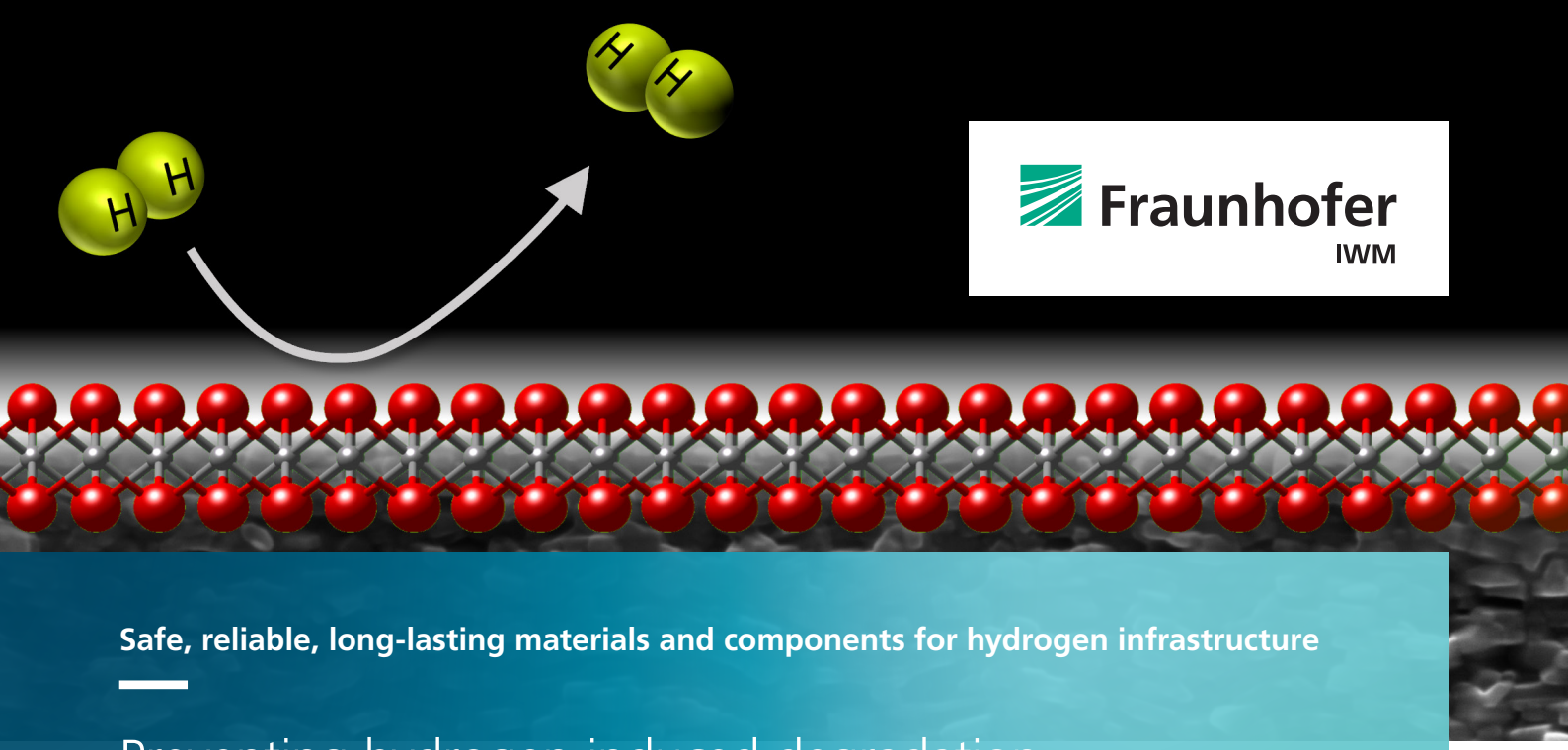

Fraunhofer IWM

Safe, reliable, long-lasting materials and components for hydrogen infrastructure

Preventing hydrogen induced degradation

Demand for barrier coatings

During the production, storage and consumption of hydrogen in a wide range of applications (e.g. electrolyzers, pressure transmitters and fuel cells), materials and components are exposed to hydrogen or atmospheres containing hydrogen.

Hydrogen is the lightest and smallest of all elements, which is the reason why the diffusion rate of hydrogen in metallic materials exceeds the diffusion rate of nitrogen or oxygen by many orders of magnitude. In addition, the incorporation of hydrogen in construction materials often results in a variety of damage mechanisms that may extremely shorten their service life. Examples include hydrogen embrittlement, hydrogen-induced delamination of coatings and sensor degradation.

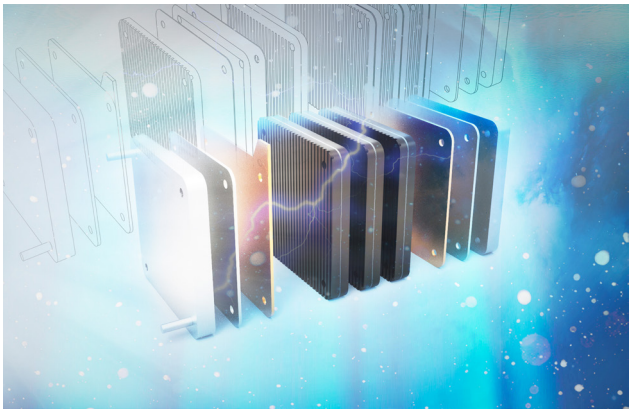

Fig.1: Illustration of a fuel cell stack.

Coating developments at Fraunhofer IWM

The development of a protective coating against both tribological or corrosive stresses and hydrogen-indiffusion requires a comprehensive consideration of the entire system. Fraunhofer IWM develops and deposits protective coatings, models their performance on an atomistic level and assesses their barrier properties under application-oriented conditions.

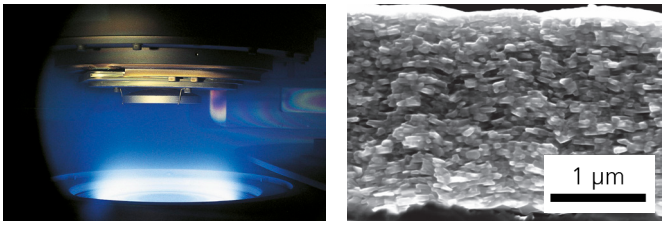

Fig.2: Intense titanium-plasma inside a PVD-process chamber (left) and microstructure of an efficient barrier coating (right).

Advantages of plasma-based coatings

- Huge variety of component materials can be coated: metals, polymers and ceramics
- Large number of different coatings of all material classes: metals, oxides, nitrides, carbon-based coatings
- Recyclability of coated component due to minor amounts of coating material
- Combined protection against both corrosive and oxidative stress and tribomechanical stress.
- Clean and easily scalable processes

Gas phase permeation measurements

For applications under hydrogen atmospheres, construction materials must be carefully selected. Engineers need reliable and quantitative parameters of hydrogen diffusion for their materials (diffusivity, permeability and solubility) in terms of product development and lifetime predictions. However, only few data is available in the literature. Furthermore, the available data often exhibits large deviations although the same material systems are considered. The reason for this is twofold. First, the materials microstructure usually varies significantly and second, many different measurement methods for the analysis of the diffusion properties are applied.

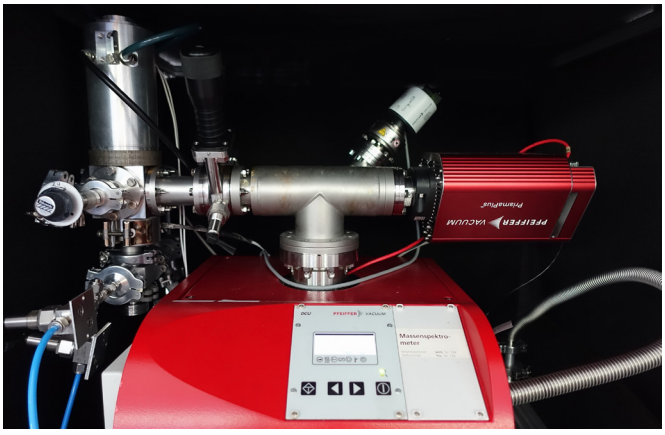

Fig.3: Gas permeation setup for the analysis of hydrogen barrier coatings.

Engineers must therefore redesign the materials and coatings they use in each case. Fraunhofer IWM provides measurement capabilities for hydrogen permeation from the gas phase through membrane materials. Suitable membrane materials include:

- metal sheets
- polymer plates
- elastomer plates

By using a gas permeation test rig, the temperature and pressure level may also be varied and provide valuable information. Oxidation or alterations of the surfaces to be tested can reliably be avoided.

Searching for effective barrier coatings

For many fields of applications like bipolar plates, pressure transmitters, MEMS devices, valves, etc., the deposition of a hydrogen barrier coating is mandatory for a stable operation and increases the component's service life. In addition, by coating a common construction material expensive and rare materials can often be saved.

The permeation reduction factor (PRF) is the determining factor for the effectiveness of a barrier layer. Starting with a PRF>1000 at room temperature, the components can be effectively protected (Fig.4).

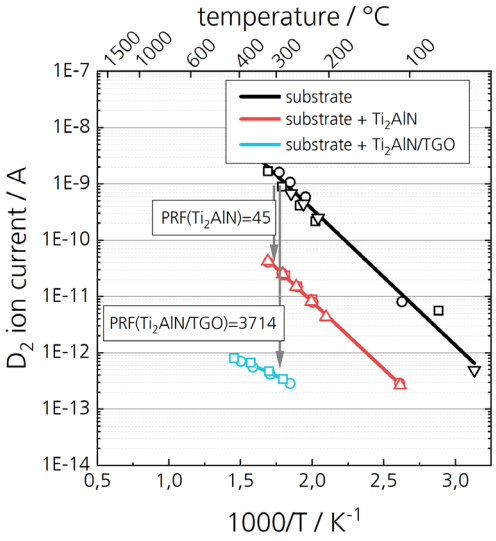

Fig.4: Investigation on the barrier properties of a Ti2AlN coating (red) with thermally grown oxides (TGO, blue) on a steel substrate in comparison to an uncoated steel membrane (black).

The Fraunhofer IWM offers testing possibilities for customer's coating systems and materials with regard to their diffusion properties and barrier effects against hydrogen indiffusion. These tests may also be combined with mechanical and corrosive stresses during the exposure to hydrogen. Micromechanical and microstructural analyses add further insight to the measured diffusion constants.

For further questions please don't hesitate to contact us via the following address.

Contact

Dr. Lukas Gröner
Tribological and functional coatings
Phone: +49 761 5142-488
lukas.groener@iwm.fraunhofer.de

Fraunhofer IWM
Wöhlerstraße 11
79108 Freiburg
www.iwm.fraunhofer.de