BMG | H2 Solutions | PEMFC

PEMFC Stack Testing

- Stack testing in a range up to 600 kW
- Cell voltage measurement up to 1000 channels
- Programmable startup- and shutdown procedures
- Automatic leakage test before each test
- Flexible testing procedures
- Power ranges: 5 kW, 10 kW, 30 kW, 100 kW, 150 kW, 200 kW, 250 kW, 600 kW
- Applications: Engineering
- Adaptation: Manual and semi-automatic
- Options: Climate chamber (-40°C to +120°C), hot/cold start, recirculation, back pressure control, high dynamic humidification

Benefits

- Recirculation saves up to 50% of hydrogen during test
- High dynamic change of operation point within 2 seconds

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BMG | H2 Solutions | **PEMFC**
FCPM Assembly (Fuel Cell Power Module)

- Scalable and flexible solution for the assembly of Fuel Cell Power Modules (FCPM) and other systems from sample shop to series production
- Handling of large and heavy products (e.g. fuel cell stacks and other system parts)
- Accurate leakage test of big fuel cell systems
- Key processes: manual assembly with automized processes, screwing, leakage testing, electrical testing, SW flashing, operator guiding system, data traceability
- 650 process steps
- Weight of product: 560 kg
- Dimensions (width x height x depth): 1.2 m x 0.7 m x 1.0 m
- 1500 single parts
- 200 kW electrical power

Benefits

- High ergonomic standards
- Guidance system for operator for each working step
- Intelligent data analysis and quality-controlled optimization of manufacturing & production processes

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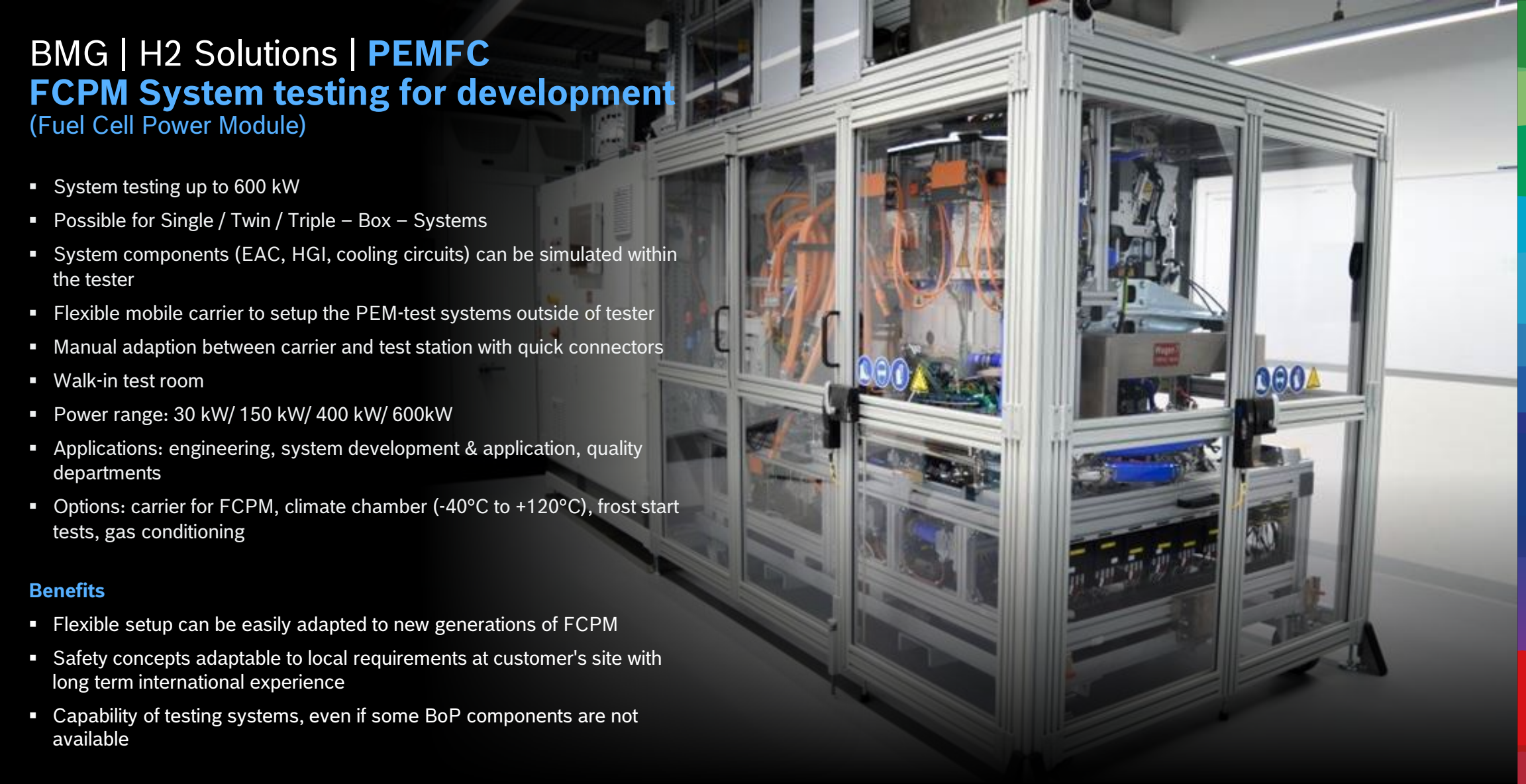
FCPM System testing for development
(Fuel Cell Power Module)



- System testing up to 600 kW
- Possible for Single / Twin / Triple – Box – Systems
- System components (EAC, HGI, cooling circuits) can be simulated within the tester
- Flexible mobile carrier to setup the PEM-test systems outside of tester
- Manual adaption between carrier and test station with quick connectors
- Walk-in test room
- Power range: 30 kW/ 150 kW/ 400 kW/ 600kW
- Applications: engineering, system development & application, quality departments
- Options: carrier for FCPM, climate chamber (-40°C to +120°C), frost start tests, gas conditioning

Benefits

- Flexible setup can be easily adapted to new generations of FCPM
- Safety concepts adaptable to local requirements at customer's site with long term international experience
- Capability of testing systems, even if some BoP components are not available

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BMG | H2 Solutions | **PEMFC**
FCPM Life-time-Container (Fuel Cell Power Module)

Endurance test for fuel cell power module (FCPM)

- Endurance tests for up to 4 x 300kW FCPM under real conditions with hydrogen
- The electrical power up to 1.2 MW produced during the tests can be fed back into the grid
- Each test cell can be entered and run individually

Key Data

H2-consumption (up to)	846 kg/d
DI-water production (up to)	7.6 t/d
Air throughput (up to)	57 t/d
Dimensions	14.5 x 3.2 x 3.1m
Weight	25 to

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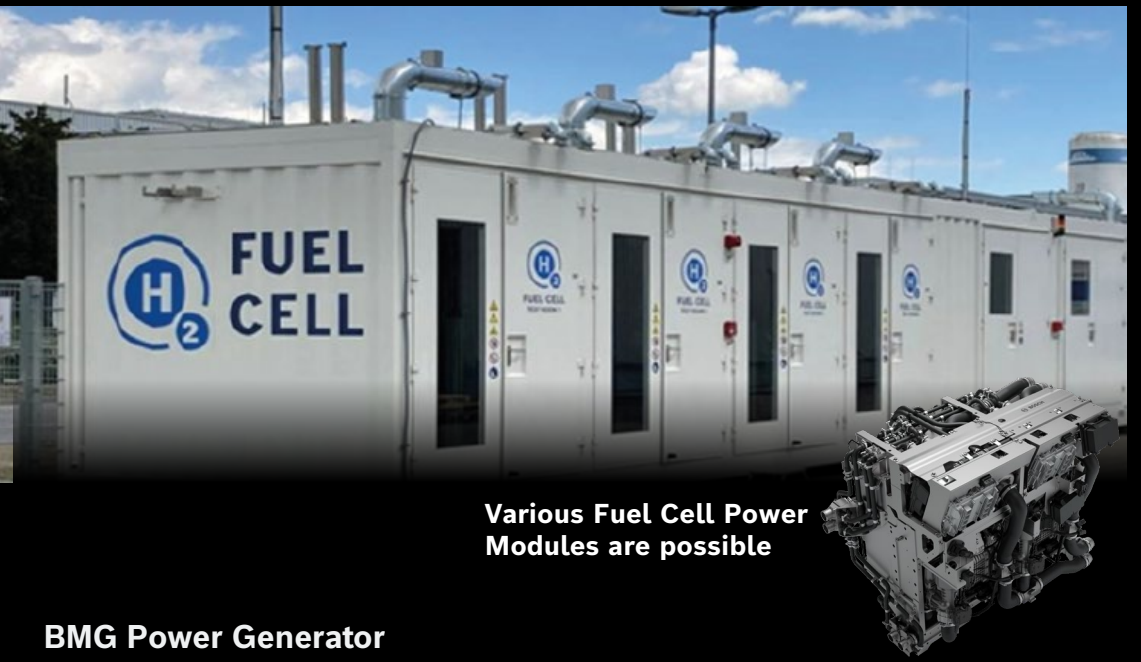
BMG | H2 Solutions | PEMFC
FCPM Power Generator



Various Fuel Cell Power Modules are possible

BMG Power Generator

- Fully automatic, CO2-neutral, unattended & safe electrical energy – whether as an emergency power generator or as a continuous runner
- Customizable for range from 200 kW to 1 MW with approx. 64 kg of hydrogen per hour (extendable to 1.7 MW)

Key parameters	PowerGen 450	PowerGen 1000
Normal power	200 – 450 kW prospective 850 kW 1 – 4 fuel cells	600kW – 1 MW prospective 1,7 MW 5 – 8 fuel cells
Peak efficiency fuel cell	58%	58%
Operating temperature	~ 30 – 45 °C	~ 30 – 45 °C
Max altitude	2000 m	2000 m
Starting temperature	> -30 °C	> -30 °C
Starting time at ambient temperature	< 28 sec	< 28 sec
Startup time at low temperature	< 200 sec	< 200 sec
Nominal hydrogen inlet working pressure	14,5 – 17,5 bara	14,5 – 17,5 bara
Weight	ca. 30 t	ca. 45 t
Size	9 m x 3 m x 3,1 m	14,5 m x 3 m x 3,1 m
Includes components	IPC, DC/AC, transformator	IPC, DC/AC, transformator
Additional attachments	– Cooler: on the roof – Bundle of nitrogen vessels – Bundle of hydrogen vessels – Compressor of pressurized air (tbc)	– Cooler: on the roof – Bundle of nitrogen vessels – Bundle of hydrogen vessels – Compressor of pressurized air (tbc)

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BMG | H2 Solutions | PEMFC
FCPM End of Line System Testing

- System testing up to 600 kW
- Tests with Single/ Twin/ Triple – Box – Systems possible
- Used for test of complete customer system before delivery
- Quick connection system to minimize cycle time
- Mobile carrier to setup and pretest the FCPM in other stations prior to connect to tester
- Automated quick connection system for all interfaces between carrier and tester to minimize cycle time
- Flexible testing procedures to assure test of specified FCPM key parameters
- Power range: 150 kW – 600 kW
- Applications: Manufacturing, End of line testing of FCPM systems
- Adaptation: Automated quick connection system for all interfaces
- Options: Carrier, moving system for carrier, calibration equipment, integration or simulation of DC/DC-converters in tester

Benefits

- Flexible setup can be easily adapted to new generations of FCPM
- Load point profiles can be created based on end user's requirements
- Multi coupling system with leakage free connections for all media connects FCPM within 5 minutes
- Safety concepts adaptable to local requirements at customer's site with long term international experience

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BMG | H2 Solutions | PEMFC
FCPM Leakage Testing

- Enhanced leakage testing with the appropriate technology depending on your requirement: pressure drop, massflow, helium-in-air or hydrogen testing
- Ready to test and scalable / expandable solution
- Seamless transferability from development to serial production for leak testing solutions
- Smallest leak rates: 1E-6 mbar*l/s
- Leakage detection example: 1 µm defect/leak
- Testing chamber: up to 10.000 liters
- Testing specimens up to 2 m³

Benefits

- Process optimization through preliminary experiments with cycle time reduction up to 35%
- A configurable standardized software for all applications, providing flexibility and ease of use across diverse operational needs
- Evacuation of the chamber is not necessary leading to reduction of costs by 10%
- Unique optimized He-in-Air technology which enables the detection of smallest leak rates of huge components

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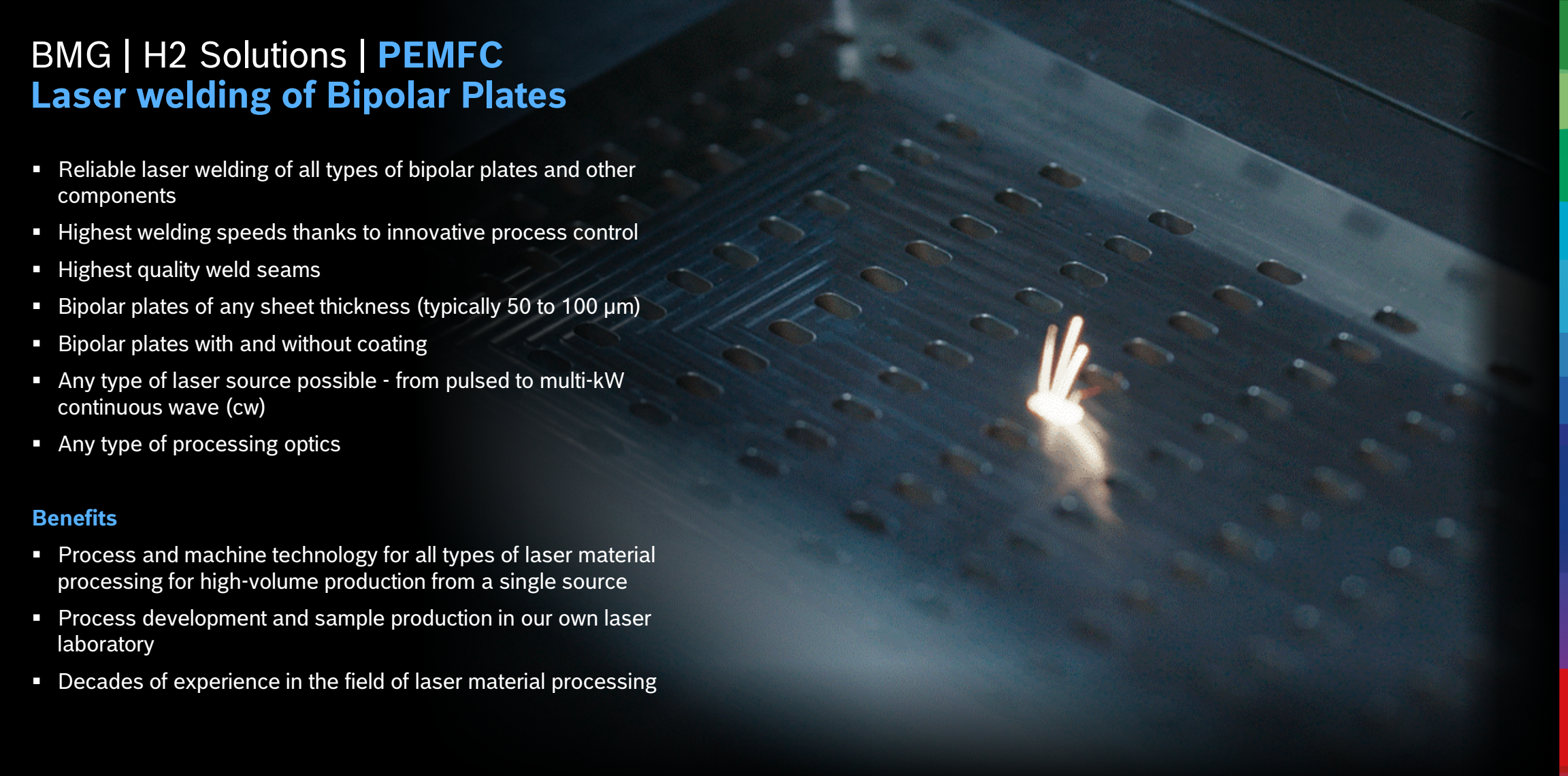
BMG | H2 Solutions | PEMFC
Laser welding of Bipolar Plates



- Reliable laser welding of all types of bipolar plates and other components
- Highest welding speeds thanks to innovative process control
- Highest quality weld seams
- Bipolar plates of any sheet thickness (typically 50 to 100 µm)
- Bipolar plates with and without coating
- Any type of laser source possible - from pulsed to multi-kW continuous wave (cw)
- Any type of processing optics

Benefits

- Process and machine technology for all types of laser material processing for high-volume production from a single source
- Process development and sample production in our own laser laboratory
- Decades of experience in the field of laser material processing

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BMG | H2 Solutions | PEMFC
Optical Inspection for Bipolar Plates

- High quality optical inspection machines and solutions for all kinds of fuel cell stack components and other parts
- Closed process control-loop of image processing to maintain process tolerances
- Powerful software framework for processing of large amount of data in short cycle time
- Variety of handling processes from pick-and-place to roll-to-roll
- Wide variety of proven high speed 2D and 3D image acquisition sensor systems
- Lateral resolutions down to few µm
- Hight measurements with µm precision in-line
- Short cycle times of seconds

Benefits

- Highspeed, high resolution sensor systems to guarantee short cycle time, maximum cost-effectiveness and best inspection quality
- Highly capable measurement systems according to quality guidelines
- 30 years of experience in close integration of machine vision systems for inspection and process guiding into handling technology
- Full-equipped machine vision lab for development of innovative applications

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BMG | H2 Solutions | PEMFC
Hydrogen Permeation Testing

- Hydrogen permeation measurement in a gas atmosphere
- Two vacuum chambers separated by a sample membrane
- Deuterium used as hydrogen carrier and permeation gas
- Mass spectrometer for precise gas analysis
- Test temperature capability up to 250°C
- Sample geometry:
  - Circular blank
  - Diameter: 33mm
  - Thickness: 0,5mm

Benefits

- Minimized floor space required
- In-house testing system and expertise for rapid job measurements & accelerated time to market
- Easy integration into common lab environments with no special requirements needed
- Increased test temperature allows for accelerated measurements in less than 3 hours (depending on sample) → Suitable for materials with lower permeability, e.g. metals
- No corrosion effects that can influence the results

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