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Technology Offer

Method and measuring device for examining the hydrogen permeability of a test object

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Abstract

This invention presents a method and apparatus for investigating the hydrogen permeability of materials, offering a simplified and cost-effective solution to test the tightness of a material. A sensor is placed on one side of the test object, while a hydrogen-containing test gas is applied to the opposite side. The hydrogen permeating through the material interacts with a sensitive sensor layer, causing measurable physical changes such as color shifts. These changes provide real-time, spatially resolved data on hydrogen diffusion. This system supports continuous, non-destructive monitoring and is significantly easier to implement than conventional techniques. Applications include non-destructive monitoring of gas pipelines, vacuum system leak detection, and research into hydrogen embrittlement.

Background

In some industries, ensuring the airtightness of systems is often crucial, particularly when dealing with flammable gases like hydrogen. To address this, methods have been developed to test the tightness of materials using gases such as hydrogen. Conventional techniques involve introducing hydrogen on one side of the material and measuring leakage on the other. These methods typically rely on vacuum systems and electrical sensors, which require complex and expensive setups. Additionally, they are limited to single, non-continuous tests and fail to provide detailed, location-specific information about leaks. There is a clear need for a simpler, more effective approach that allows for continuous monitoring and provides spatially resolved data to pinpoint leak locations in real-time, ensuring material integrity without the drawbacks of the existing methods.

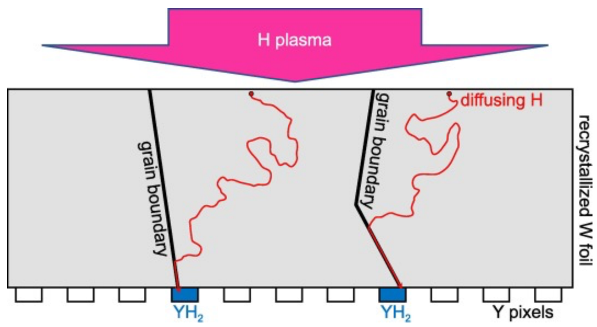

Figure 1: Schematic of the experimental setup used to test material tightness by determining the hydrogen permeability. Yttrium (Y) indicator pixels, used as sensor layer in this case, are deposited on one side of the sample material (a recrystallized tungsten foil). Hydrogen, supplied from the opposite side through plasma or ion beam loading, permeates through the material. The Y pixels, especially those in contact with grain boundaries, react by transforming into YH2, indicating the pathways where hydrogen diffusion occurs. [1]

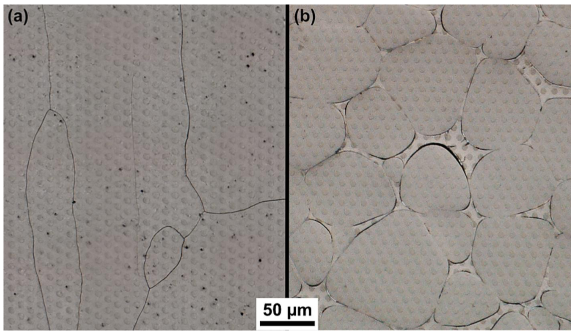

Figure 2: Optical microscope images showing Y indicator pixels deposited on (a) a tungsten sample and (b) a tungsten heavy alloy. In both images, Y pixels that detect hydrogen diffusion are visible. The bright areas in (b) represent the FE-NI matrix within the alloy. Hydrogen diffusion is more pronounced along the grain boundaries, visible as darkened pixels, indicating areas of higher permeability.[1]

Technology

This invention focuses on testing the tightness of materials using a hydrogen-containing gas and an advances sensor system. The sensor, placed on one side of the material, features a hydrogen sensitive layer, for instance made of Yttrium (Y). On the opposite side, the material is exposed to hydrogen, which

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permeates through potential weaknesses. The sensor reacts by undergoing a detectable physical change, such as a color shift from Y to YH2, indicating the presence of hydrogen. Using patterned tiny sensor elements, in the example discontinuous Y pixels, allows for spatially resolved detection of hydrogen permeation across the material. This setup enables real-time, continuous, and non-destructive monitoring if material tightness. Figure 1 shows an example of how the technology is applied. The system effectively identifies areas where hydrogen permeates, as the microscopic images of Y indicator layers deposited on tungsten show (Figure 2). The technology's ability to localize leaks across the surface of material makes it more efficient and cost-effective than traditional methods.

Advantages

- **Simple and Cost-effective:** Simplified design reduces the need for expensive equipment, lowering operational costs.
- **Continuous Measurement:** Enables continuous, real-time monitoring of hydrogen permeability for long-term assessments.
- **Non-destructive Testing:** Suitable for long-term testing a wide range of materials and thicknesses without causing damage.
- **High Spatial Resolution:** Provides precise, localized detection of hydrogen leaks, improving accuracy in identifying potential issues.

Potential applications

- **Non-destructive Monitoring of Gas Pipelines:** Early detection of damage points in pipelines exposed to hydrogen.
- **Leak Detection in Vacuum Systems:** Ensures the airtightness of vacuum systems or other sealed environments by identifying hydrogen leaks.
- **Materials Science Research:** Supports research into the causes and effects of hydrogen embrittlement in various materials.

Patent Information

PCT application (WO2021/224124A1), regionalized and pending in EP and US.
Priority date: 04.05.2020 (DE102020111959A1).

Publications

[1] A. Manhard, et al., Nuc. Mar. Energy, 36 (2023), 101498, https://doi.org/10.1016/j.nme.2023.101498

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