FREUDENBERG
PERFORMANCE MATERIALS

Relevance of long term stability and accelerated testing for fuel cell industry

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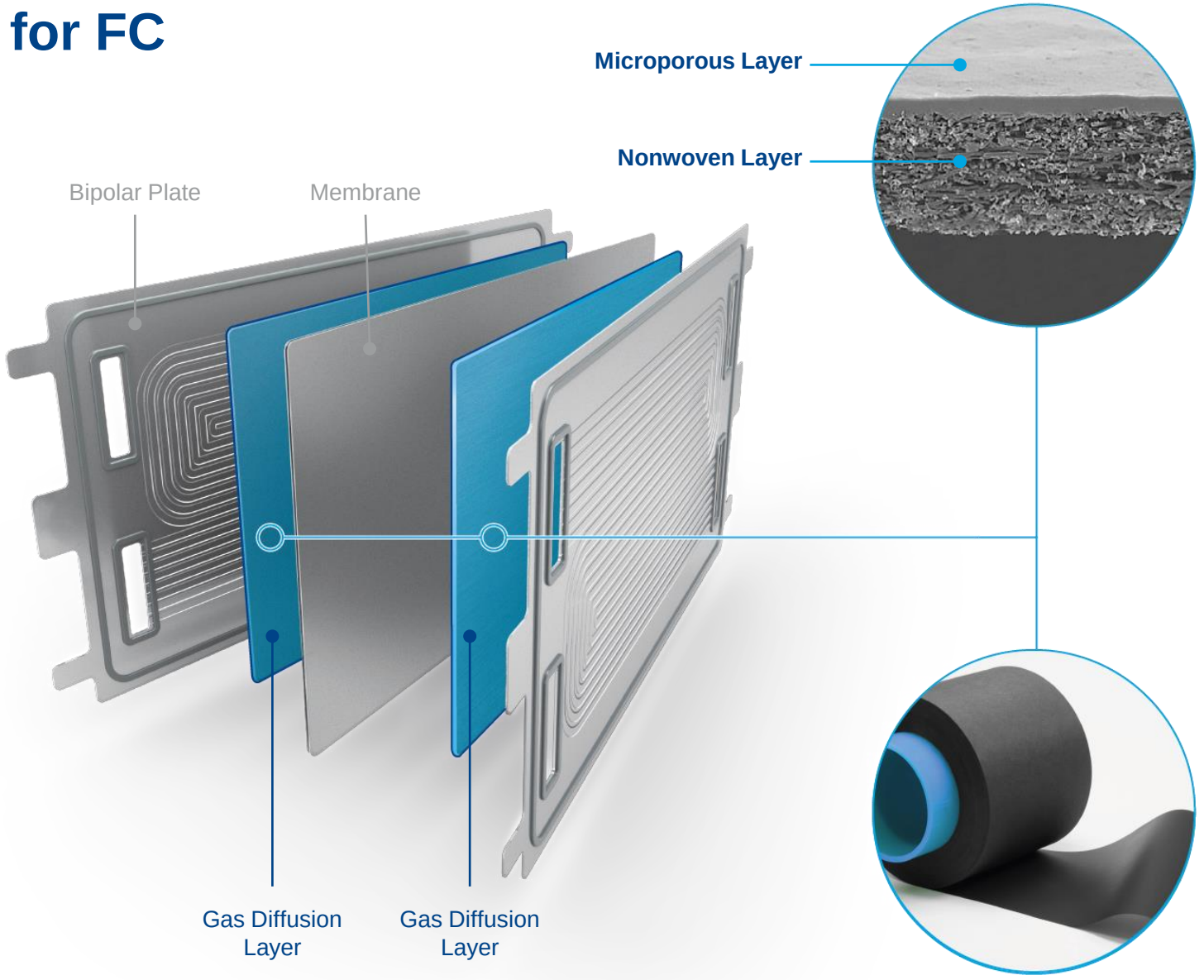
INNOVATING TOGETHER

FPM´s Gas Diffusion Layer for FC

Innovative New Mobility Material

- Perfect management of reaction media optimized for all operation modes
- Exceptional functional flexibility
- Excellent quality standards
- High thermal and electric conductivity
- Superior processing properties
- Full control of process chain allows optimum product characteristics, high and consistent material quality

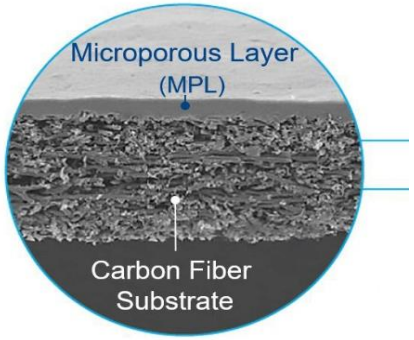


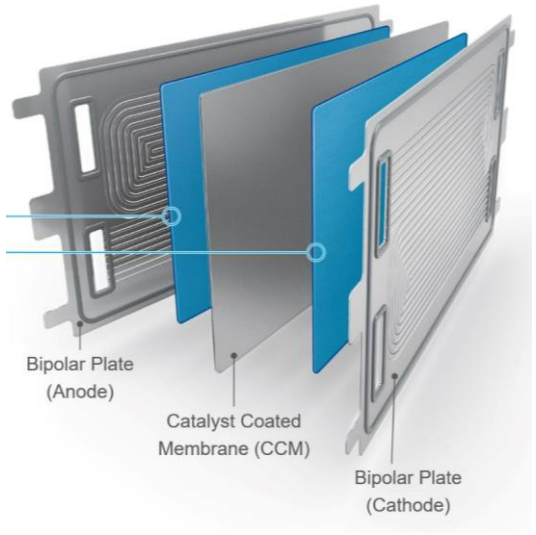
FPM's Role in the Value Chain

FPM
FPM's Customer

Component | **MEA** | **Stack / System** | **End-Use**

Gas Diffusion Layer (GDL)
(Cross Section)

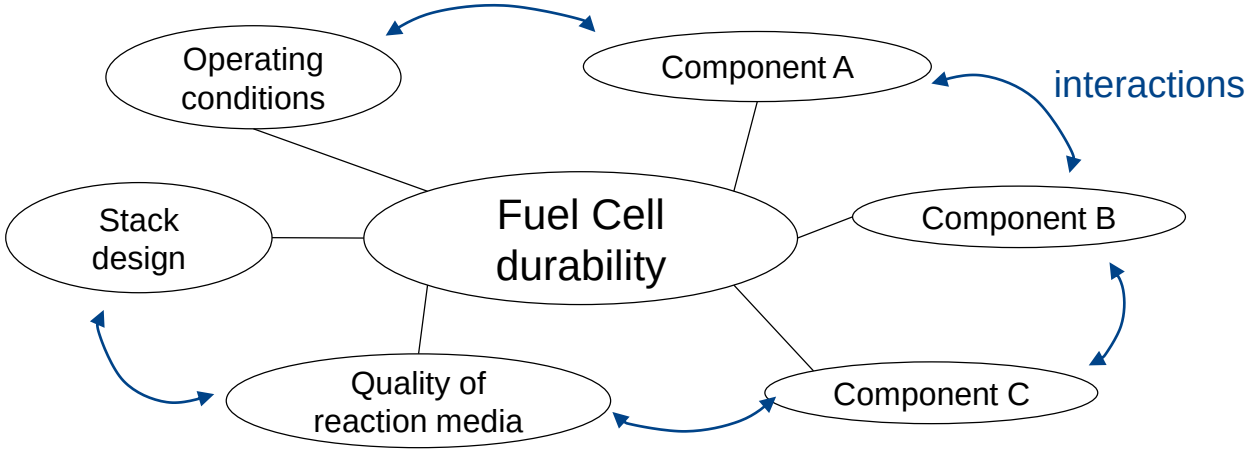




Fuel cell target applications require long lasting designs

- New application areas bring increased lifetime goals for fuel cell systems:
  - ~6.000 h (e.g. passenger cars, 2015)
  - ~20.000-30.000 h (e.g. heavy duty, trucks, bus, boat, 2021)

- Durability of Fuel Cell system is affected by multiple parameters



- Knowledge of detailed degradation mechanisms is required
  - To design highly durable components
  - To design highly durable stacks and to select non-stressing operating conditions

Accelerated testing required for lifetime validation

- Optimization of Fuel cell characteristics is related to re-designing the stack and operating conditions to obtain
  - Improved performance → BOL-tests required (well known)
  - Improved long term stability → durability tests required (to be established)

→ Sensible test procedures are required to facilitate an estimation of lifetime

- Duration of development phase for new FC programs: ~1 - ~3 years (= 9.000 – 30.000 h)
  - Acceleration of durability tests required to assess development approach and assess progress

→ Accelerated testing is important to facilitate quick assessment of durability

Summary

- New areas of application require highly durable stacks

- Detailed understanding of degradation mechanisms required to design long lasting systems
  - Derive stressing conditions that promote degradation
  - Design components and select conditions that allow long lifetime

- Accelerated testing required to preview durability
  - Testing required, sensitive for stressing conditions
  - Prove ahead of time that high durability will be reached

Thank you.