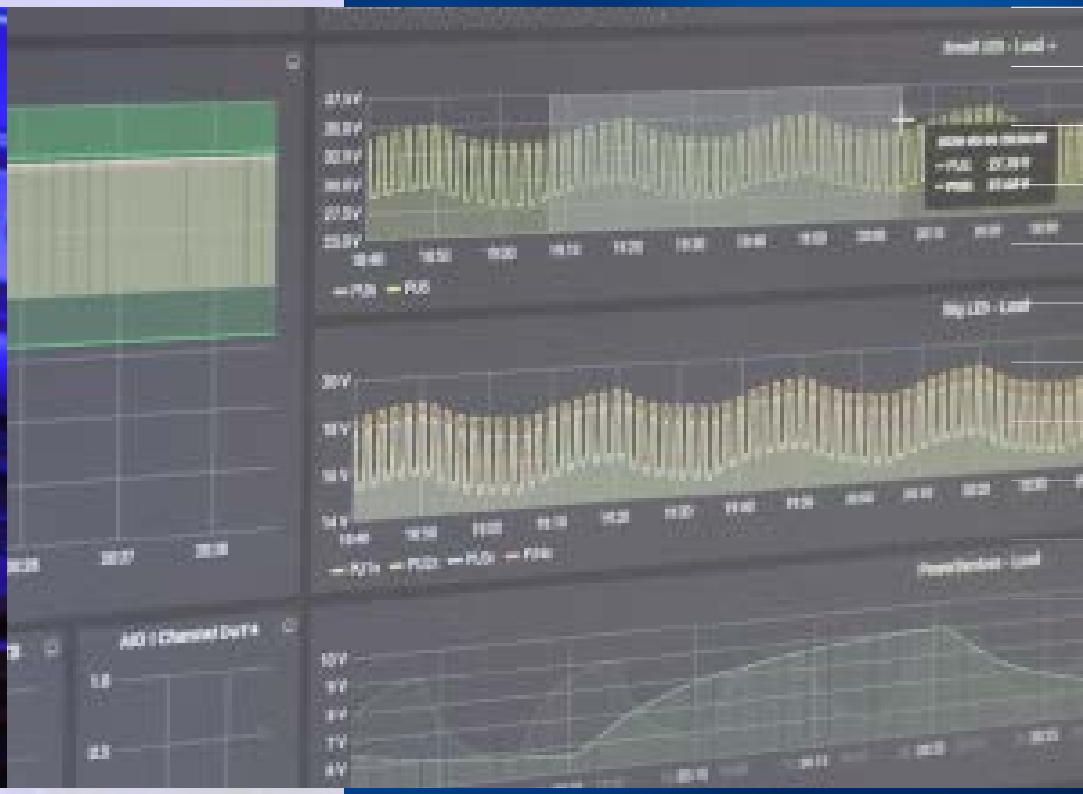
Our focus / competences

- Thermal resistance analysis of materials and systems (thermal impedance analysis)
- Derating analysis up to ≤ 160°C
- Heat path analysis of microelectronic packages and systems
- Determination of thermal properties of thin films (temperature dependence) - temperature range: 20°C to 500°C
- Determination of the thermal interface resistance
- Validated thermal models for failure analysis and design guidelines

Environmental Simulation Laboratory





Active and passive thermal reliability testing

Our focus / competences

- Temperature shock test -80°C to 220°C
- Drying and heating oven up to 300°C
- Alternating climate chamber -40°C to 180°C
- Power cycle test up to 80 A
- Condition monitoring by means of Temperature Tensitive Electrical Parameters (TSEP)
- Data exploration and processing for early failure detection and lifetime modeling

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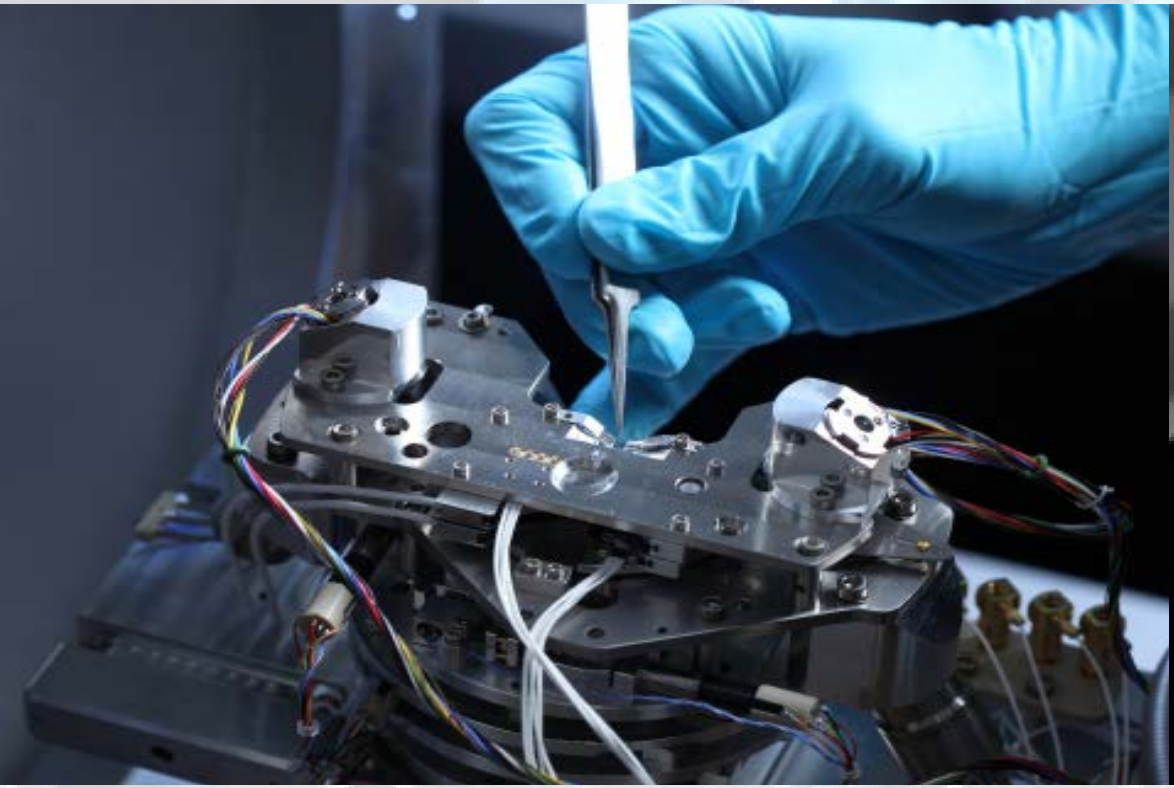
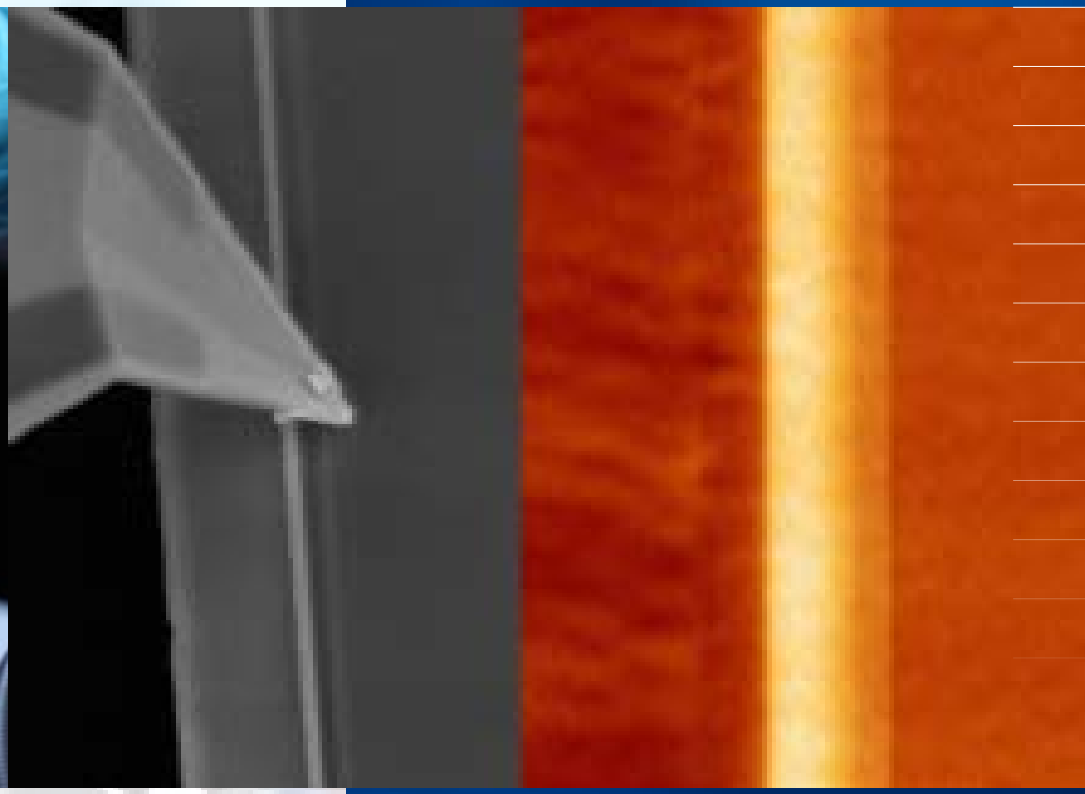
Thin Film Analysis





Single and multilayer systems in the nm to µm range

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Contact

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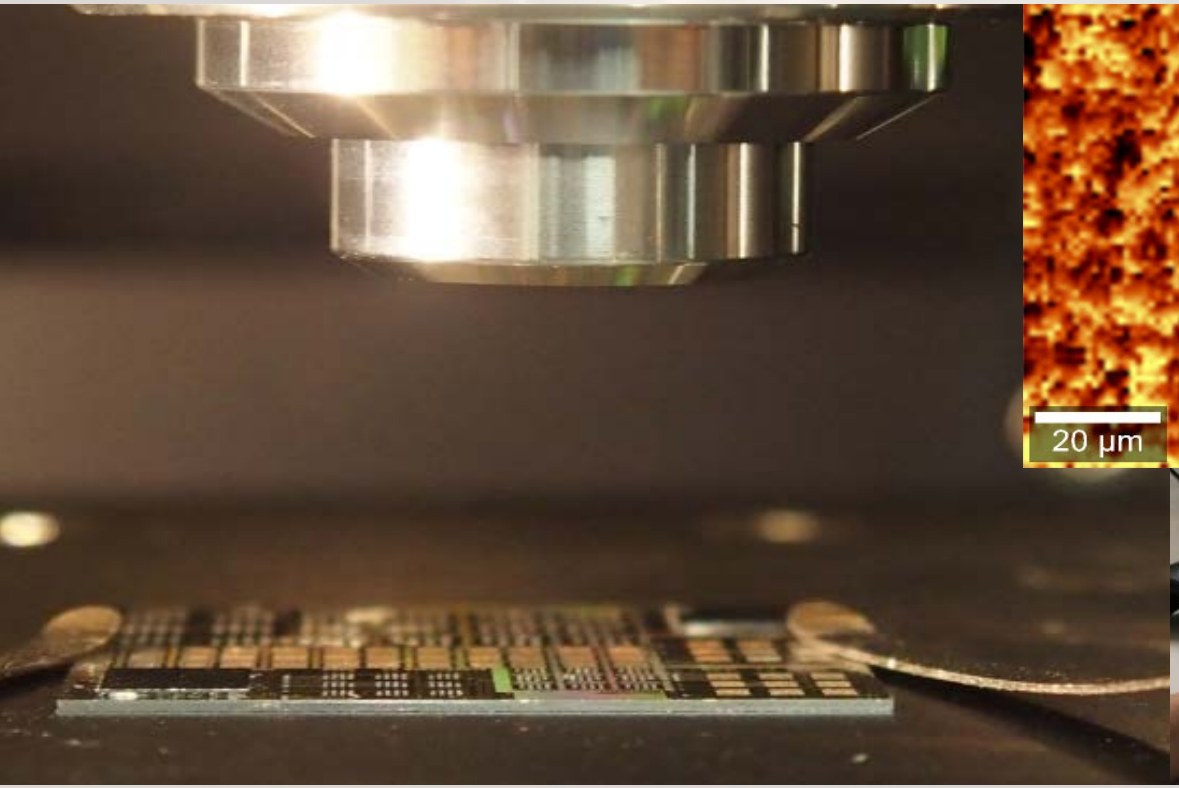
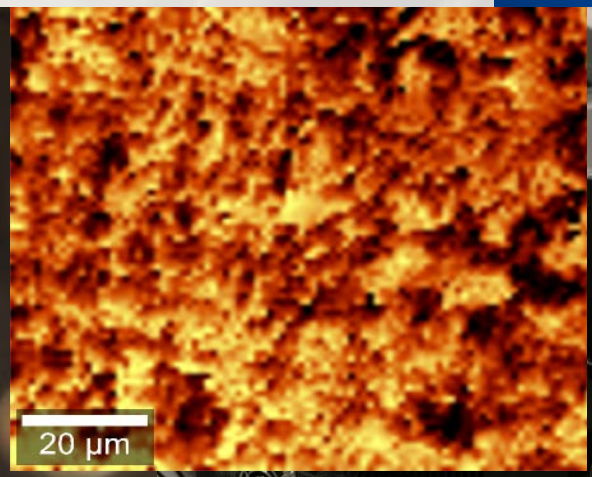
Our focus / competences

- Scanning Probe Microscopy (SPM) analysis under different atmospheres (Ar, N, vacuum, air)
- Topography and roughness analysis
- Kelvin Probe Force Microscopy (KPFM)
- Scanning Thermal Microscopy (SThM)
- EBAC (Electron Beam Absorbed Current) / EBIC (Electron Beam Induced Current)

Raman Characterization





Non-contact analysis method for material characterization

Our focus / competences

- Chemical composition of materials
- Crystallinity, phase transformations and phase compositions
- Impurities and defects
- Polarization analysis
- Residual stress analysis
- Texture analysis
- Temperature range -196°C to 600°C

Contact

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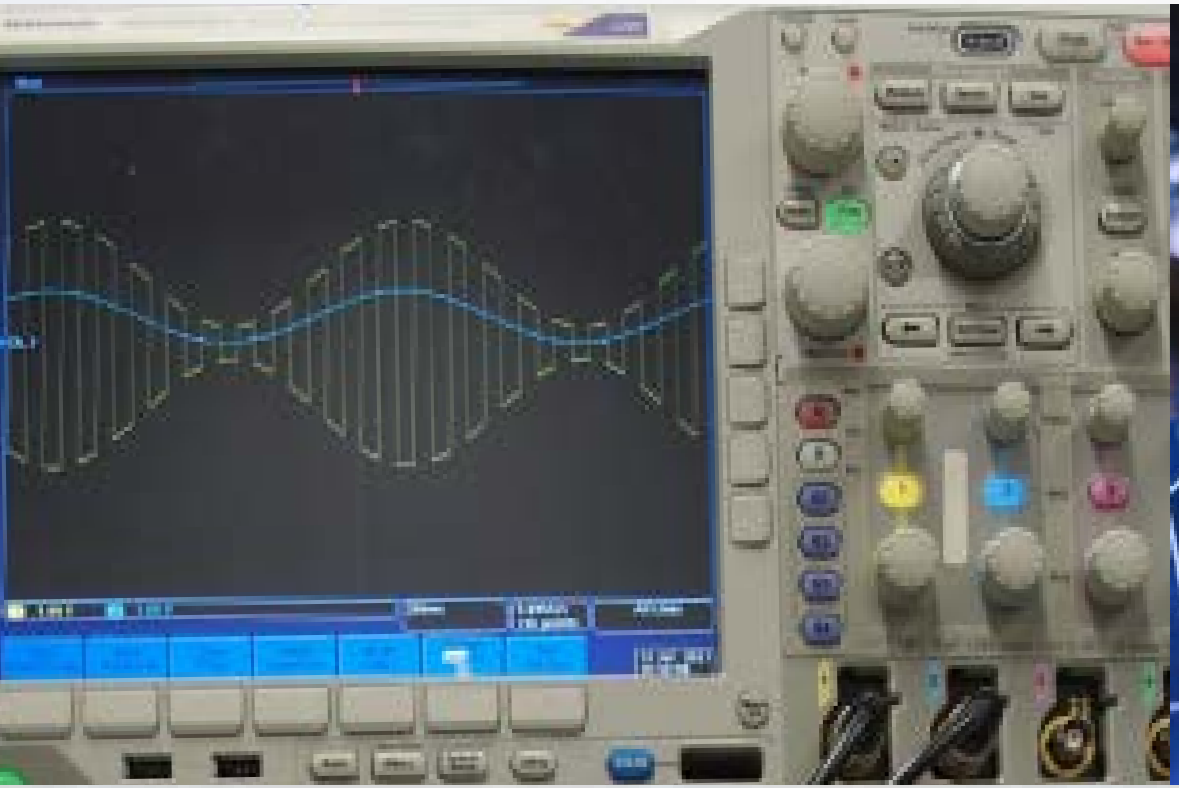
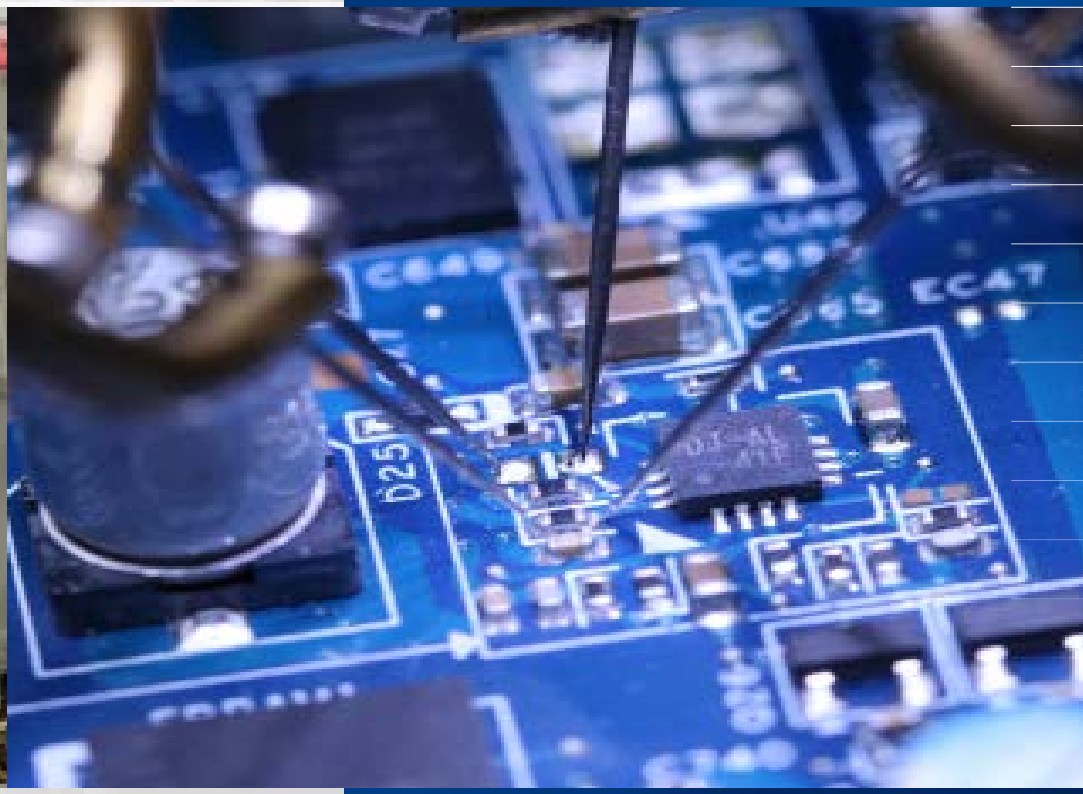
Electronic Laboratory





Analysis of functional materials up to electronic systems

Our focus / competences

- Analysis of static and dynamic hysteresis
- Piezoelectric analysis
- Breakdown voltage analysis ±1 A (±500 V)
- Current/voltage characteristics
- Frequency range 0.01 Hz to 150 MHz (2 GSa/s)
- Temperature range -50°C to 400°C
- Electrical impedance analysis

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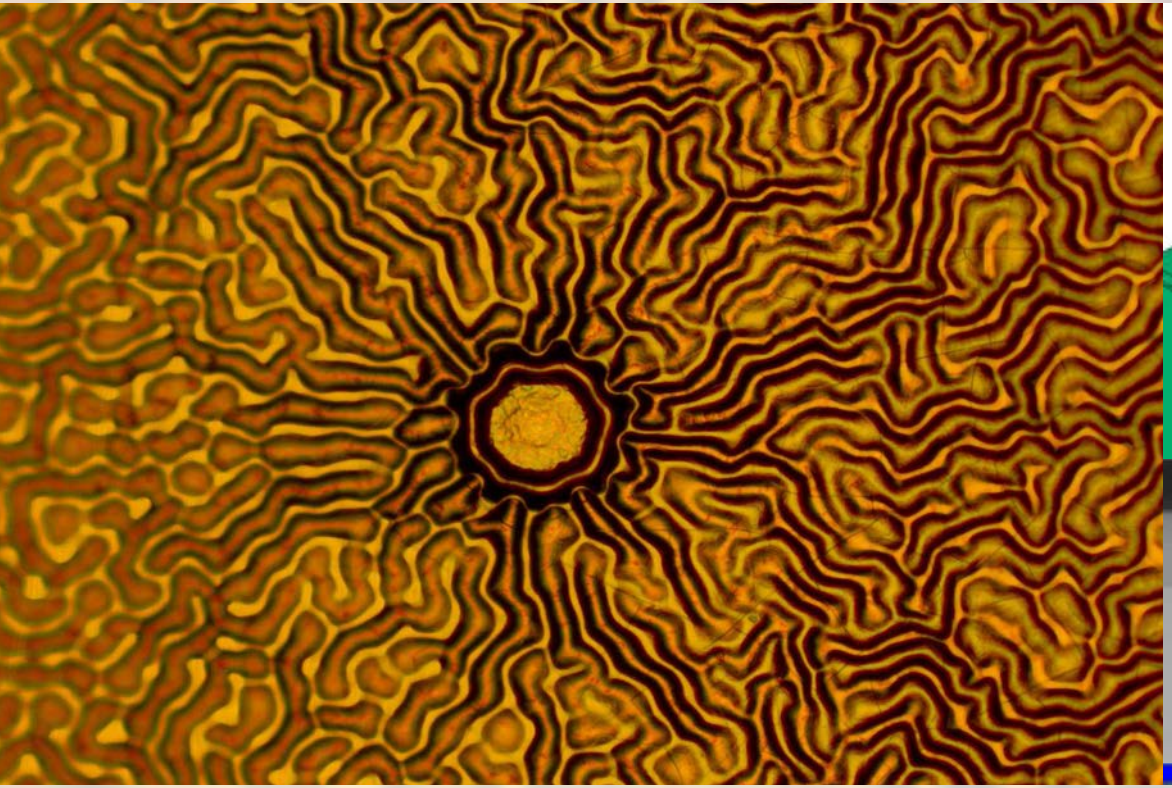
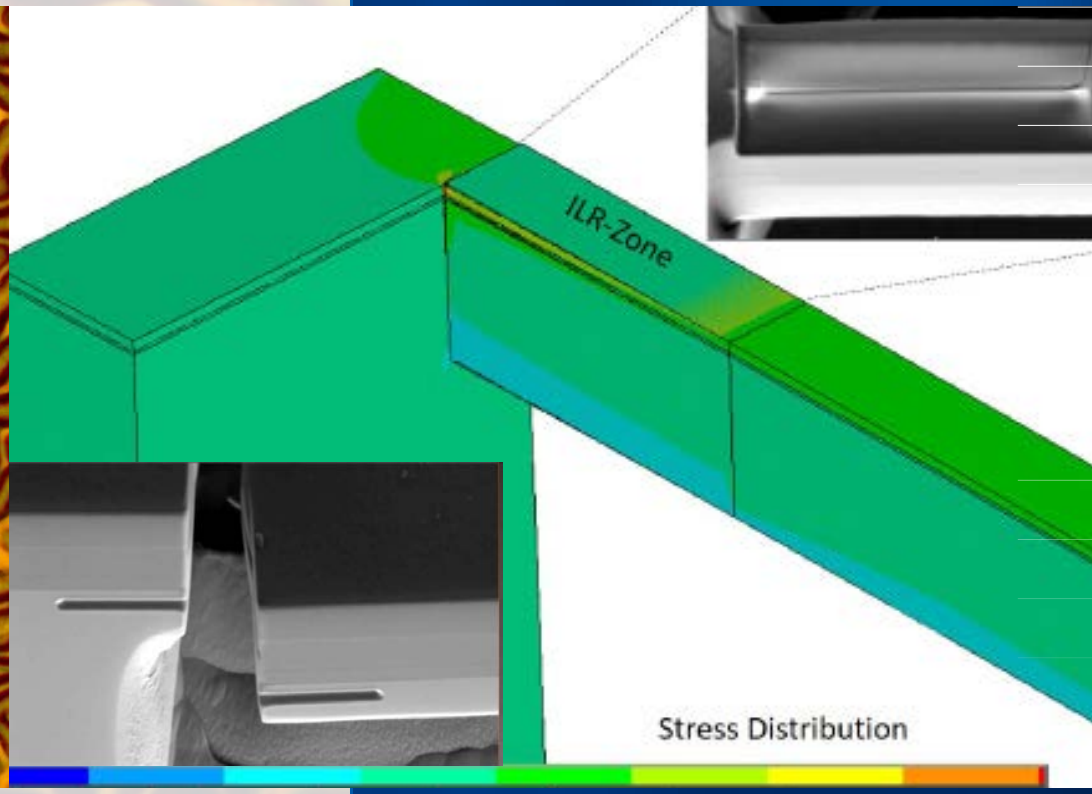
Phase, Morphology and Residual Stress Analysis





Structure and morpholgy influence on residual stresses in single and multilayer systems

Our focus / competences

- High resolution EDX & EBSD analysis in the nm range
- High resolution morphology characterization by FE-SEM
- Interface & phase analysis
- Local residual stress analysis by IL-R (Ion Layer Removal) method

We innovate Materials

Contact

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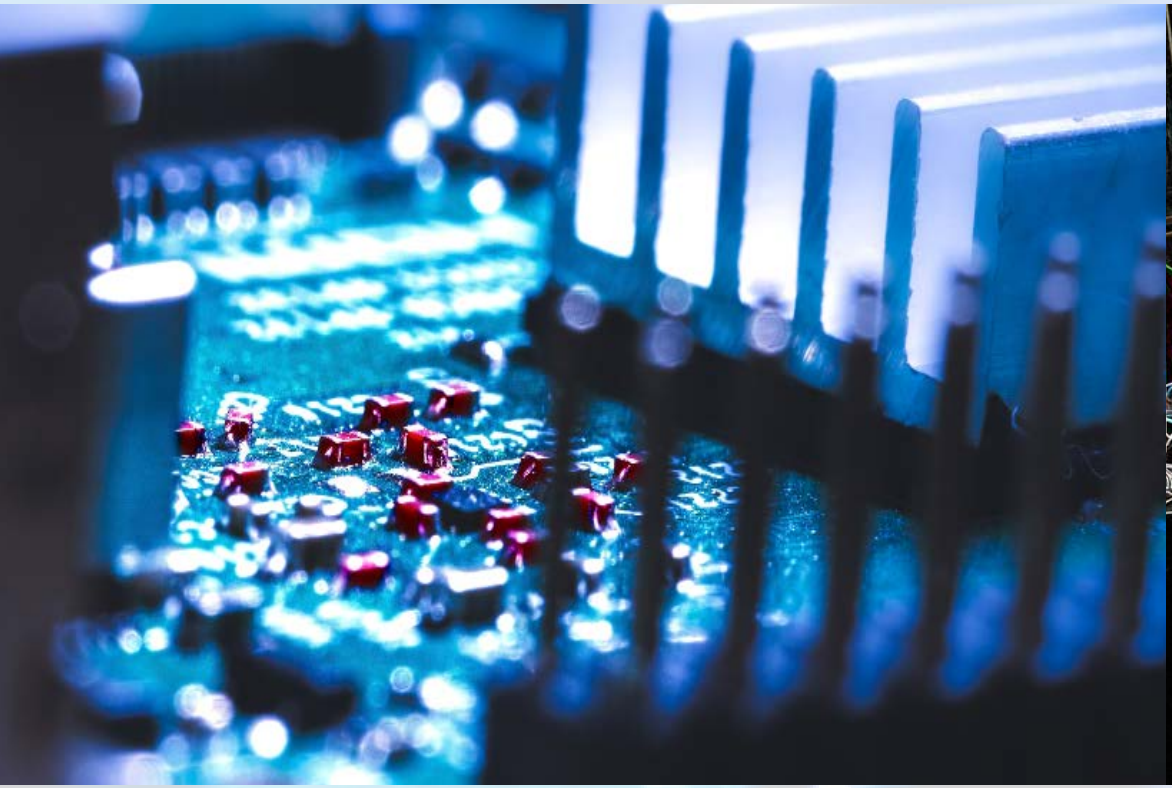
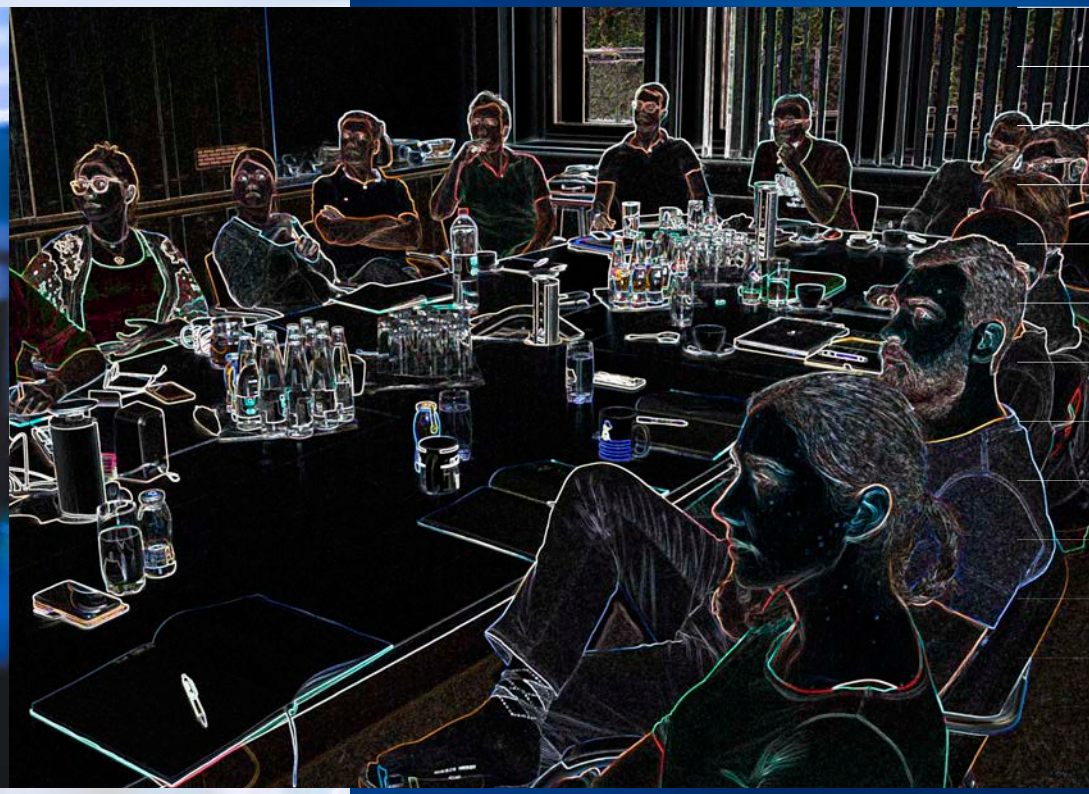
Seminars @ MCL





Staff training in microelectronic test methods, analysis chains and material characterization

https://www.mcl.at/services/mcl-academy/

Our focus / competences

- Analysis chains for microelectronics
- Applied Thermal Impedance Analysis
- New methods in thermal analysis of thin film systems
- Material, layer and microstructure characterization using high-resolution 3D methods (SEM, CT)

Contact

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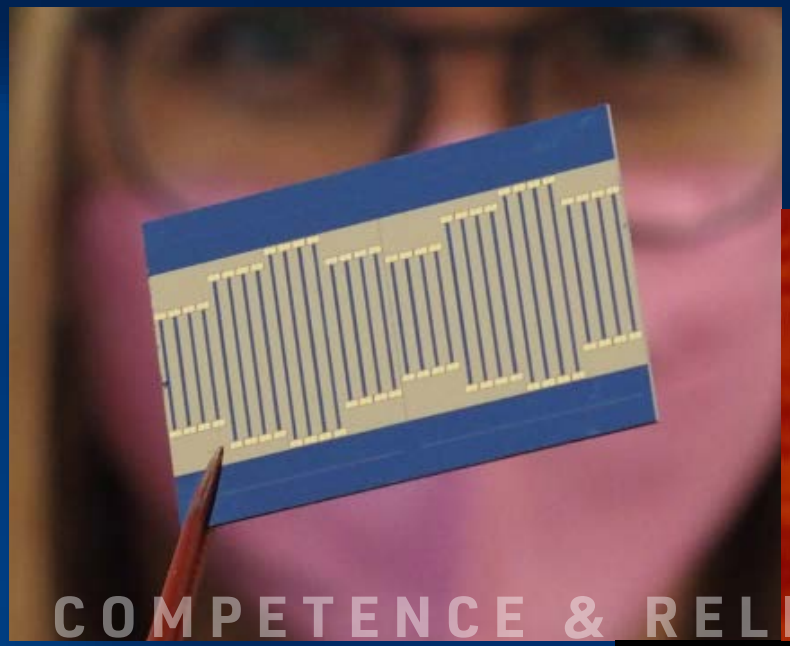
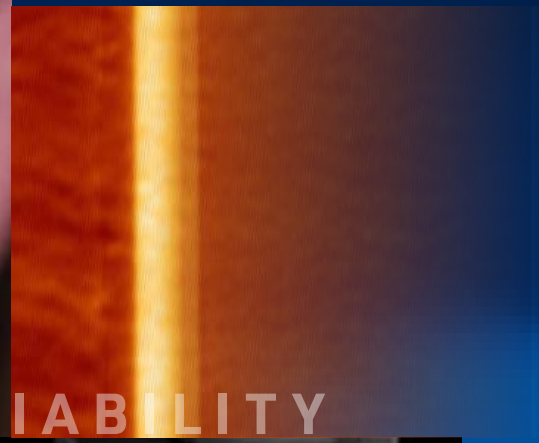




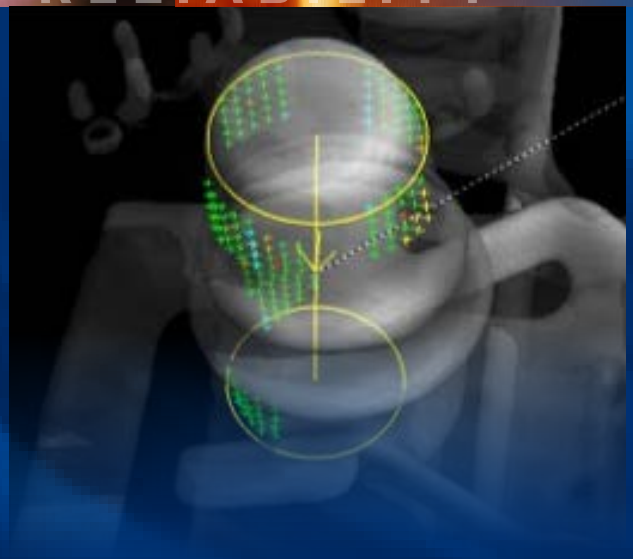
COMPETENCE & RELIABILITY

Service offer

- Analyses of materials, products, process defects, PCB defects and component failures
- Thermal analysis on material and system level
- Mechanical testing (tensile, shear test, nanoindentation, ...)
- Determination of aging phenomena and processes
- Localization and visualization of material and/or system failures
- Environmental simulation (TS, TC, PTC, HTOL, ...)
- Thin film analysis (material analysis and physical properties)
- Phase, Morphology and Residual Stress Analysis
- System evaluation of new materials
- Physics of Failure (PoF)
- Seminars and Workshops

Equipment

- Computer tomograph - Nanotom
- SAM 400 (PVA TePla)
- Confocal UV Raman microscope - alpha300R (Witec)
- Bond tester - SigmaCondor (xyzTec)
- µDMA - RSA-G2 (TA-Instruments)
- MK56 & 53 thermal cycling ovens (Binder)
- Temperature shock - ShockEvent T/60/V2 (Weiss-technik)
- TF Analyzer 3000 (aixACCT Systems)
- TDTR - PicoTR (Netzsch)
- Scanning Probe Microscope (Semilab)
- PU / SMU / Frequency Generators
- Leica TXP EM



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