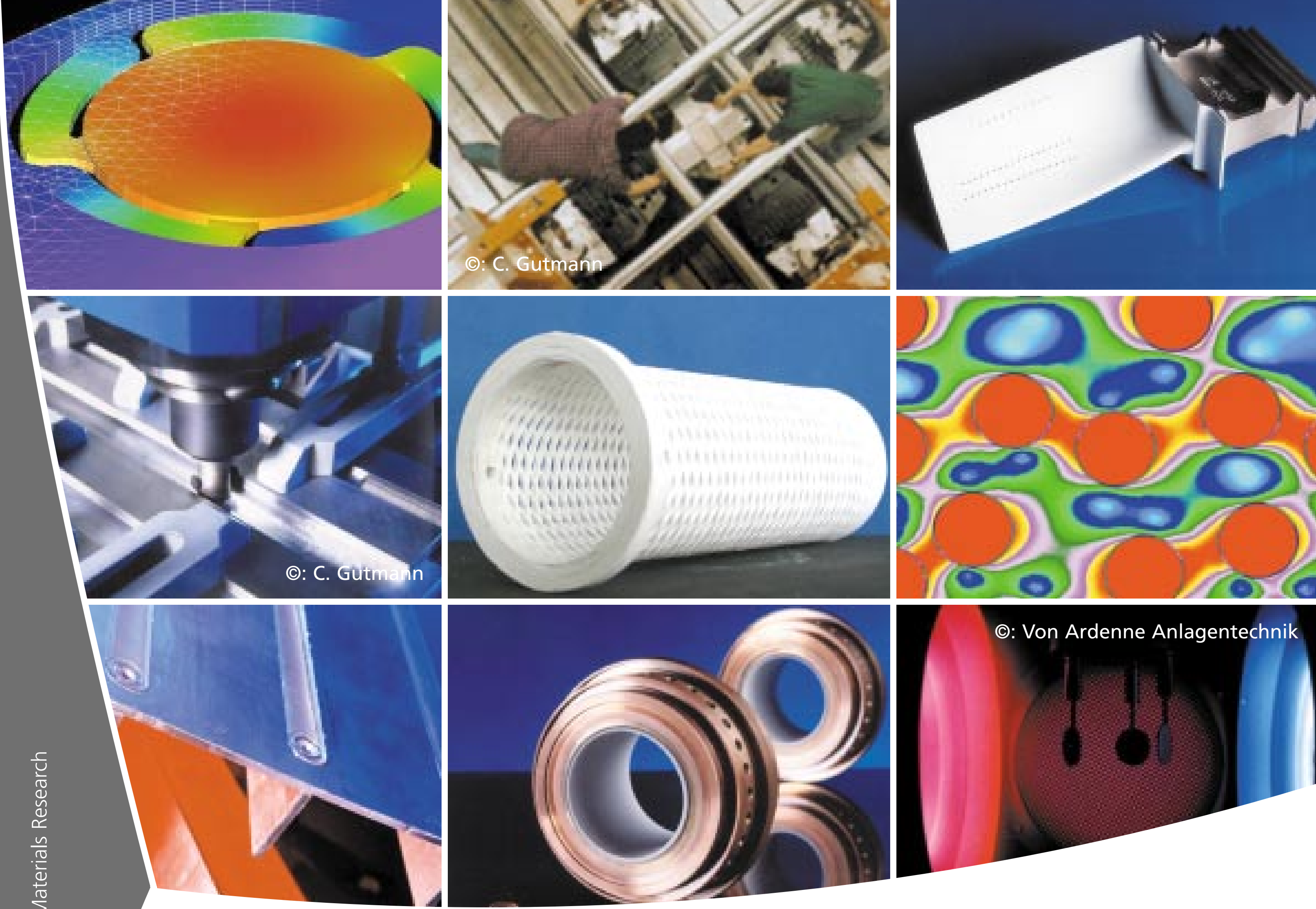


Institute of Materials Research

Materials technology – paving the way for complex components

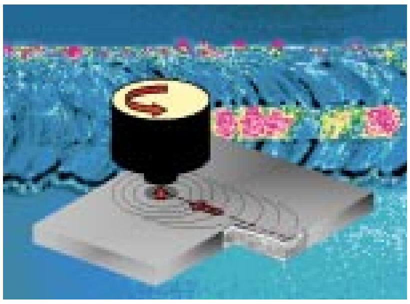
DLR

Institute of Materials Research

Today technical systems have achieved such a high degree of complexity that further improvements can only be made by a multidisciplinary systems approach. Here the materials play a key roll since often only their availability allows to realize the complete system. The investigation and development of new materials alone would only lead us half-way. Nowadays manufacturability, availability and last not least costs decide similarly on the technical usability and therefore also on the commercial application and success of a material.

Consequently interdisciplinary research teams at the Institute of Materials Research not only develop new high performance materials but also work on technologies for their production and integration into complex component systems. This is done in collaboration with national and international partners from industry, universities and research laboratories. The main emphasis of the research and development work in the institute is focused on applications for aeronautics with transfer into aerospace, energy technology and traffic.

Friction Stir Welding

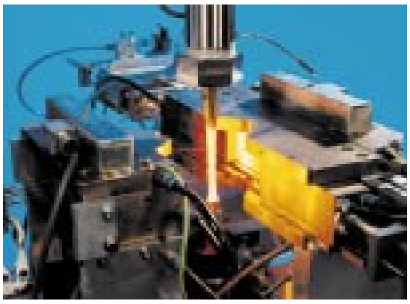


Non-destructive testing of a friction stir weld by ultrasonic inspection.

Friction stir welding (FSW) is a simple, clean, and innovative joining process specifically developed for light metal alloys. Since the temperatures are well below the melting point, problems associated with liquid/solid phase transformation are avoided. This allows high quality joining of materials, such as high strength aerospace aluminum alloys, that have been traditionally difficult to weld by conventional methods. The attractive mechanical properties, especially in fatigue and strength, enable cost and weight savings in friction stir welded integral structures.

The FSW-related activities at the Institute of Materials Research include development of the FSW technology, mechanical characterization, investigation of corrosion resistance and non-destructive testing of the integrity of the friction stir welds. The goal is to take advantage of the opportunities offered by FSW to produce light, low cost and safe metallic integral structures for aircraft fuselages. Therefore damage tolerance testing and the development of structural integrity assessment methods of welded integral structures is an essential part of the activities.

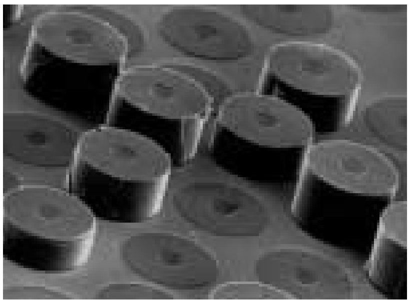
Mechanics of Materials



Testing of thermal barrier coatings under service-like conditions.

The advancement of structural safety of aircraft and space vehicles, the extension of their service lives, and the qualification of new materials and advanced manufacturing processes are the main topics of the mechanics of materials activities of the Institute of Materials Research. Fatigue crack growth and the fracture behavior of light weight structures and of high temperature materials are of special interest. Crack growth investigations and modeling of the material behavior take into account uniaxial and biaxial loading and the influence of temperature and service environment.

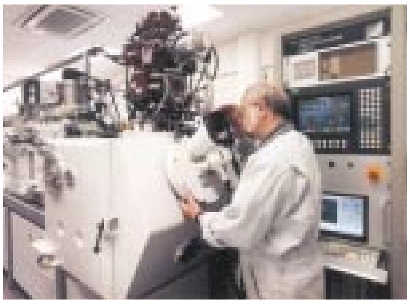
Light Metal Composites



Push-out test on a fiber-reinforced titanium matrix composite.

Reinforcement of titanium alloys with ceramic fibers originates lightweight composite materials with outstanding mechanical properties like high strength and stiffness. These composites have the potential to increase tremendously the efficiency of aero engine compressors. A processing route elaborated at DLR enables both the production of simple-shaped specimens for basic research as well as prototypes of more complex components made from titanium matrix composites. The research and development activities are embedded in cooperations with national and international customers and partners. Numerical methods accompany the experimental investigations. Modeling of the material behavior and simulation of the performance of components accelerate the transfer of the lightweight composites into applications.

High-temperature Coatings

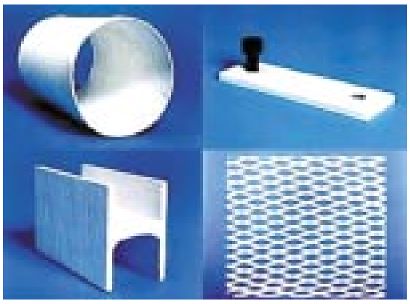


The 150 kW EB-PVD coater allows pilot-scale processing of thermal barrier coatings.

High-temperature resistant metallic and ceramic coatings reduce the influence of severe environmental conditions on materials and components. For example, in aero engines thermal barrier coatings allow to considerably increase the operating temperatures of turbine blades leading to a decrease in fuel consumption and similarly to cleaner exhaust gases. Electron beam physical vapor deposition (EB-PVD) allows to produce extremely smooth and damage tolerant thermal barrier coatings. Jointly with end users and research partners new complex coating systems are developed at the Institute of Materials Research. For investigation of the coating systems a full range of characterization and testing methods is available. This includes various microstructural characterization methods as well as thermal test procedures including both standard thermal cycling as well as complex thermal gradient mechanical fatigue tests. The results gained here lead to a better understanding of the failure behavior of the coatings. Not only does this lead to further improved coating systems, it also lays the basis for the generation of profound life time prediction models.

Oxidation resistant coatings are developed for nickel-base superalloys and titanium alloys. For titanium alloys and titanium aluminides an effective oxidation and corrosion protection is necessary to ensure the safe operation of components for instance used in aero engines. Particularly engineered magnetron sputtering coatings have the potential to raise the application temperatures of titanium aluminides up to 900 °C.

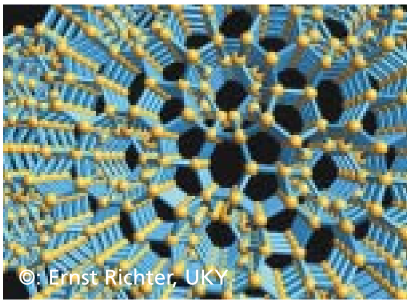
High Temperature Ceramic Matrix Composites



WHIPOX® components are manufactured from oxide fibers and oxide matrix.

The emission of combustor pollutants may be reduced significantly by implementation of thermal protection systems on the basis of oxide fibers/oxide matrix tiles. DLR has developed WHIPOX (**w**ound **hi**ghly **p**orous **ox**ide ceramic composites), a highly porous ceramic matrix composite. WHIPOX structures are cost effective and are characterized by excellent high temperature stability in oxidizing atmospheres, high damage tolerance and thermal shock resistance. The main activities at the Institute of Materials Research focus on the engineering of components and structures for aerospace applications.

Functional Materials



Clathrates – nano-engineered novel thermoelectric materials.

Materials, contacting technology, and system design for thermoelectric sensors and energy converters aimed at application at elevated to high temperatures (300-1000 °C) are under development for device solutions in aerospace, traffic technology and laboratory measurement techniques. The operational spectrum of the Institute of Materials Research ranges from fundamental research up to manufacturing of prototypes on industry demand. Nanostructured thermoelectric high-temperature materials from novel material classes showing improved application-relevant properties are prepared and characterized in international co-operation.

Microanalysis

Failure of a thermal barrier coating.

Microstructural characterization and microanalysis are essential tools for understanding the relations between processing and properties of materials. Optical microscopy, scanning electron microscopy, and transmission electron microscopy as well as X-Ray diffractometry, X-Ray fluorescence spectroscopy and calorimetric methods are important characterization techniques available at the Institute of Materials Research.

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