



Seal-less PEM electrolyzer stack design based on thermoplastic carbon-composite bipolar foils

The image shows a cutaway model of a seal-less PEM electrolyzer stack.

The electrolyzer design of tomorrow

Nowadays, proton exchange membrane (PEM) electrolyzers are costly due to the extensive use of critical and expensive raw materials such as titanium, iridium or platinum. Furthermore, PEM electrolyzer stacks use a large quantity of elastomer gaskets to seal the individual cells within the stack, which leads to high chance of leakage in a PEM electrolyzer stack.

A PEM electrolyzer requires the sealing of bipolar plates, frames and membrane-electrode-assemblies with typically 2–10 gaskets per electrolyzer cell. In a stack assembly with up to several 100 cells, this can result in thousands of individual sealing interfaces needed to ensure hydrogen leak-tightness and safe operation. Failure of a single gasket will lead to rejection of the entire stack and thus drastically increases costs for refurbishment and leak proofing.

Furthermore, titanium is typically the material of choice for the bipolar plate due to its high corrosion resistance and high lifetime. Titanium is considered a critical material and substantially drives the cost of the PEM electrolyzers. In light of these challenges, Fraunhofer UMSICHT has developed a novel, seal-less PEM electrolyzer based on carbon-composite bipolar plates, offering a low-cost alternative as a PEM electrolyzer design of tomorrow.

Industrial sectors

- Energy
- Hydrogen
- Electrolyzer OEM
- Carbon Capture and Utilization (CCU)
- Sustainable Aviation Fuels (SAF)
- Synthesis gas production

Our solution

Ultra-thin (0,1 – 0,8 mm) thermoplastic carbon-composite bipolar foils from Fraunhofer UMSICHT offer a cost-effective and long-lasting alternative for common bipolar plates in PEM electrolyzers.

The carbon-composite bipolar foils have been proven for stable operation in lab scale PEM electrolyzer cells (12.5 cm², figure 1A/B) for more than 500 h under dynamic load in an accelerated stress test (AST) switching between 1 A·cm⁻² and 3 A·cm⁻². The degradation rates after a conditioning phase of 100 h are 16 and 32 μV·h⁻¹, respectively. Commonly degradation rates for PEM electrolyzers using titanium-based bipolar plates are reported in the range from 10–32 μV·h⁻¹. [1]

Due to the thermoplastic properties of the carbon-composite bipolar foil, it can be welded to similar thermoplastic frames and membrane electrode assemblies. This allows for a fully welded stack design (figure 1D), which offers the following advantages:

- Reduction of the number of components in the cell, which in turn reduces the number of stacking processes and thus the assembly effort.
- The joining process eliminates vulnerable sealing surfaces and replaces them with robust weld seams, which contributes significantly to a reduction in production waste.

Our services

With the innovation in carbon-composite bipolar foils and seal-less electrolyzer designs, we offer services in:

- A fully welded stack design without any gaskets for highly automatable production of PEM electrolyzer stacks
- Integration of carbon-based bipolar plates into existing electrolyzer designs, including design considerations for other cell components (e.g., porous transport layers, frames)
- Qualification of carbon-based materials for PEM electrolysis application from cell to stack level

Your benefits

- **Material development and manufacturing technology:** Benefit from our extensive expertise in material development and manufacturing technology for carbon-composite foils.
- **Integration and durability assessment of carbon-based materials into electrolyzers:** All relevant test infrastructure and expertise in the application development for PEM electrolyzers is available in-house, shortening development time.

Further information

<https://s.fhg.de/UpsC>

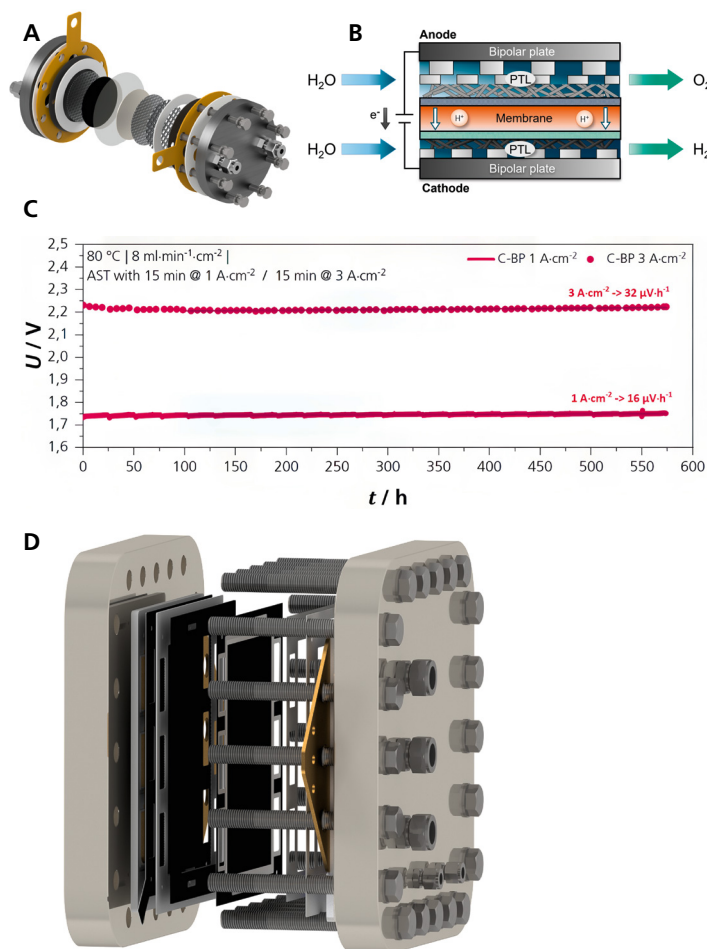


Figure 1: A) Lab-scale test cell and B) schematic cross section of the cell for accelerated stress testing in PEM electrolysis. C) Accelerated stress test of a carbon-composite bipolar plate over 550 h at alternating current density of 1 and 3 A·cm⁻². D) Seal-less PEM electrolyzer design with carbon-composite bipolar plates with 450 cm² single cell active area.

Contact

Prof. Dr. Ulf-Peter Apfel
Electrolysis / Business
development
Phone +49 208 8598-1578
ulf-peter.apfel@
umsicht.fraunhofer.de

Dr.-Ing. Michael Joemann
Bipolar foil
Phone +49 208 8598-1436
michael.joemann@
umsicht.fraunhofer.de

Dr. Kai Junge Puring
Electrolysis / Technical
implementation
Phone +49 208 8598-1529
kai.junge.puring@
umsicht.fraunhofer.de

Fraunhofer Institute for
Environmental, Safety and
Energy Technology UMSICHT
Osterfelder Strasse 3
46047 Oberhausen, Germany
www.umsicht.fraunhofer.de