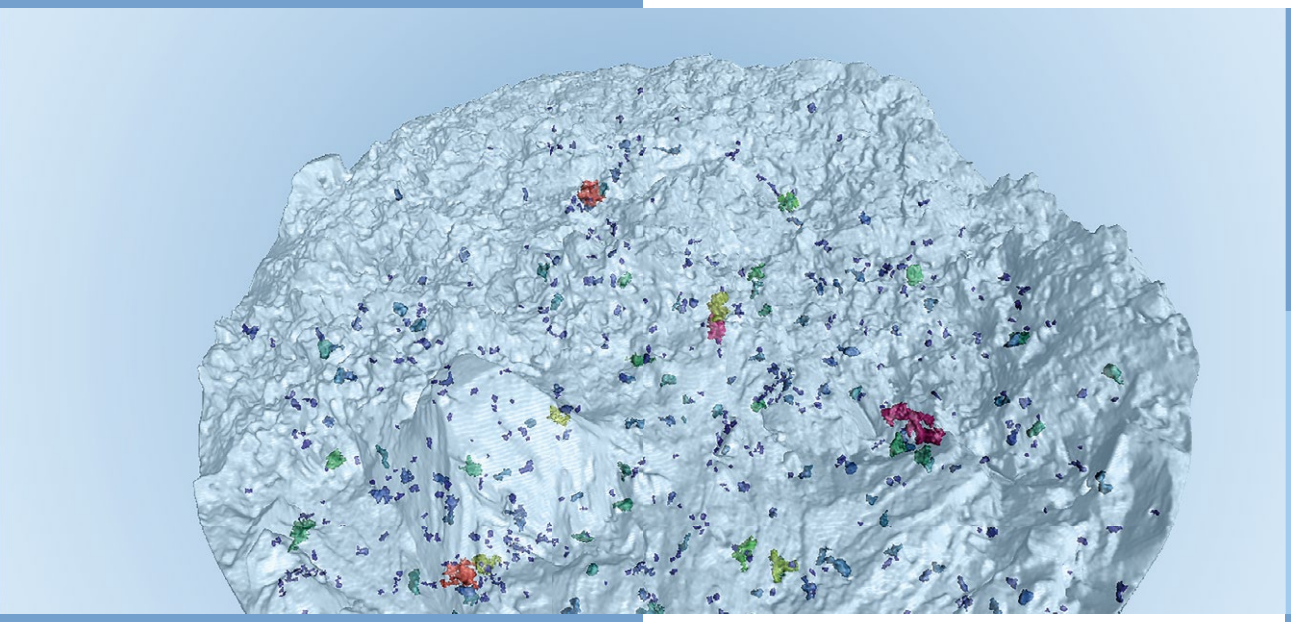
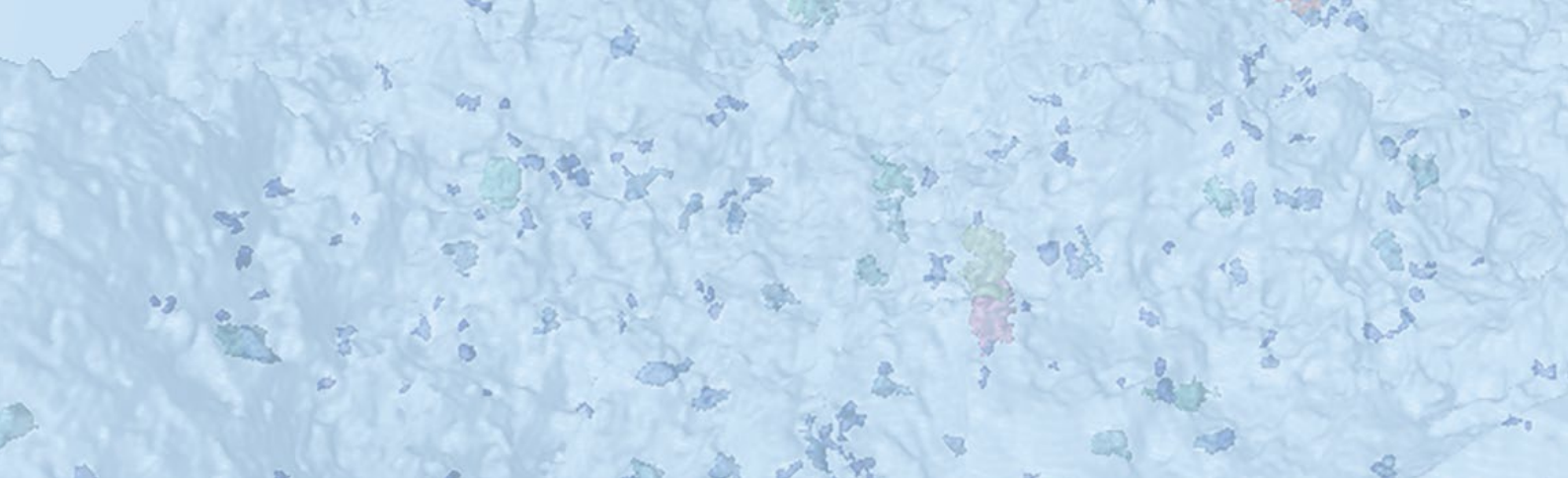
IABG. The Future.



Materials Testing and Failure Analysis

IABG



Materials Testing and Failure Analysis

We offer our customers universal, competent and prompt support in failure analysis, materials testing and the development of remedial measures for further product and process development. The IABG materials testing laboratory is an independent facility accredited for material and failure analyses. In the field of failure analysis we are VDI 3822-compliant for systematic methods. We implement complementary testing methods in agreement with our clients both in our fully equipped laboratory and on-site. Our experts draft failure evaluation reports based on the following aspects:

- Determination of failure mechanisms
- Deduction of possible failure causes
- Definition of remedial measures
- Active failure prevention

Standardised work processes permit us to quickly and flexibly develop an examination concept tailored to your request. Our statement of work gives you an initial insight. The materials we examine range from metals to non-metals, from synthetics to composite materials and material combinations. Our expertise covers the evaluation of different production and manufacturing processes – including additive manufactoring.

We use the following methods to characterise systems, components, materials and defects:

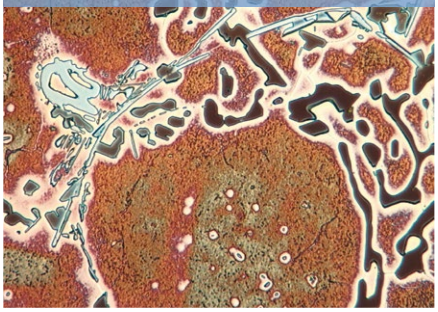
- Macroscopy and stereoscopy
- Metallography / materialography
- Hardness testing
- Scanning electron microscopy (SEM)
- Chemical and physical materials analyses
- Non-destructive testing
- Environmental simulation

We advise you on matters concerning series production and development and respond in depth to specific questions. More experts are also available to provide aggregate services for design, layout, simulations, functional tests and environmental simulation. Contact us and we will gladly bundle up a combined service package for you.

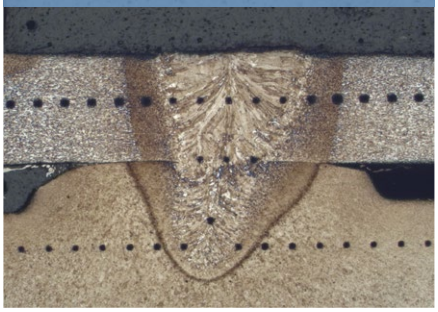
Examination Methods

MACROSCOPY & STEREOSCOPY

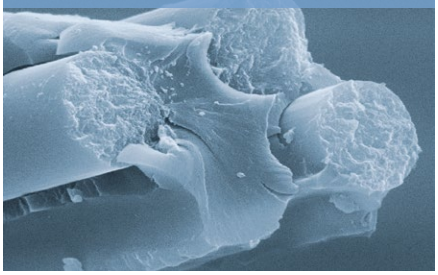
METALLOGRAPHY / MATERIALOGRAPHY



HARDNESS TESTING

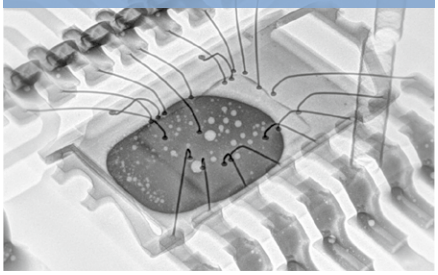


SCANNING ELECTRON MICROSCOPY (SEM)



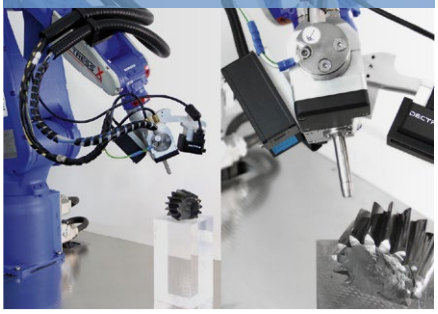
CHEMICAL AND PHYSICAL MATERIALS ANALYSES

NON-DESTRUCTIVE TESTING



ENVIRONMENTAL SIMULATION

RESIDUAL STRESS ANALYSIS (XRD)



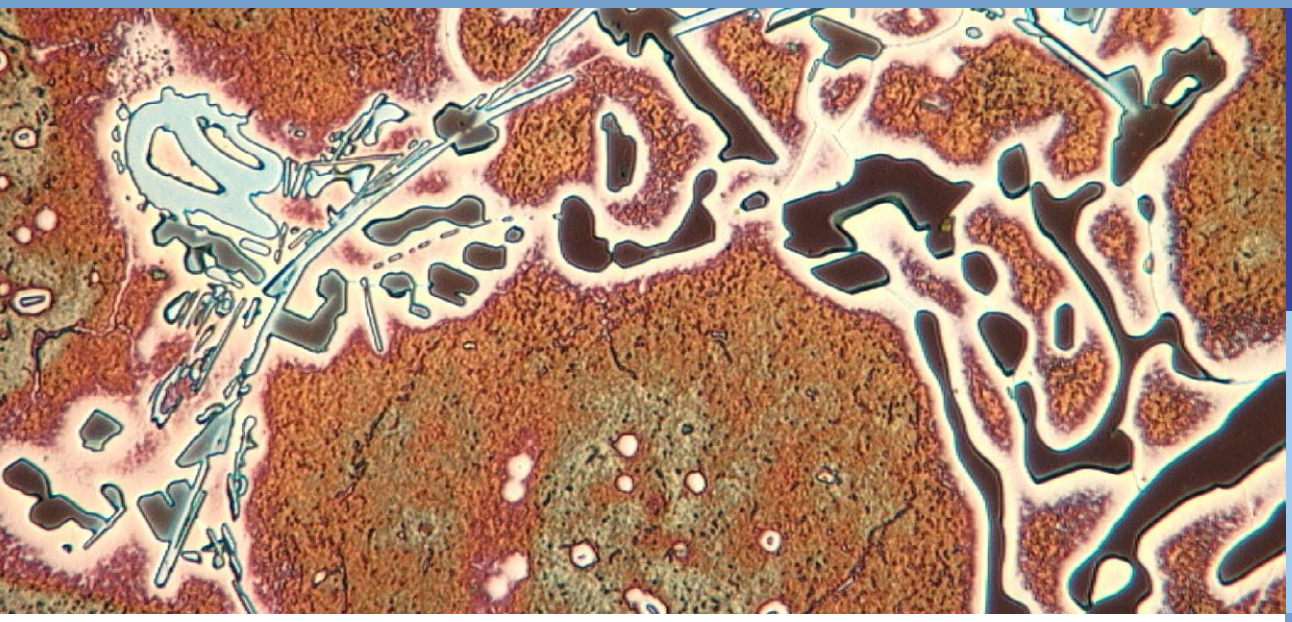
Industrieanlagen-Betriebsgesellschaft mbH
geprüft durch IABG tested by
Ottobrunn

Our seal stands for the quality of our accredited and certified test facilities

Macroscopy and Stereoscopy

Our single-lens reflex cameras and the binocular stereomicroscope with a total magnification of up to 90 : 1 plus the depth profile measurement option enable a broad spectrum of possible photos for macroscopic documentation. Digital camera systems record the samples as general and detailed photos at all stages of the examination. Leading-edge photography technology, image processing systems and databases permit numerous analyses and corresponding archiving.

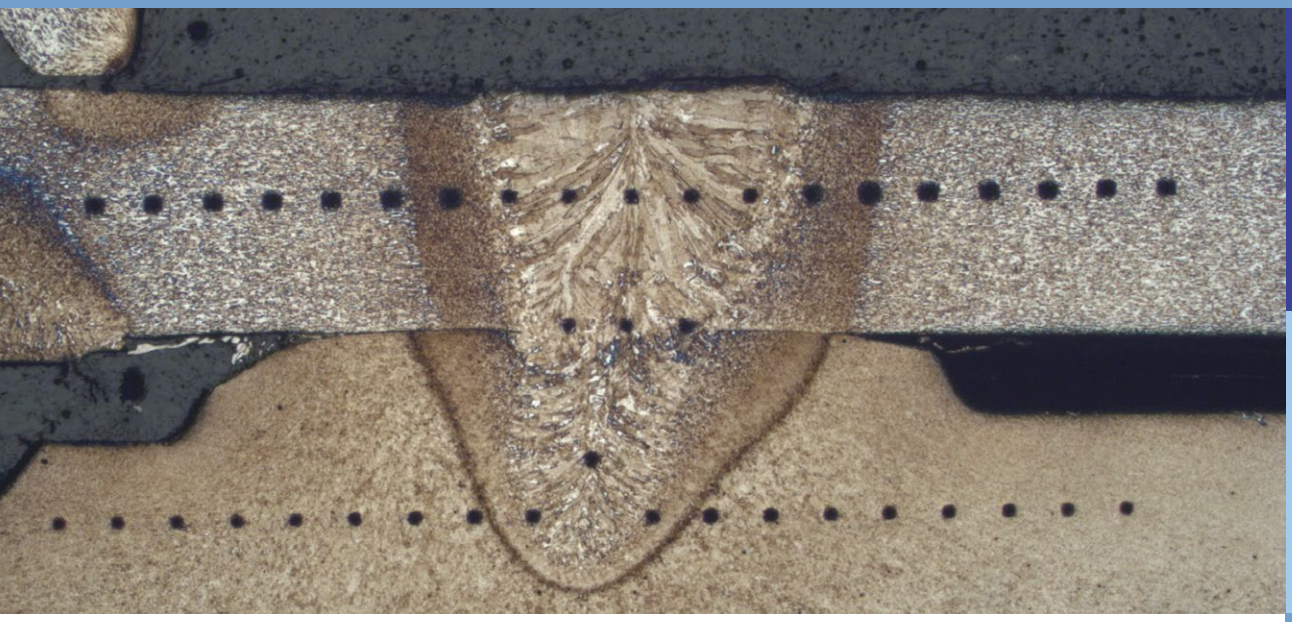
- Macroscopic component documentation
- Stereomicroscopic examinations
- Documentation of test set-ups and procedures
- Filming of tests
- Digital image analysis



Metallography / Materialography

The examination of prepared microsections of all sorts of materials is performed using light microscopes in a magnification range of 10 : 1 to 1250 : 1. Microstructural characteristics, inhomogeneities and possible defects are documented with the digital camera system and included into an Image Access database. We implement a wide range of analysis methods like grain size analysis, cast iron analysis, determination of degree of purity and determination of retained austenite, all in compliance with the specifications and standards demanded. We perform in-depth analyses and nominal-actual value comparisons based on current quality assurance standards, general standards and customer-specific standards.

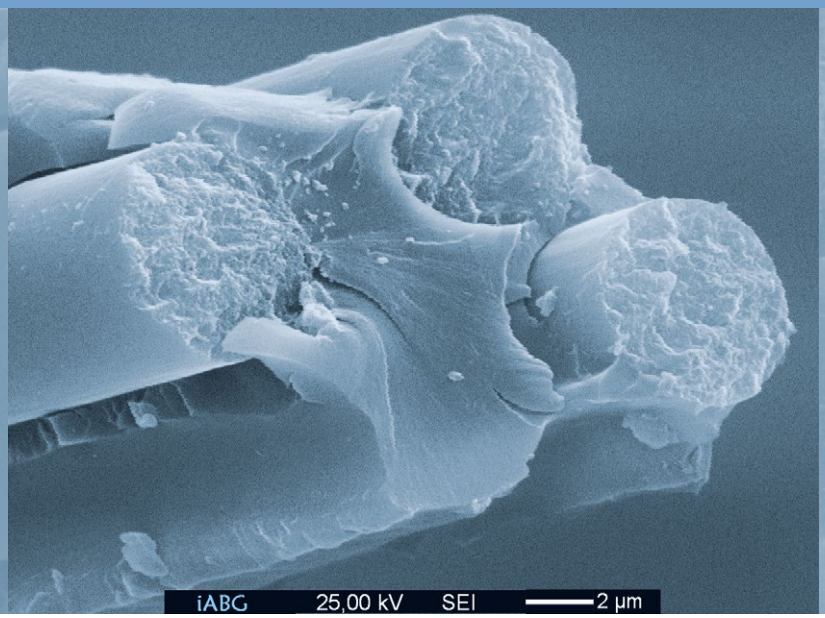
- Microstructural contrasting (chemical / light optical)
- Determination of microstructure
- Determination of degree of purity
- Determination of non-metallic inclusions
- Determination of retained austenite
- Grain size analysis
- Cast iron analysis
- Documentation of defects
- Qualitative assessment of microstructures
- Quantitative assessment of microstructures (image analysis)
- Examination of coating systems
- Joints
- Surface roughness measurement (tactile / light optical)



Hardness Testing

The determination of the material hardness of steels, light metals, synthetics, elastomers and ceramics is performed with mobile and stationary systems. We determine case hardening, core hardening and hardness profiles according to customer specifications and/or current standards (CHD, RHT, NHT, DS). Macrohardness and microhardness tests are made on samples and components applying different loads from 0.01 to 250 kg / kp.

- Brinell
- Vickers
- Rockwell
- Leeb
- Shear force
- Shore A and D
- IRHD method M
- Erichsen hardness test rod

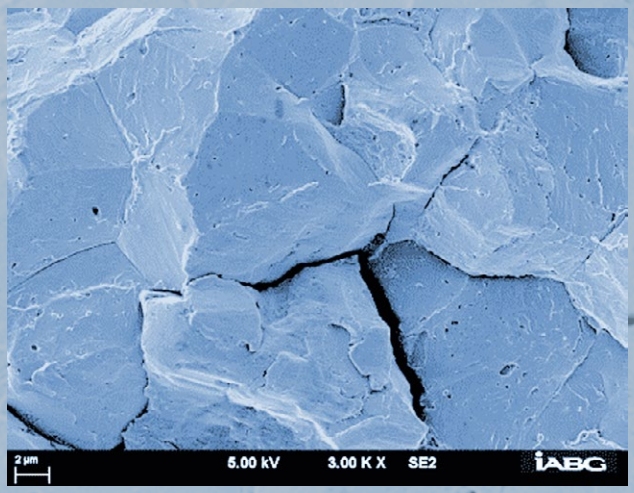


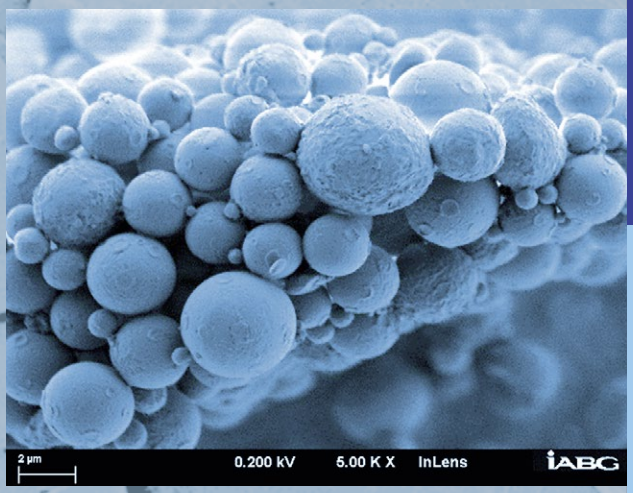
Scanning Electron Microscopy (SEM)

The scanning electron microscope is used to perform fractographic, topographic and analytical examinations. The images are displayed simultaneously via the secondary electron (SE) and back-scattered electron (BSE) detectors. We use energy-dispersive micro-area analysis (EDX) for the qualitative and semi-quantitative detection of the elementary composition of the materials to be examined, including phases, foreign material and non-metallic inclusions (NME). The results are displayed in graphs and tables or as spatially resolved images using the mapping function.

The use of the scanning electron microscope covers the following aspects of testing and analysis.

- Topography examinations
- Morphology examinations
- Fractography
  - Detection of microscopic fracture characteristics
  - Determination of fracture origin areas
  - Fracture propagation analyses
  - Detection of fracture-initiating effects
- Microstructure analyses
- Detection of defects
- Particle analyses
- Energy-dispersive micro-area analysis
  - Detection of foreign phases (inclusions, impurities)
  - Asbestos examinations
- 3D rendering
- Colour coding of details





Zeiss Merlin Gemini Scanning Electron Microscope

The high-resolution field emission scanning electron microscope and an energy dispersive X-ray micro-area analysis (EDX) are used to run topography and morphology tests.

A field emitter gives magnifications of up to 500.000 : 1, which corresponds to a resolution of 0.6 nanometres on a sample surface. In addition, very low acceleration voltages can be selected, which permits testing of non-conductive materials like biological samples, plastics or ceramics.

Using four detectors, tests and analyses are performed at acceleration voltages of 0.1 kV to 30 kV in secondary and backscattered electron contrasts.

Application range

- Fractography
- Particle analyses
- Topography examinations
- Qualitative and semi-quantitative determination of materials (EDX)
- Tests on grinding probes
- Asbestos examinations

The tests are provided on a cross-sector and cross-material basis for semi-finished products, samples, components, and metallic and organic materials.

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Chemical and Physical Materials Analyses

Using different qualitative and quantitative methods of examination we demonstrate internal chemical and physical relationships in all sorts of materials. The spectrum of our expertise in analytics ranges from the identification of a material (an inorganic or organic solid body) to the elementary analysis of trace elements and the determination of crystalline and molecular structures. Our offering also includes the determination and evaluation of indispensable physical parameters like glass transition temperature, inherent stress condition and fibre volume content.

Materials testing through:

- Spark optical emission spectroscopy (spark OES)
- Fourier transform infrared spectroscopy (FTIR)
- Gas chromatography–mass spectrometry (GC-MS)
- Time-of-flight mass spectrometry (TOFMS)
- Carrier gas hot extraction of the elements C, S, H, N, O
- Differential scanning calorimetry (DSC)
- Thermogravimetric analysis (TGA)
- Dynamic mechanical analysis (DMA)
- Determination of density
- Residual stress measurements by x-ray
- Photometric analyses
- Coating inspections
- Compression set

These tests are carried out on metals/alloys, synthetic materials/organic compounds, ceramics, salts, liquids and laminates.

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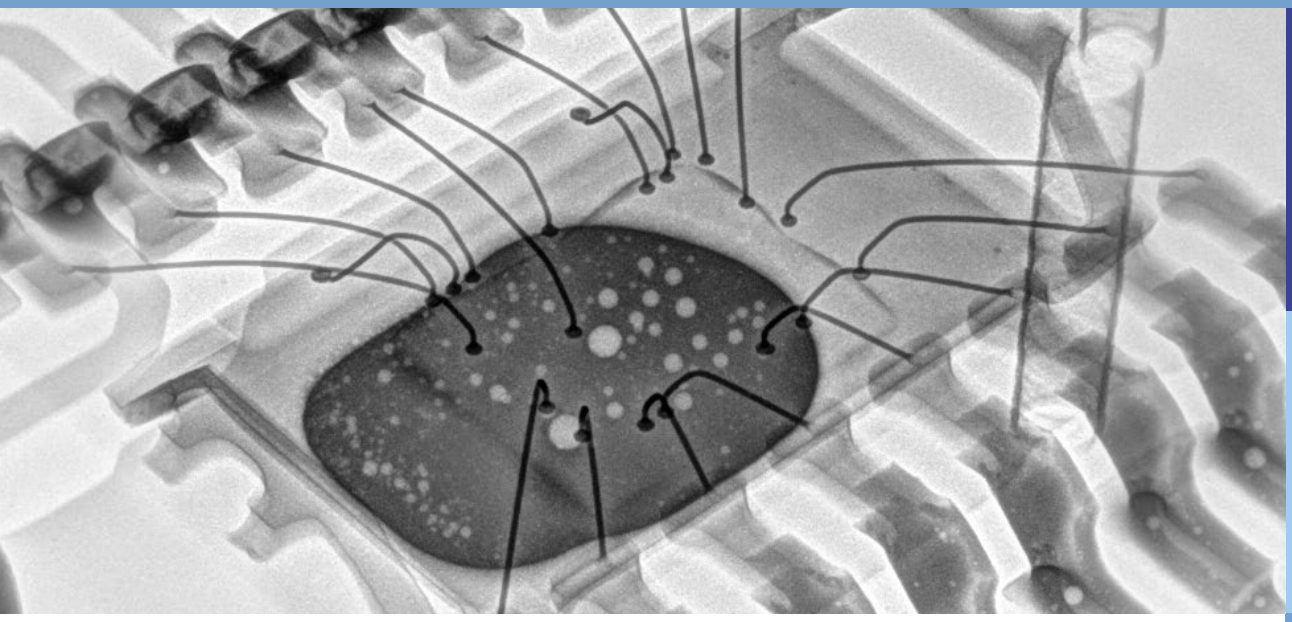


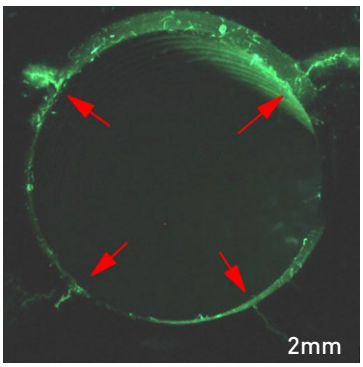
Non-destructive Testing (1/3)

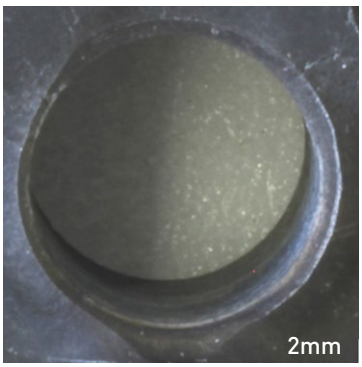
In-the-field metallography techniques

We perform in-situ examinations on large components and systems or to meet special requirements with respect to non-destructive evaluation of microstructures. In addition to applying replication techniques we carry out surface preparations, light microscopic examinations and hardness tests (rebound method) on the surfaces of the objects to be examined.

Fluorescent dye penetrant test (PT)

The fluorescent dye penetrant test is a method used to detect defects which open up to the surface. It can also be applied in-situ independent of the material and size of the component. The evaluation and documentation are done using UV light. Detected defects are evaluated in a nominal-actual value comparison and displayed in a test log.





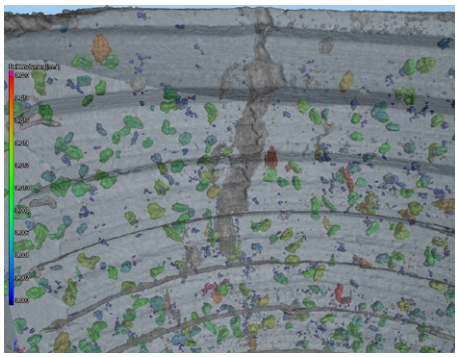
Non-destructive Testing (2/3)

micromex X-Ray Inspection System (sD/CT)

The x-ray test is a non-destructive volumetric test for synthetic materials, ceramics, laminates and composites (hybrids) and various alloys. In addition to dynamic testing in real time, the internal structures are examined as are defects and inhomogeneities. The 2D mode and x-ray tomography are used to generate digital mappings of samples and components. The length, surface and volume of detected structures are measured. A nominal-actual geometrical comparison is made by comparing a scanned volume with an imported CAD dataset. The real structures from the tomography can be output in the form of a CAD dataset. We also gladly work together with customers at short notice to perform 2D tests. The test results are evaluated according to customer specifications and presented in the form of mappings, videos and reports.

We support you with matters as below:

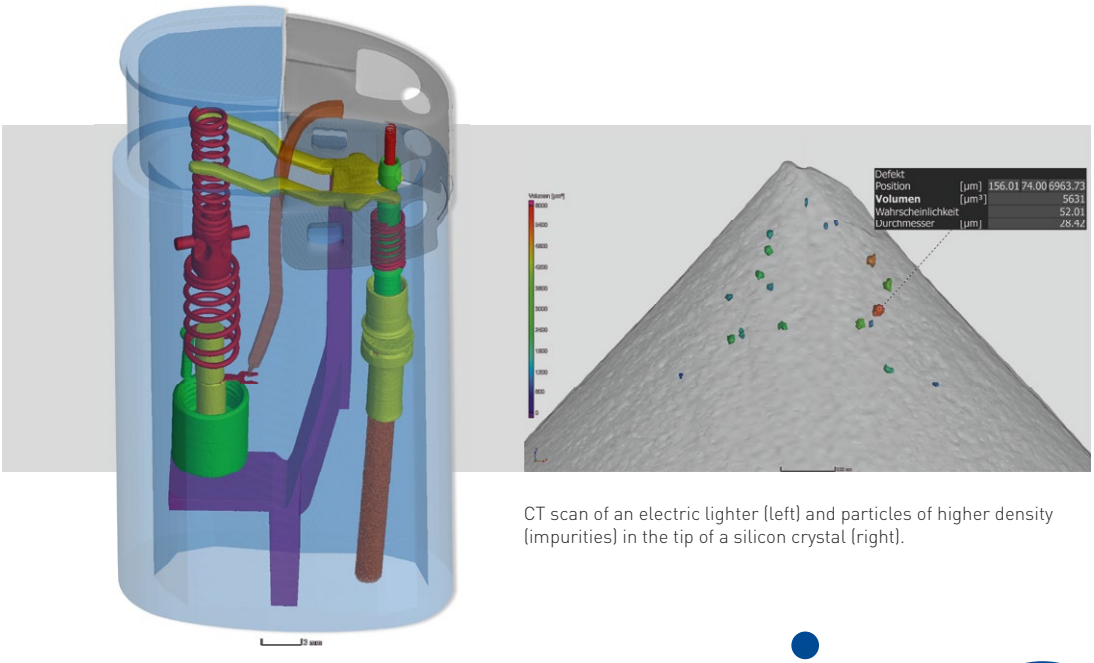
- Non-destructive volumetric testing
- Dimensional measurement
- Collection of real CAD data as calculation basis
- Assembly tests for complex machinery
- Characterisation of defects
- Characterisation of composites and laminates
- Method projects (customer-specific) configured for all types of semi-finished parts, samples and components.



Non-destructive Testing (3/3)

X-ray inspection systems v|tome|x m (CT)

Test items are converted into digital volumes using computer tomography. Two X-ray tubes of the v|tome|x m (300 kV microfocus tube and 180 kV nanofocus tube) are combined with a digital 4,000 x 4,000 pixel detector to cover a very broad spectrum of tests with high magnification and performance. These range from high-resolution CT scans (down to < 0.5 µm) of low absorbing samples to the inspection of cylinder pistons. The maximum sample size is 500 mm dia. x 600 mm height and the 3D scan volume is max. 420 mm dia. x 400 mm height with weights of up to 50 kg. The metrology version achieves a measuring accuracy of up to 4 + L / 100 µm in compliance with VDI 2630.



CT scan of an electric lighter (left) and particles of higher density (impurities) in the tip of a silicon crystal (right).

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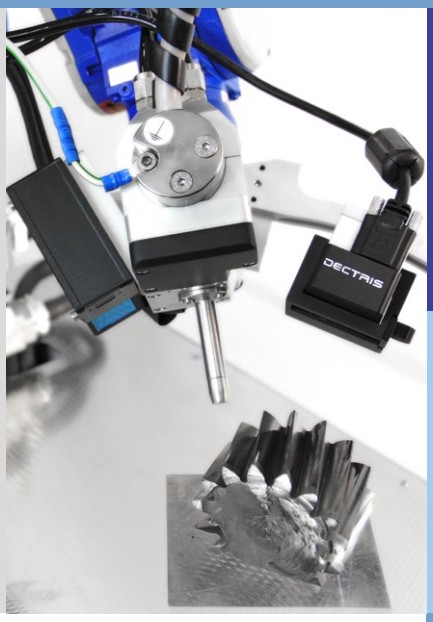
Environmental Simulation

In our laboratory we perform tests in compliance with general standards and customer-specific requirements on components, coatings and samples under various climatic conditions:

- Scratch tests
- Corrosion tests (e.g. stress-crack corrosion, NSS test, AASS test and CASS test)
- Chipping test
- Storage tests
- Chemical resistance tests with subsequent determination of the degree of rusting and blistering
- Macroscopic and microscopic analyses
- Documentation

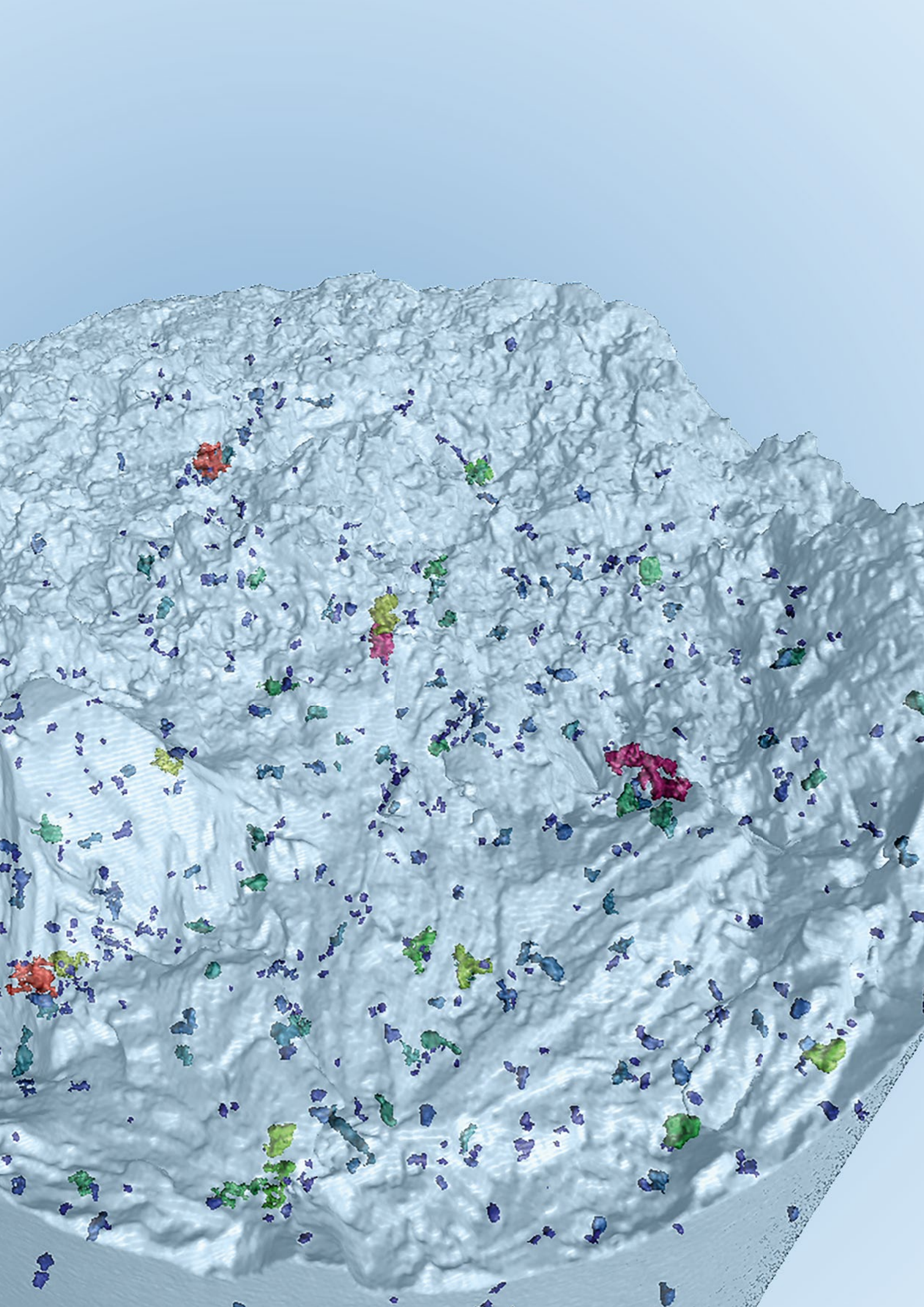
Our large-scale climatic chambers and test facilities complement our range of services for environment simulation.



Residual Stress Analysis (XRD)

X-ray diffraction (XRD) represents a well-established technique for precise residual stress analysis on poly-crystalline materials. We carry out residual stress measurements on a wide range of metals and alloys. Our compact diffractometer is mounted on a 6-axis robot, enabling the investigation of components of variable shapes and dimensions. Artefact-free removal of the component surface by electrolytic polishing enables measurements of residual stresses at different component depths.

- Non-destructive residual stress analysis with X-ray diffraction (XRD)
- Metal parts of all compositions and with complicated geometries can be analyzed
- Depth profiling by electrochemical polishing
- Uni-directional and multi-directional (full tensor) residual stress analysis
- Quantification of retained austenite



AUTOMOTIVE

INFOCOM

MOBILITY, ENERGY & ENVIRONMENT

AERONAUTICS

SPACE

DEFENCE & SECURITY

About IABG

IABG offers integrated, ground-breaking solutions in the sectors Automotive • InfoCom • Mobility, Energy & Environment • Aeronautics • Space • Defence & Security. We provide independent and competent consulting. We implement with future viability and target orientation. We operate reliably and sustainably. Our success is based on an understanding of market trends and requirements, on our staff's technological excellence and a fair relationship with our customers and business partners.

As a development partner we provide quality control services and develop solutions in the areas of functional efficiency, quality, design, and materials. We offer a broad spectrum of products and services, ranging from numerical analysis to experimental testing to the realisation of turnkey, customised test systems that we operate for the customer.

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