Fraunhofer ISE

Fraunhofer Institute for Solar Energy Systems ISE

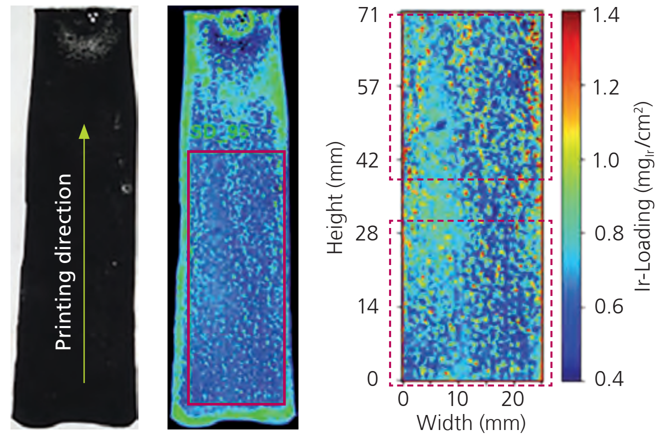
Hydrogen Technology Materials and Components

Ex-situ Analytics

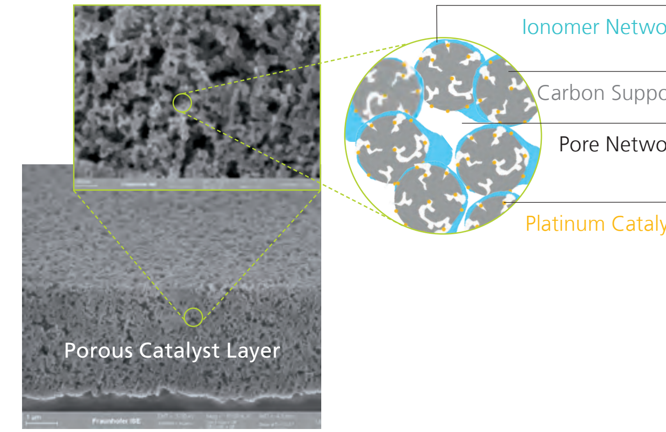
www.ise.fraunhofer.de/hydrogen-technologies

Ex-situ Analytics

Ex-situ analytics provides insights into the microstructure of hydrogen technology materials and components. Properties like pore and particle size, element distribution and concentration in liquids, etc. are measured using high-end analytical equipment without actually operating the components, thus saving time and money.



µXRF Scan of an electrolyzer catalyst layer showing an inhomogeneous iridium loading across the area.



SEM image of a fuel cell catalyst layer.

Our Offer

- micro X-ray fluorescence scanning (µXRF)
- scanning electron microscopy with focused ion beam (FIB-SEM, STEM) and energy dispersive X-ray spectrometry (EDX)
- X-ray photoelectron spectrometry (HT-NAP-XPS)
- mass spectrometry for liquids (ICP-MS) / gases (MS)
- ion (IC) and gas chromatography
- two-phase flow and bubble formation analysis
- H_2 thermography
- interfacial contact resistance (ICR)
- nitrogen physisorption / chemisorption with H_2 or CO
- rheological characterization
- contact angle measurement
- temperature-programmed reduction, oxidation, desorption (TPR, TPO, TPD)
- Karl-Fischer titration
- FTIR (transmission, ATR, DRIFTS)
- magnetic suspension balance

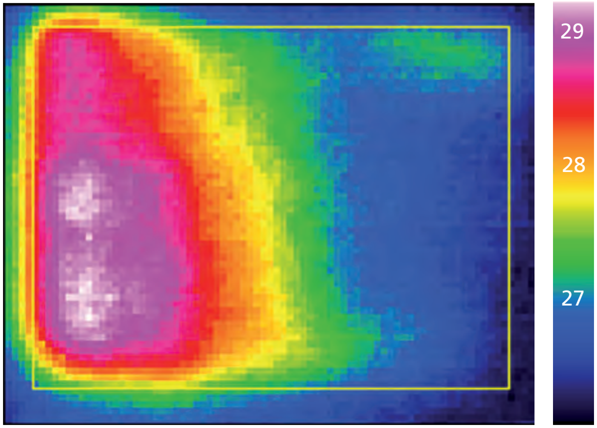
Hydrogen Technology Materials and Components

Our core competence is our understanding of the reactive components in hydrogen (H_2) technologies – whether it is the reactor for synthetic H_2 derivatives or the membrane electrode assembly for electrolysis or fuel cells. We emphasize four perspectives of our research and development.

1 A strong in-situ characterization with state-of-the-art measurement techniques enables the evaluation of component behavior in operation.
2 Our industry-like production processes allow us to design specific component architectures and use selected material compositions.
3 Our modeling provides a physical understanding of components and allows us to evaluate variations in materials and operation mode.
4 The fourth perspective is a strong expertise in ex-situ analytics using modern state-of-the-art equipment. This enables us to obtain meso-, micro- or nanoscopic results from different components and materials used in H_2 technology. For example, we use scanning electron microscopy (SEM) to visualize nano particles used as catalysts in fuel cells and electrolyzers. Mass spectrometry (ICP-MS) is used to analyze trace element or ion concentrations down to parts per trillion (ppt) in liquids like fuel cell product water or cooling liquids. Energy dispersive X-ray (EDX), when combined with SEM, enables the visualization of element distribution at micro and nano scales. Micro X-ray fluorescence (µXRF) can provide large and quantitative macroscopic maps (27 x 24 cm²) of element distributions of catalyst-coated membranes (CCMs) or other layer-like structures.

Our key expertise is the ability to combine the results of our ex-situ analytics with a deep knowledge of in-situ behavior, production requirements and theoretical understanding of the corresponding components or devices.

We are continuously looking for partners in our mission to contribute to a better understanding of H_2 technology components. Our analysis will help producers of H_2 technology components to improve performance and quality. We enable system manufacturers to identify failures or contaminations caused by H_2 technology components.



H_2-thermography image of a fuel cell MEA with a damaged membrane.

For producers of H_2 technology components and for system manufacturers integrating H_2 technology components, we use a broad range of ex-situ analytical equipment, which measures component properties in relation to their performance and degradation behaviour. Examples include:

- platinum or iridium loading maps of catalyst layers using µXRF
- membrane and catalyst layer thickness using SEM
- size distribution of platinum nanoparticles using highly resolved STEM
- tomographic visualization of element distribution in porous layers using FIB-SEM and EDX
- trace element analysis in product water, cooling liquids or exhaust gases using ICP-MS, IC or gas mass spectrometry
- degradation and corrosion analysis of bipolar plates using ICR or corrosion current measurements
- insights into reaction mechanisms and surface degradation using HT-NAP-XPS
- membrane stability towards radicals using fenton testing
- material testing for Direct Air Capture applications using DynaSorb-BT
- analysis of gases, solids and liquids using FITR with different sample presentation devices (e. g. ATR)
- study of reaction mechanisms using DRIFTS

Further Information

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