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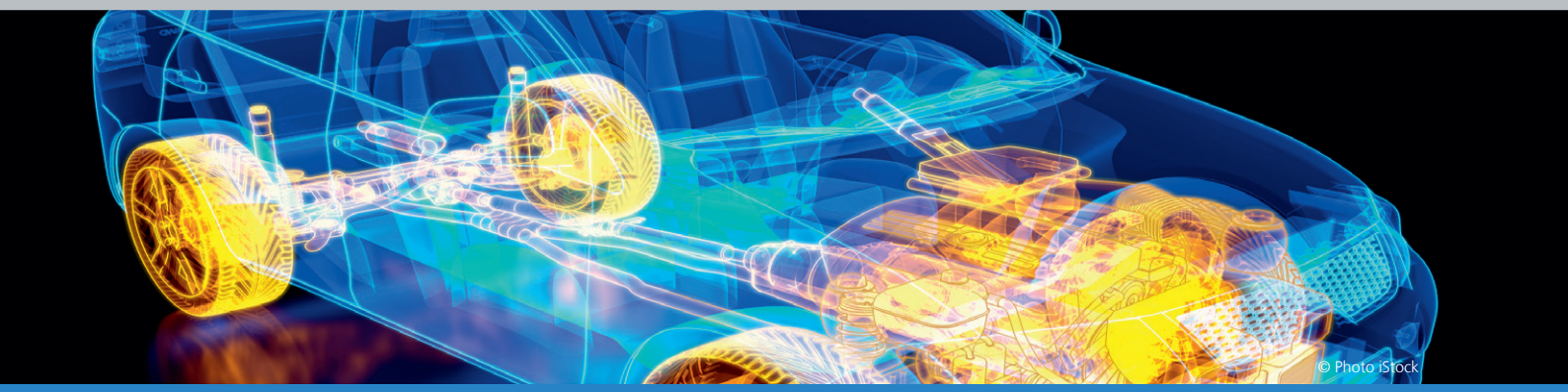
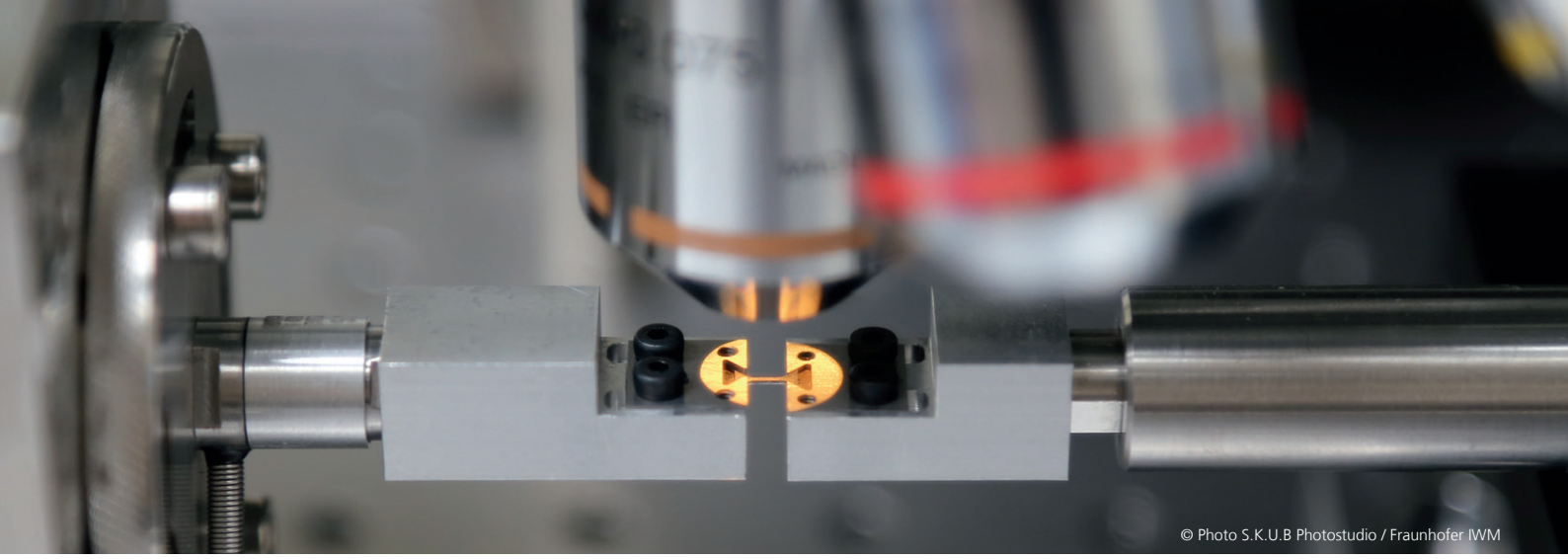
FRAUNHOFER INSTITUTE FOR MECHANICS OF MATERIALS IWM



OPTIMIZED USE OF MATERIAL PROPERTIES, NEW MATERIAL AND COMPONENT FUNCTIONS FOR AUTOMOTIVE APPLICATIONS



Materials solutions for the entire product lifecycle

Climate and environmental regulations create the need to act for automobile manufacturers and their suppliers. Limiting exhaust emissions is a central motivator for finding intelligent material solutions for powertrain or weight of the vehicle. Similarly, electric vehicles require new safety concepts and sustainable designs. The demand for efficient energy storage remains unbroken. The use of hydrogen based propulsion systems will increase. Many functional high performance components still rely on critical raw materials and companies are searching for substitution materials to secure their competitiveness. Complex demands and optimization strategies lead to multi material designs. Closely related to this is their feasibility and new production methods, especially in the field of joining technology. Efforts to increase efficiency lead to materials and components being operated to their very limits, which result in R&D challenges for the optimization of materials and for robust component design.

This is where the Fraunhofer Institute for Mechanics of Materials IWM comes in: as a partner in research and development for automobile manufacturers and their suppliers concerning issues of safety, reliability, durability and functionality of materials in components and production processes. Our work is to predict and push the performance limits of materials and components, describe changes in materials during production and service or to precisely adjust functions and properties. The Fraunhofer IWM's expertise is especially effective where materials in components and production processes are exposed to extreme and complex stress conditions and where improvements in efficiency and functionality can only be realized trough in-depth and holistic understanding.

Materials Design

We explain material behavior and predict material properties using computational and experimental methods based on solid-state physics and materials mechanics. Our ambition is the targeted design of structures, properties, and functions. We identify the effects of crystalline defects and microstructures on the macroscopic behavior of materials. This enables us to make effective and efficient use of material and energy resources in order to achieve sustainable improvements to technical systems.

Services

- Multiscale, experimental and computational design of materials for multifunctional tasks
- Identification of material properties, development of material models, predication of physical, chemical and mechanical properties, material substitution, material screening
- Materials modeling using methods based on quantum mechanics (from first principles, density function theory) on classical atomistic mechanics (molecular dynamics), and on multiscale materials modeling (MMM)
- Determination of micromechanical local properties and lifetime assessment
- Combinational high-throughput screening, experimental and computational, to identify novel material systems with specific structures and compositions for desired properties and functions
- Design and manufacture of artificial mesoscale meta-materials with novel properties

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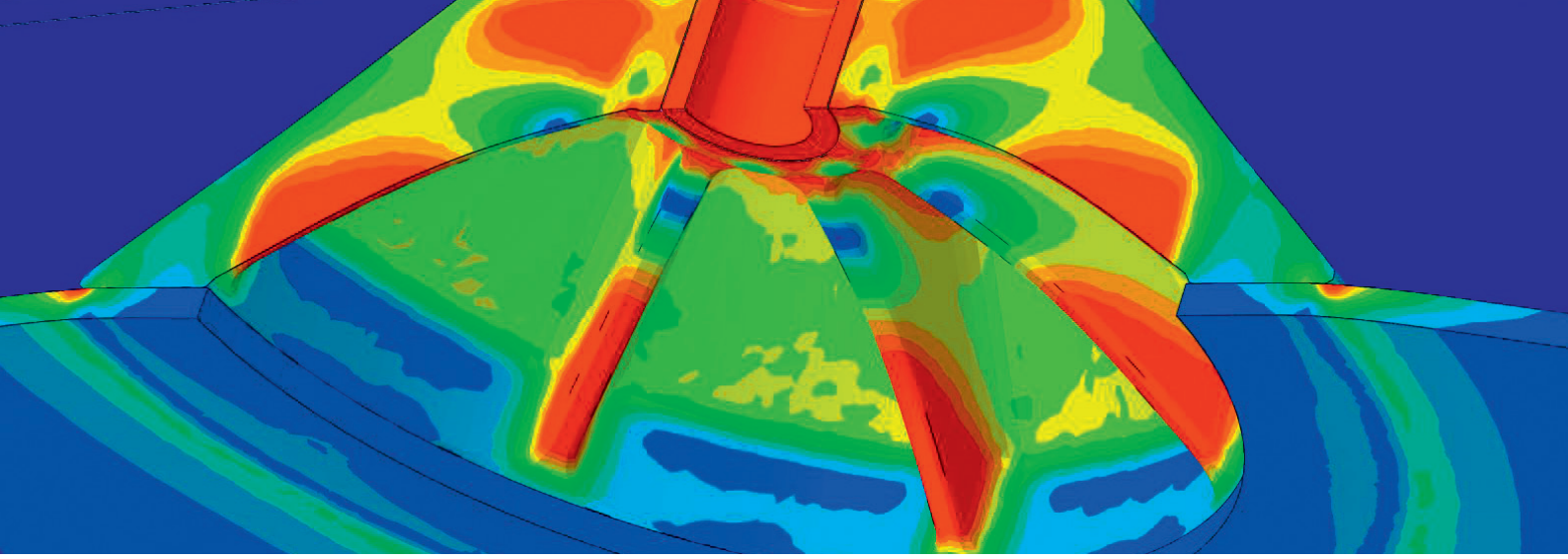

Manufacturing Processes

Our understanding of processes and sophisticated simulation techniques enables us to design efficient and reliable manufacturing processes. Our services include investigations into and the technological development of manufacturing processes for the production of semi-finished products and components with functional properties. This work ranges from powder technology processes, including complex fluid systems, to microfluids, the forming and processing of ductile materials as well as processing techniques for brittle materials and glass forming.

Services

- Innovative manufacturing processes for precision contours and functional components with defined property profiles
- Simulation-assisted optimization of the energy and material efficiency of manufacturing processes
- Modeling and simulation of powder technology and fluid dynamic processing stages, simulation methods for generative manufacturing
- Forming process simulations including microstructure development and thermodynamics
- Forming, processing and damage analyses for brittle materials such as glass and silicon
- Investigation and optimization of abrasive and erosive processes

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Tribology

We carry out research on friction and wear. We optimize tribological systems and develop solutions that reduce friction and protect against wear with the aid of technical ceramics, innovative lubricants, tribological coating systems and tribo-materials conditioned through manufacturing technology.
We investigate friction, abrasion, running-in and wear mechanisms as they affect the tribo-chemistry of machine elements such as roller and slide bearings, cutting and forming tools or motor and gearbox elements. We use experimental techniques, multiscale modeling and numerical simulations as well as microstructure analysis.

Services

- Determination of mechanical and tribological properties of materials, composites and coatings under operational conditions
- Evaluation and optimization of the performance of protective wear-resistant coatings and friction contacts
- Load analyses, trials and evaluation of failure mechanisms for metal, ceramic and polymers components
- Production and evaluation of smooth and structured diamond-like carbon coatings for extreme tribological conditions
- Development and application of lifetime prediction methods

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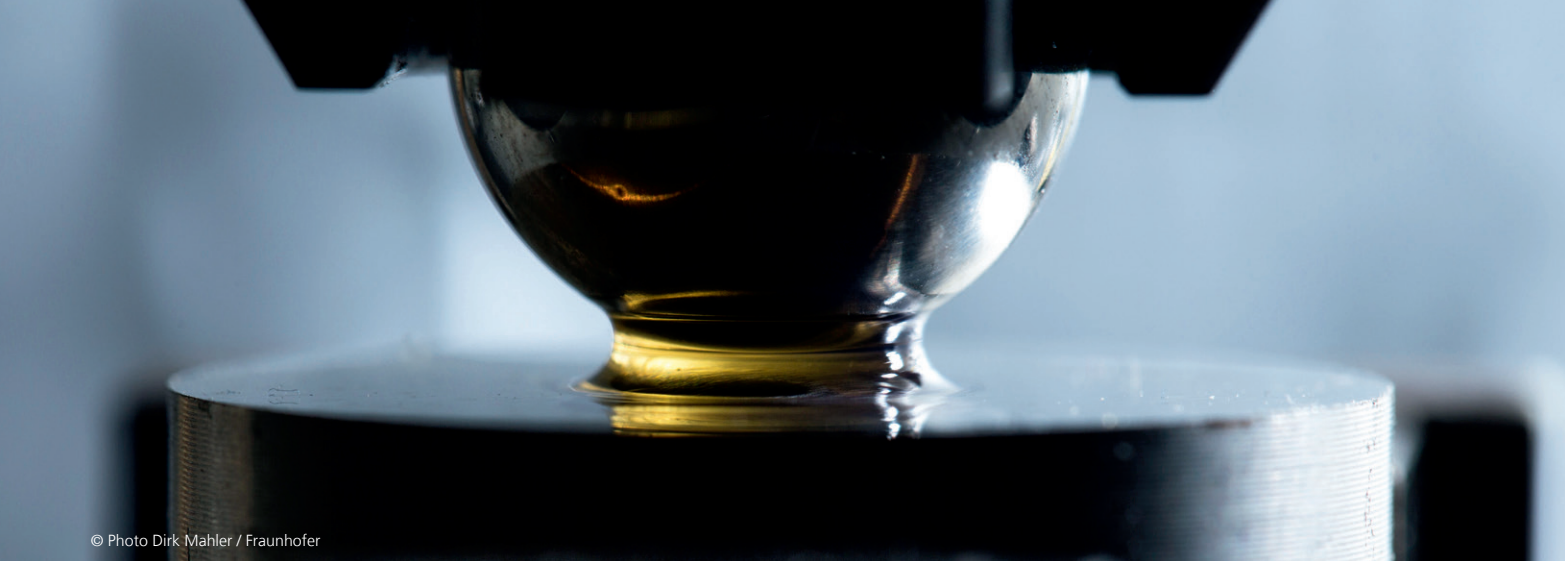

Component Safety and Lightweight Construction

The assessment of lightweight structures and components with safety-relevant demands under operational loads represents the center of our research work. The applications range from proving the safety of power plant components to confirming the defect tolerances of civil, vehicle and aerospace components to crash analyses of vehicle components. The focus is on the operational behavior of modern metallic materials as well as joins, composites and multi material constructions.

Services

- Characterization and modeling of materials and components taking into account service relevant loading from creep to fatigue to impact and crash
- Assessment concepts to prove the structural integrity of highly stressed safety-relevant components
- Fracture mechanics safety analyses, assessment of defect tolerance and derivation of inspection intervals
- Crash simulations of automotive and railway components with customized material models
- Assessment of weldments and adhesive and mechanical joins with respect to service and crash loads
- Process simulation: mechanical joining, welding and mechanical surface treatments for durability enhancement
- Experimental and numerical assessment of composites and multi material constructions
- Probabilistic analyses

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Assessment of Materials, Lifetime Concepts

We assess the influence of microstructure, internal stresses and damage on component functionality and life expectancy. We are particularly interested in linking specific analyses and experiments to advanced material models and in understanding the demands placed on our clients' components. Our work is focused on modeling cyclical thermomechanical loads and on identifying the degradation mechanisms involved in corrosion, stress corrosion cracking and hydrogen embrittlement. In acute cases of damage, we can carry out surveys for our clients.

Services

- Simulation, identification and assessment of the microstructure and internal stresses related to manufacturing and loading
- Investigations into material degradation through corrosion, stress corrosion cracking and hydrogen embrittlement
- Identification of damage mechanisms associated with cyclical thermomechanical loads
- Mechanism-based material models for time and temperature related plasticity and damage
- Software for calculating life expectancy using finite elements programs
- Damage analysis, identification of technical liability, surveys, development of new testing techniques
- Construction of test rigs

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Project examples where mechanics of materials provides solutions for enhanced realiability, safety, functionality or efficiency:

	Assessment of reliability and safety, prediction of lifetime	Simulation and optimization of manufacturing processes	Material design, assessment of new materials
Body Parts	X	X	X
Joints	X	X	X
Zylinders	X	X	X
Piston Rings	X	X	X
Exhaust Comp.	X		X
Wheels	X		
Brakes	X		
Axles	X		
Gears	X	X	X
Bearings	X	X	X
Magnets		X	X
Batteries	X	X	X
Injectors			X
Connectors	X	X	X
Windshields	X	X	
Headlamps		X	
Lubricants	X	X	X
Fuel Cells	X		
Fuels	X	X	X
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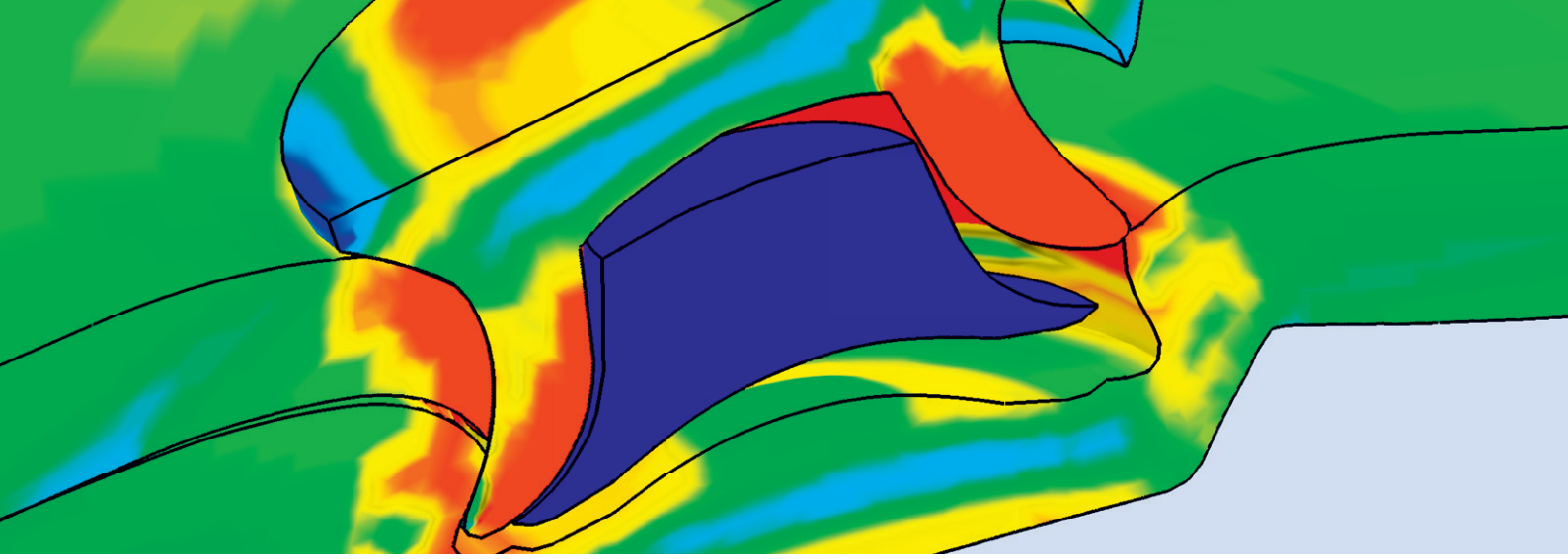

Fraunhofer IWM: Mechanics of materials expertise for your competitive advantage

- Whether you are in business or a public institution, we address your materials related research and development concerns in application-oriented projects from damage analysis and process development to materials innovations.

- We realize solutions for the optimized use of material properties to improve the reliability, life expectancy and safety of components and develop new materials as well as resource-efficient manufacturing processes.

- Our research focuses upon material changes in processes and components. For this purpose, we are developing specific material models, characterization and simulation methodologies.

Characterization and analysis

- We determine material and component properties under mechanical, thermal, tribological and corrosive loads.

Description, evaluation, simulation

- We develop material models to describe material mechanisms such as crack formation, deformation, failure, wear and fatigue.
- We analyze and simulate material and component behavior on various scales during the production process as well as when in use.

Development and optimization

- We develop solutions along the entire process chain to achieve higher manufacturing yield and energy efficiency, increased component life expectancy and improved component quality.
- We develop functional coatings and sustainably functional materials.

Fraunhofer: research for the future

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 72 institutes and research units at locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of more than 25,000, who work with an annual research budget totaling 2.3 billion euros. Of this sum, almost 2 billion euros is generated through contract research. Around 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

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