

TOGETHER WE'LL FIND A CUSTOMIZED  
SOLUTION FOR THE CHALLENGES YOU  
FACE

CONTACT US!

### First Contact

Cooperation with the Fraunhofer Institute for Mechanics of Materials IWM starts with a non-binding consultation. Here we explore which goals can be achieved and potentials for the financial aspects and time frame of your project. Regardless of size, we ensure the highest professionalism in handling all projects.

The Fraunhofer IWM works with the most modern equipment available. This enables unexpected insights into the behavior of materials and components, thus enabling innovative solutions.

Our customers' information is strictly confidential. Mutual confidentiality agreements may be signed before the first meeting. Confidentiality agreements may also be part of the cooperation contract.

### Quality Management

Hundreds of successful research and development projects every year as well as a certified quality management system demonstrates our reliability regarding the execution of projects within the framework of industry. High customer satisfaction (as confirmed by surveys) shows that the Fraunhofer IWM enjoys a very good reputation.

### Using Materials Intelligently

The Fraunhofer IWM is a research and development partner for industrial as well as public clients in the areas of reliability, safety, durability, and functionality of components and systems. We work out solutions to ensure operational safety of components under high operational strain, develop functional materials and resource efficient production processes.

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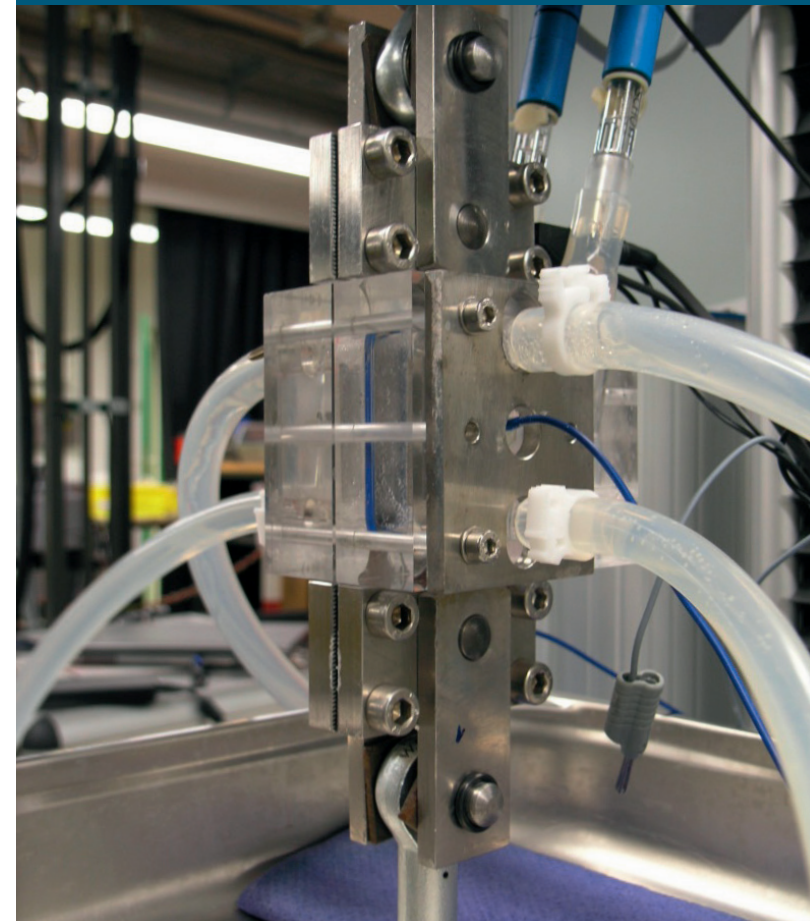
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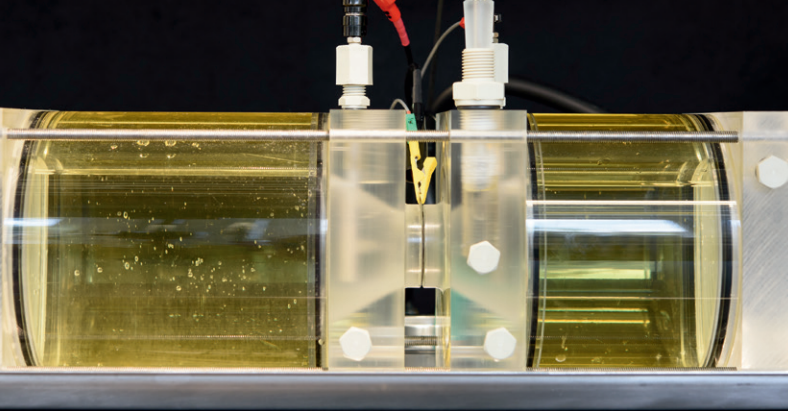
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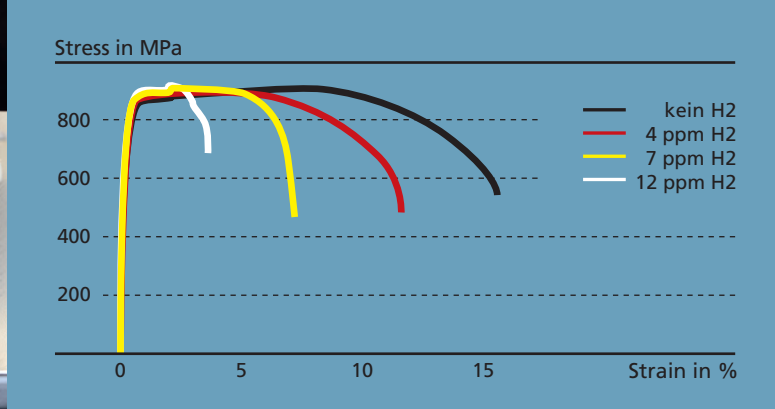
## HYDROGEN EMBRITTLEMENT: MATERIALS QUALIFICATION AND SIMULATION

Cover image: tensile testing machine with cell for in situ electrochemical loading with hydrogen.

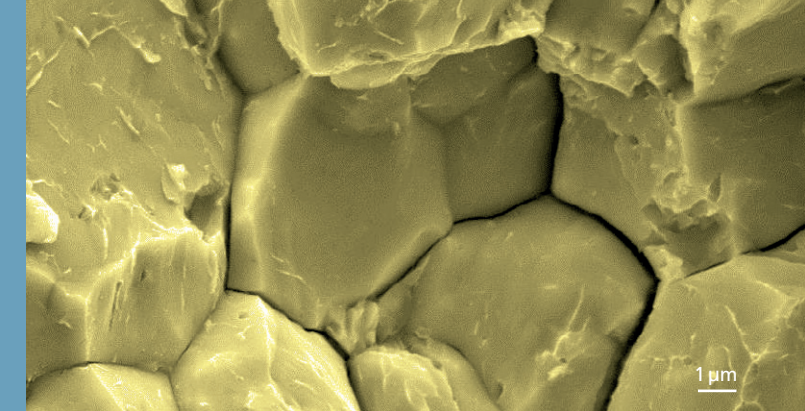




Permeation cell for the measurement of diffusion coefficients.



Stress-strain curve of steel with varying hydrogen content.



Typical fracture morphology caused by hydrogen embrittlement.

### Characterizing and simulating hydrogen embrittlement

In our laboratories we characterize material properties under the influence of hydrogen. This includes microstructural analyses, mechanical tests, stress analyses as well as the measuring of hydrogen contents and diffusion coefficients. The results are then used in models to predict stress limits and the life expectancy of components.

#### The mechanism of hydrogen embrittlement

In 1875 W.H. Johnson wrote:

»This change is at once made evident to anyone by the extraordinary decrease in toughness and braking strain of the iron so treated, and is all the more remarkable as it is not permanent, but only temporary in character, for with lapse of time the metal slowly regains its original toughness and strength« (Proceedings of the Royal Society of London (23), 168-179, 1875).

Today we know that hydrogen embrittlement can occur when an external or internal source of hydrogen coincides with a material or material condition which is prone to hydrogen embrittlement as well as external mechanical stress and/or residual stresses.

#### Services

- Proof of hydrogen embrittlement.
- Qualification and characterization of materials and welding seams for hydrogen applications.
- Damage examination of components and development of corrective measures.
- Residual stress optimization to avoid the formation of cold cracking in welding seams.
- Support of complex development projects in the areas of power-to-gas and other innovative hydrogen technologies.
- Optimization of degassing heat treatments, for example after galvanic coating.
- Optimization of welding and heat treatment methods.
- Development of protective coatings against hydrogen.
- Material selection for hydrogen applications.
- Applicability of lubricants in rolling bearings, key word: »white etching cracks«.

#### Material characterization

- Measuring of total hydrogen content with inert gas fusion.
- Thermal desorption spectroscopy up to 1100 °C to determine binding energy.
- Permeation tests for the measurement of diffusion coefficients and density of traps in metals.

- Slow tensile tests (SSRT, CERT) with in situ hydrogen loading.
- Hollow sample test rig for stress and fatigue tests with internal gas pressure up to 200 bar and variable test temperature.
- Autoclave for hydrogen loading with up to 500 bar pressure and 350 °C and in situ examination of stressed samples.
- Crack growth and fatigue tests with in situ hydrogen loading.
- Notched tensile tests, for example following ASTM F 519 and DIN EN 2832.
- Microstructure and stress analyses.

#### Simulation

- Simulation of hydrogen distribution over time and space, based on diffusion and trapping behavior in components, welding seams and full material.
- Development of models for the prediction of hydrogen related fracture formation and calculation of static stress limits for random component geometries.
- Life expectancy prediction in case of hydrogen related crack growth.