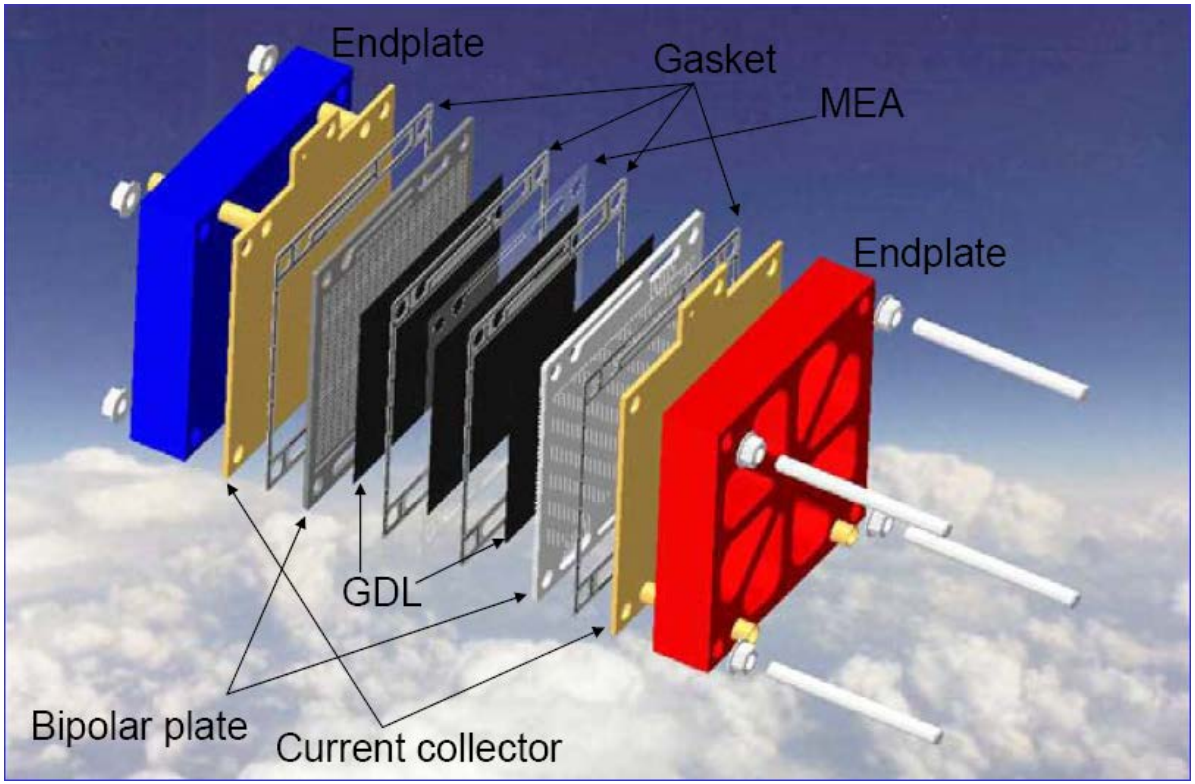
# Материалы и конструкционные особенности ТЭ




Основные компотетны МЭБ:

Мембрана, электролит, катализатор

Но, ничего не будет работать без:

Графитовая бумага, ткань

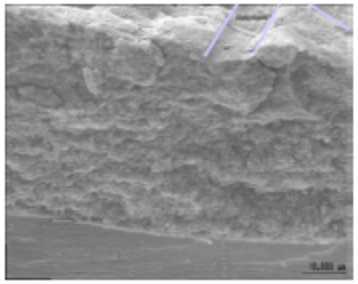
Титан, стеклографит, сталь (нержавейка)

Герметики, клеи, прокладки

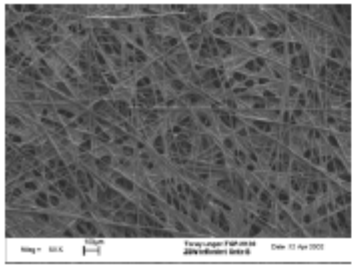
Кроме того, очень важно:

Система подвода газов и хладогена

# Различные масштабы

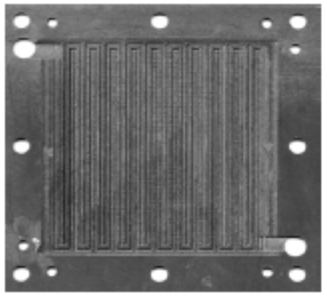


nm Skala



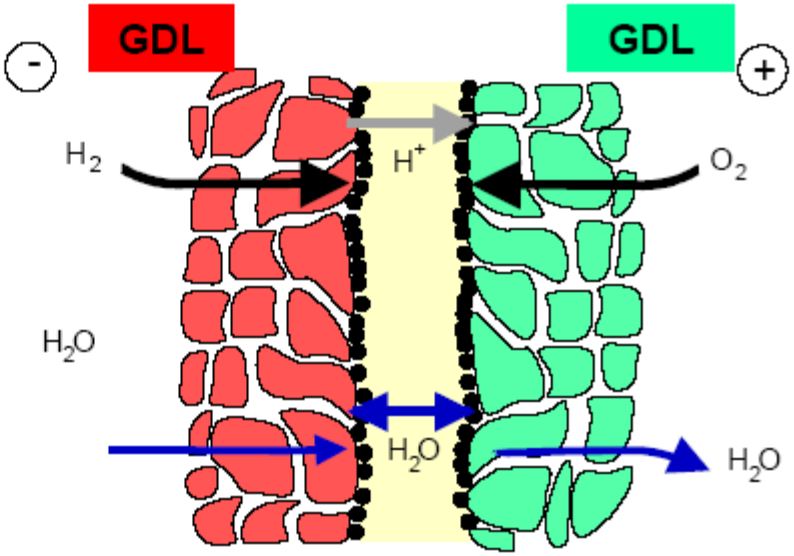
μm Skala

100 mm



mm Skala

## Transport processes in a PEMFC

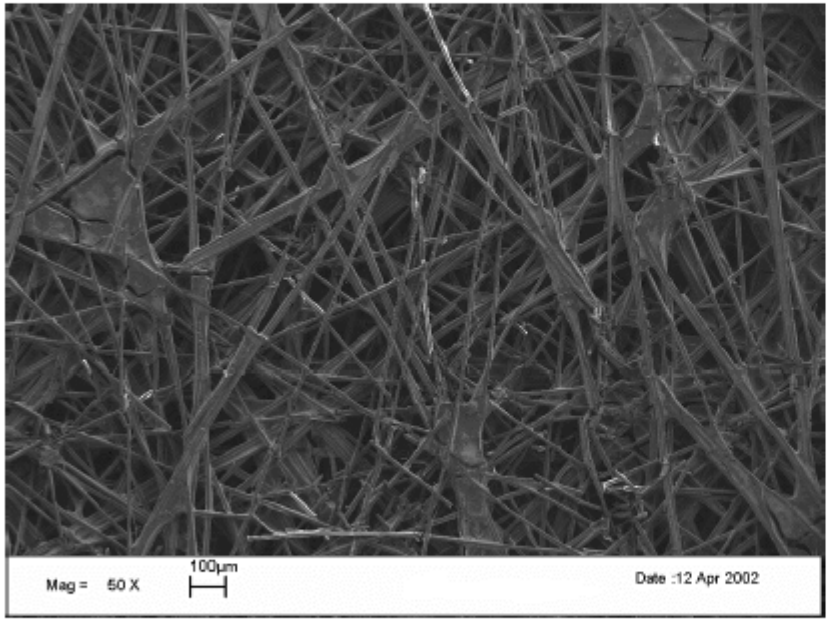


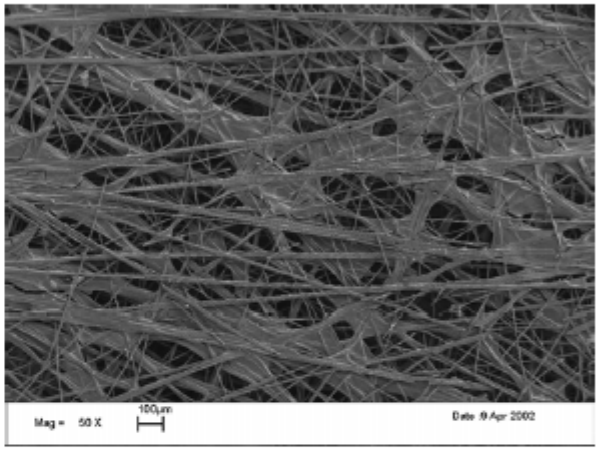

**membrane**

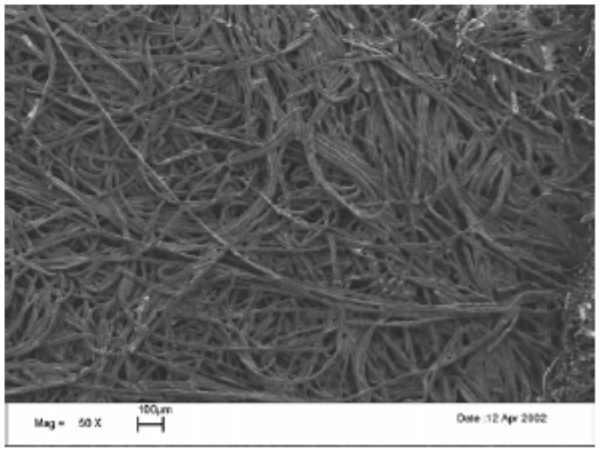
| | |
|---|---|
| Anode | $H_2 \rightarrow 2\ H^+ + 2\ e^-$ |
| Kathode | $2\ H^+ + 2\ e^- + 1/2\ O_2 \rightarrow H_2O$ |
| Gesamt | $H_2 + 1/2\ O_2 \rightarrow H_2O$ |

# Газодиффузионные слои (ГДС)

Gasdiffusion layers from different sources



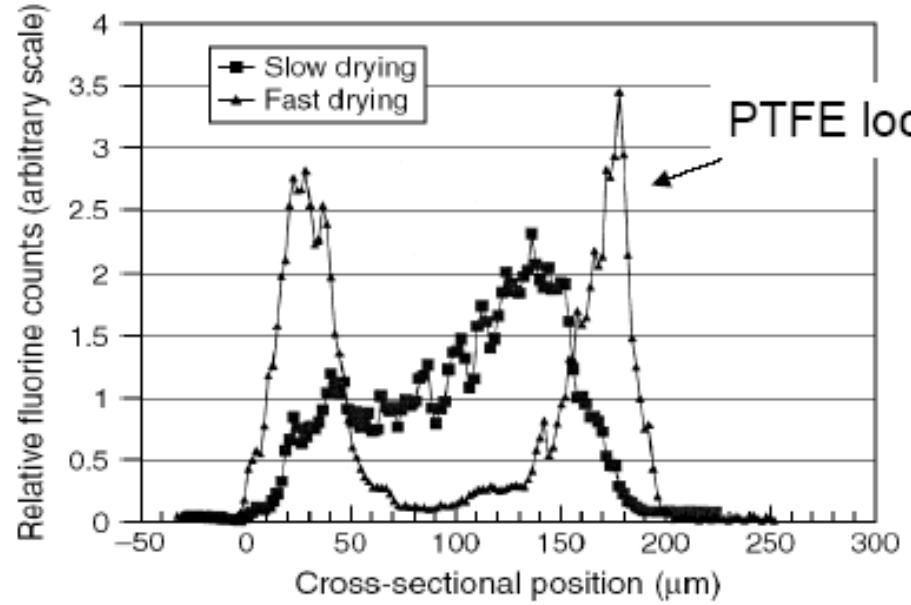



# Газодиффузионные слои (ГДС)

## PTFE distribution (REM, EDX)

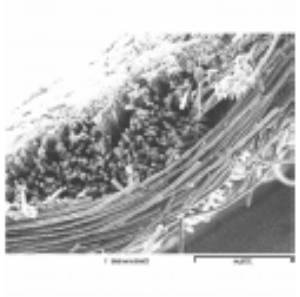
Scanning Electron Microscopy and Energy Dispersive X-Ray Microanalysis

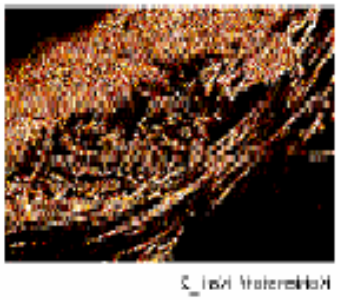


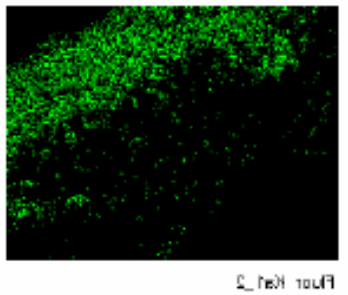

PTFE located near the surface

Mathias, Roth, Fleming, Lehnert, handbook of fuel cells ,2003

- PTFE distribution depends on process conditions

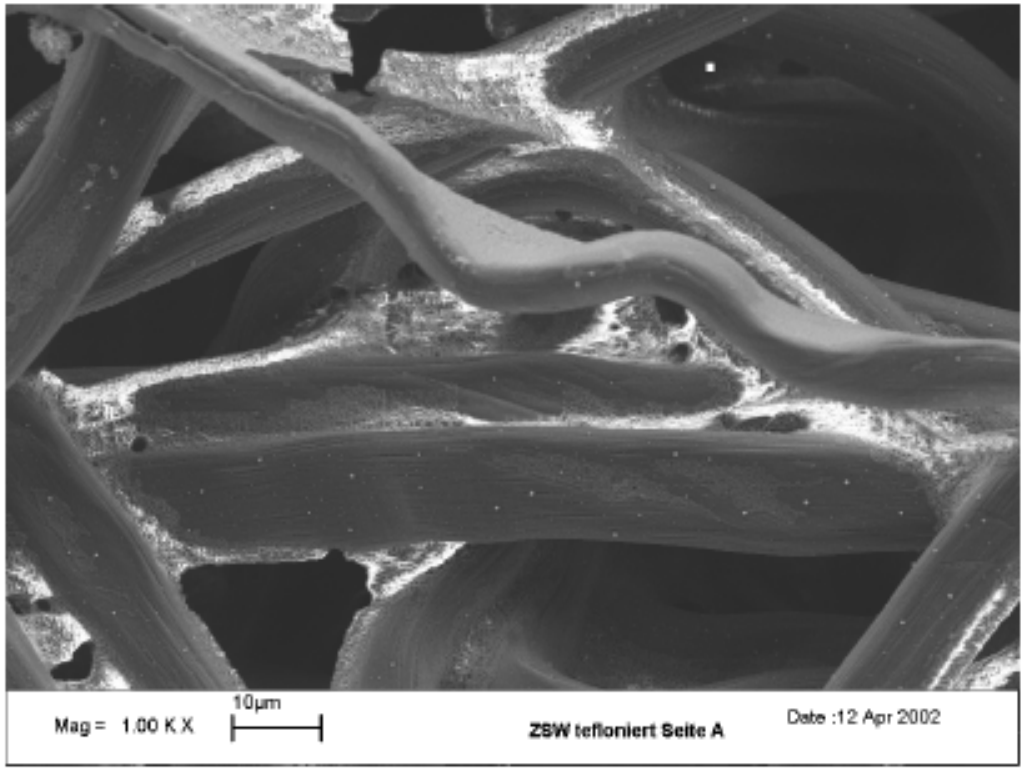




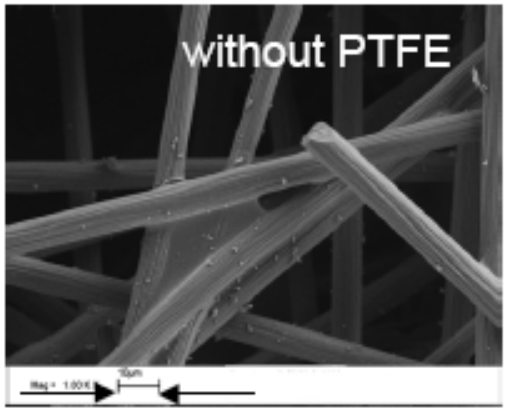


# Газодиффузионные слои (ГДС)

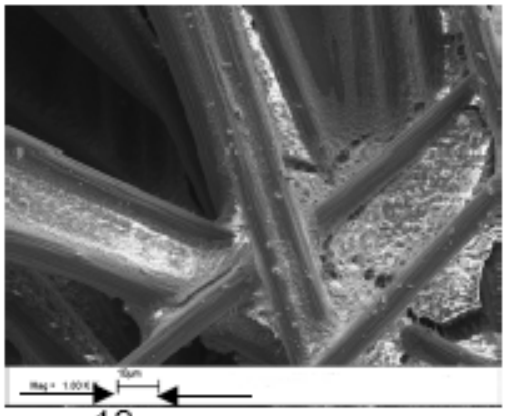
Influence of PTFE on structure




with PTFE

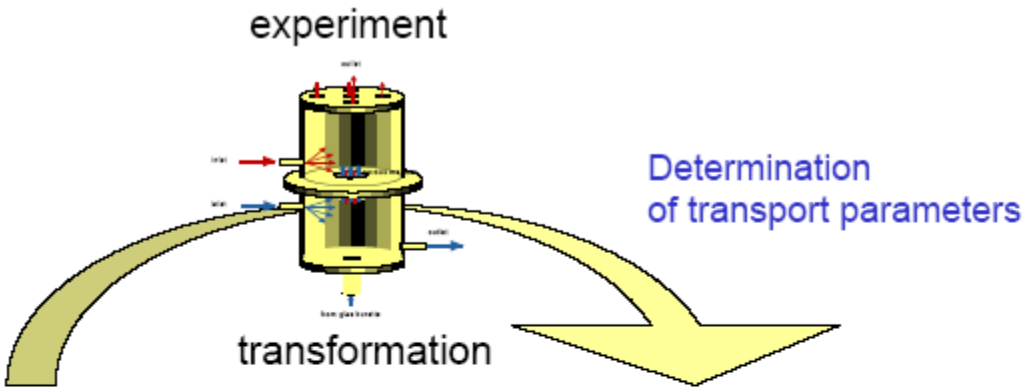


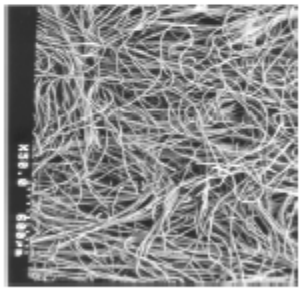

10 µm



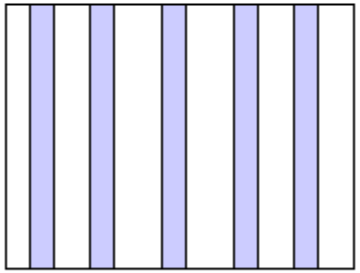
10 µm

# Газодиффузионные слои (ГДС)



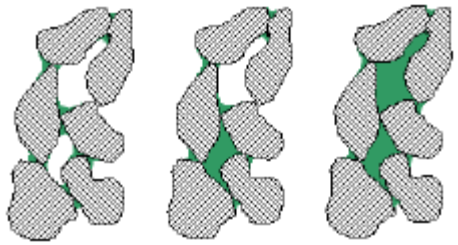



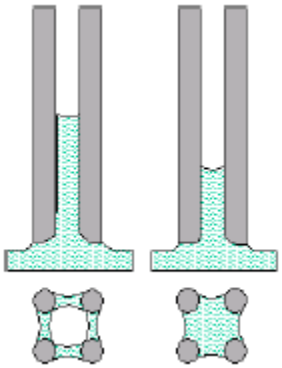
real structure



idealized structure

$\Psi$, $\langle r \rangle$, $\langle r^2 \rangle$



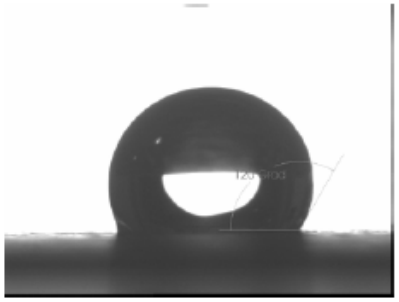


# Газодиффузионные слои (ГДС)

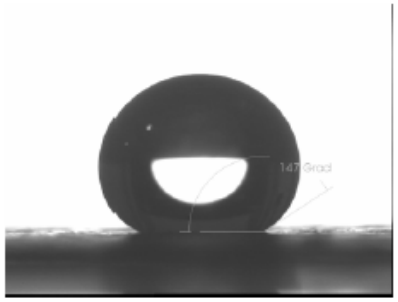
contact angle of water on GDLs

TGP-H-120



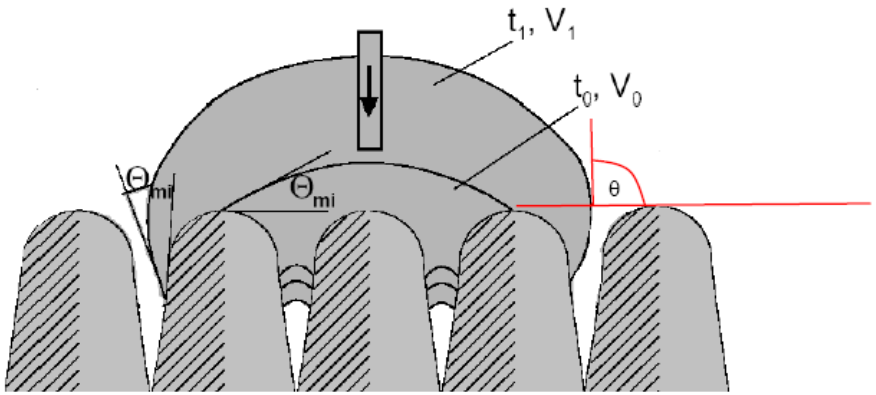


without PTFE

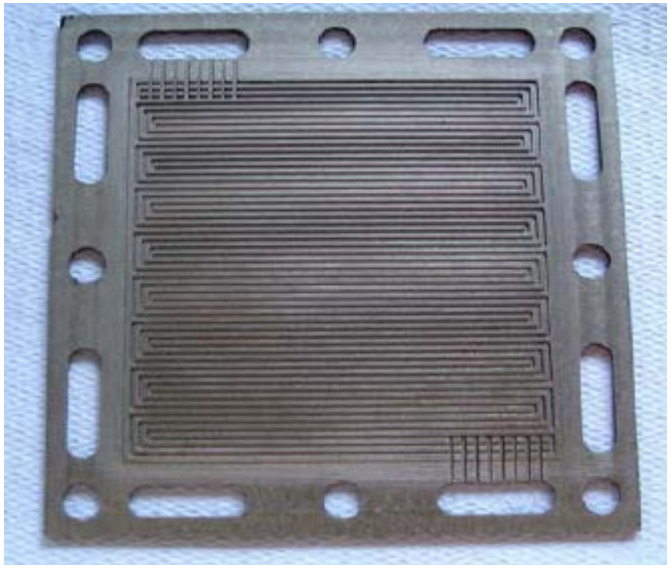


with PTFE

influence of surface roughness on contact angle

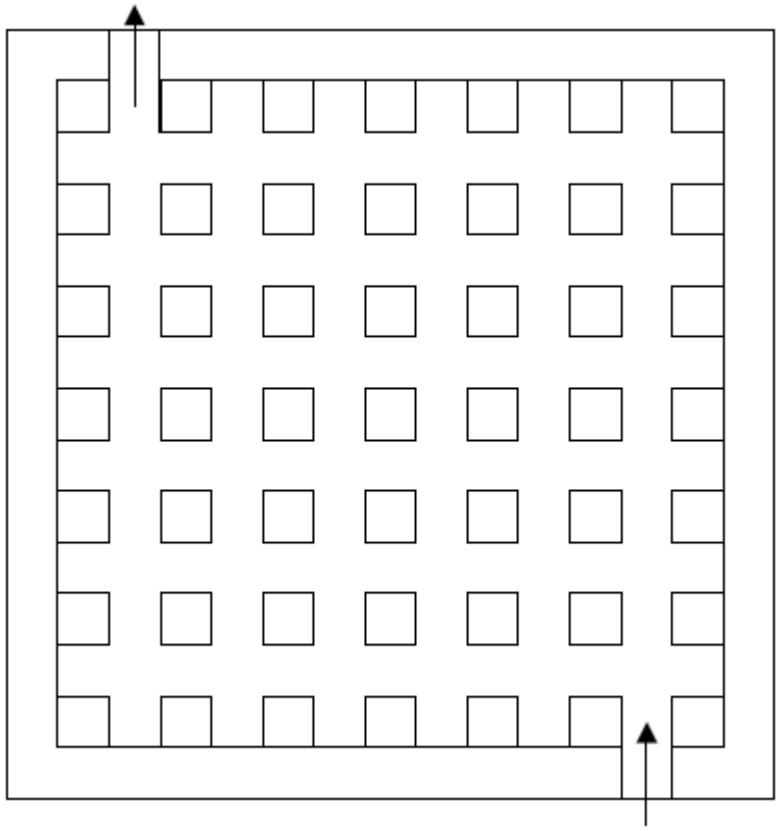


# Биполярные пластины



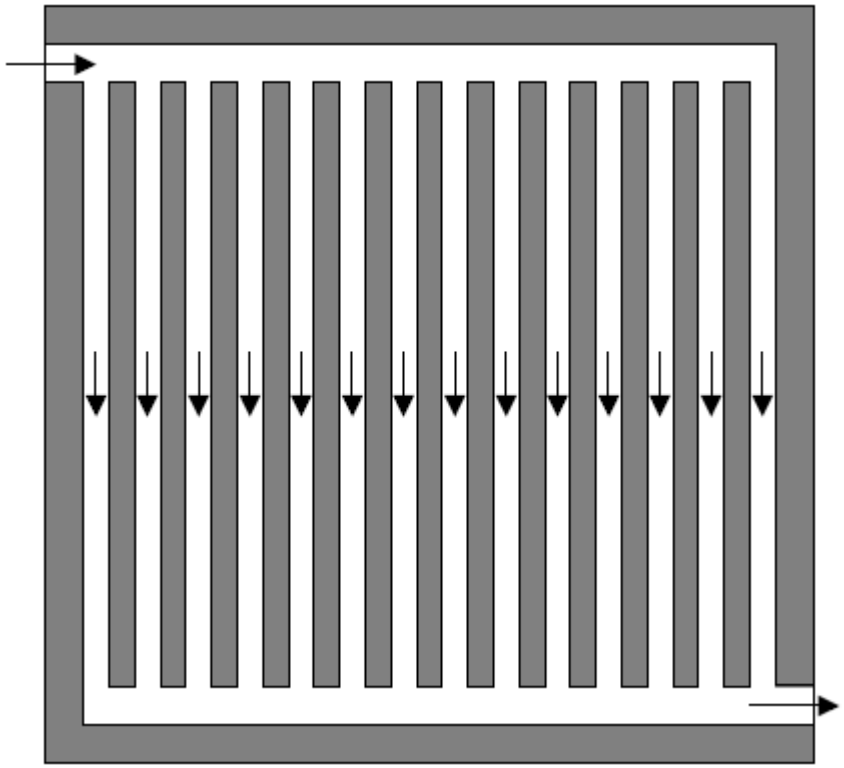
# Биполярные пластины

## Pin-Type Flow Fields



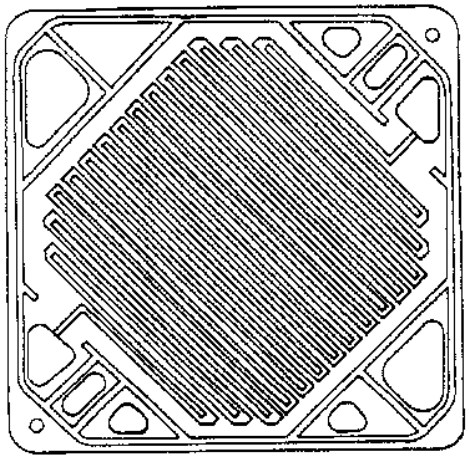
# Биполярные пластины

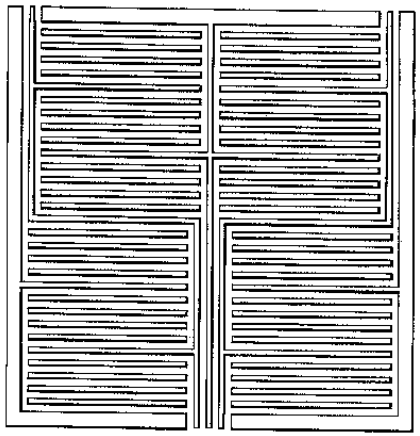
## Parallel Design

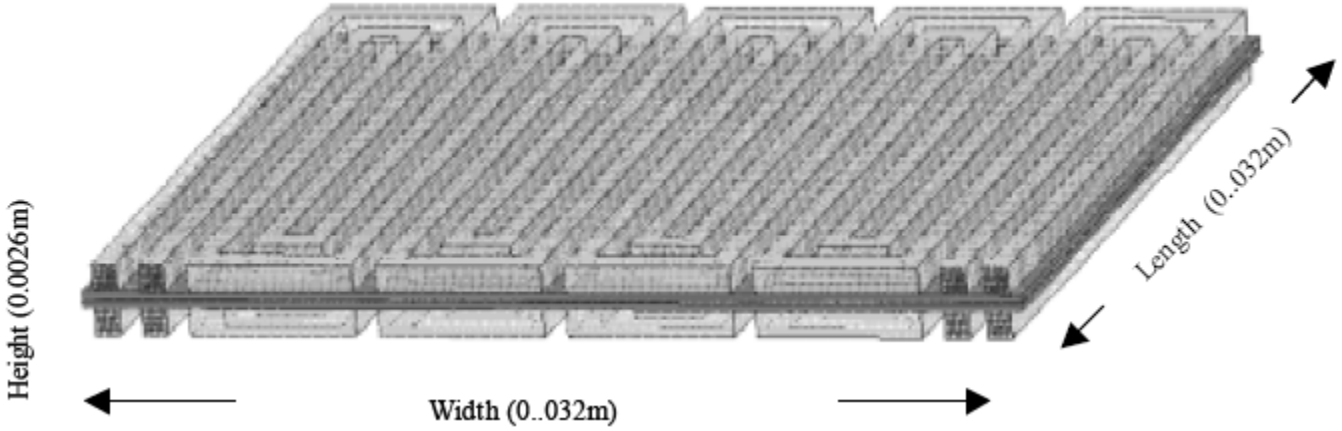


# Биполярные пластины

Различные варианты геометрии:

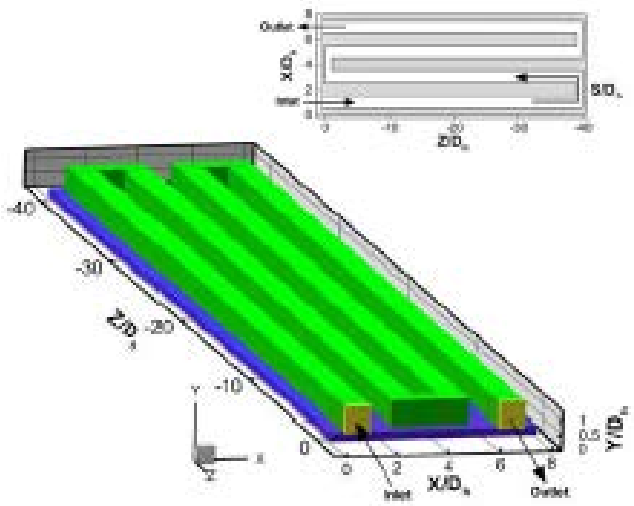


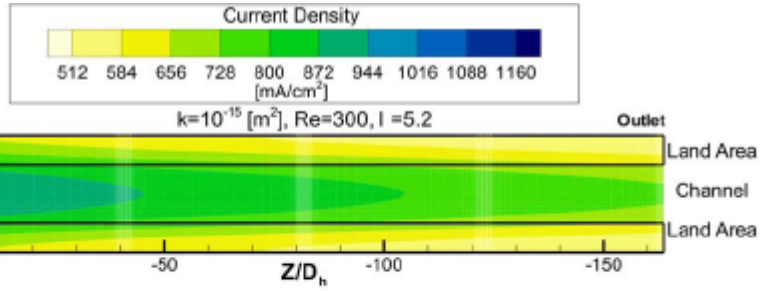


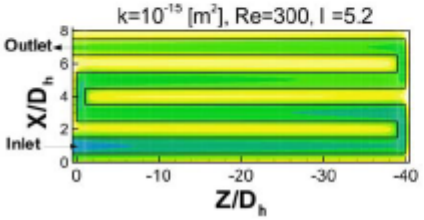


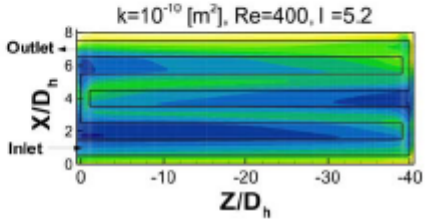
# Биполярные пластины

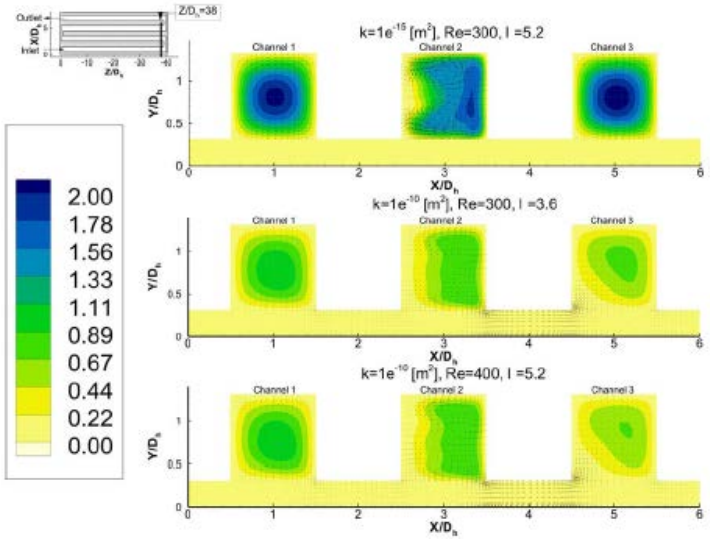
## Расчет оптимальной геометрии:

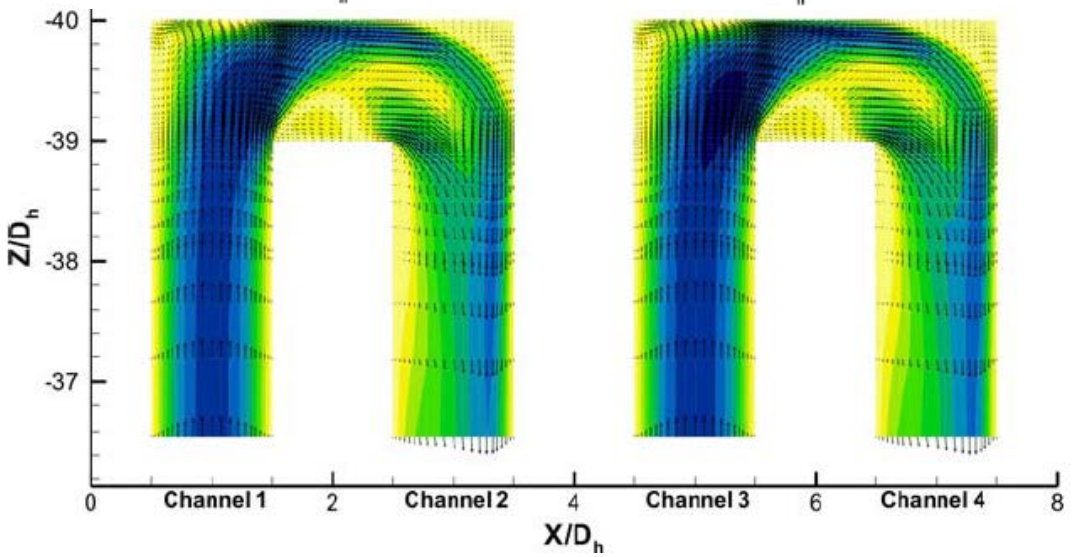


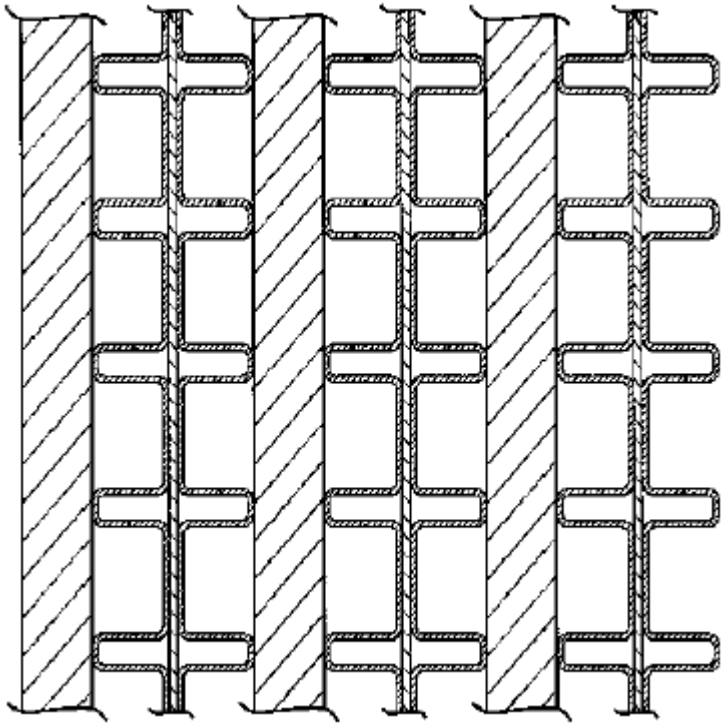



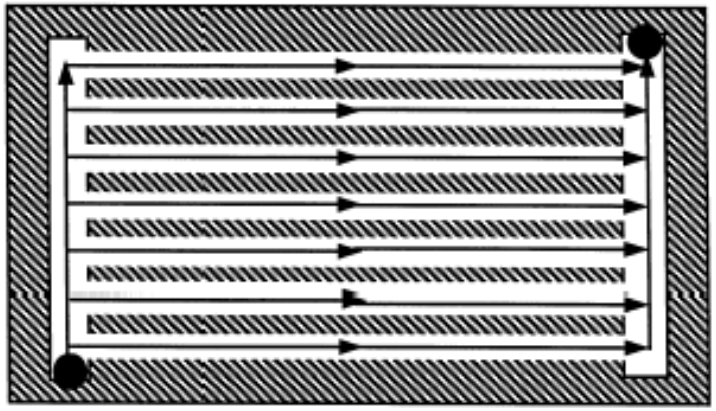
# Биполярные пластины

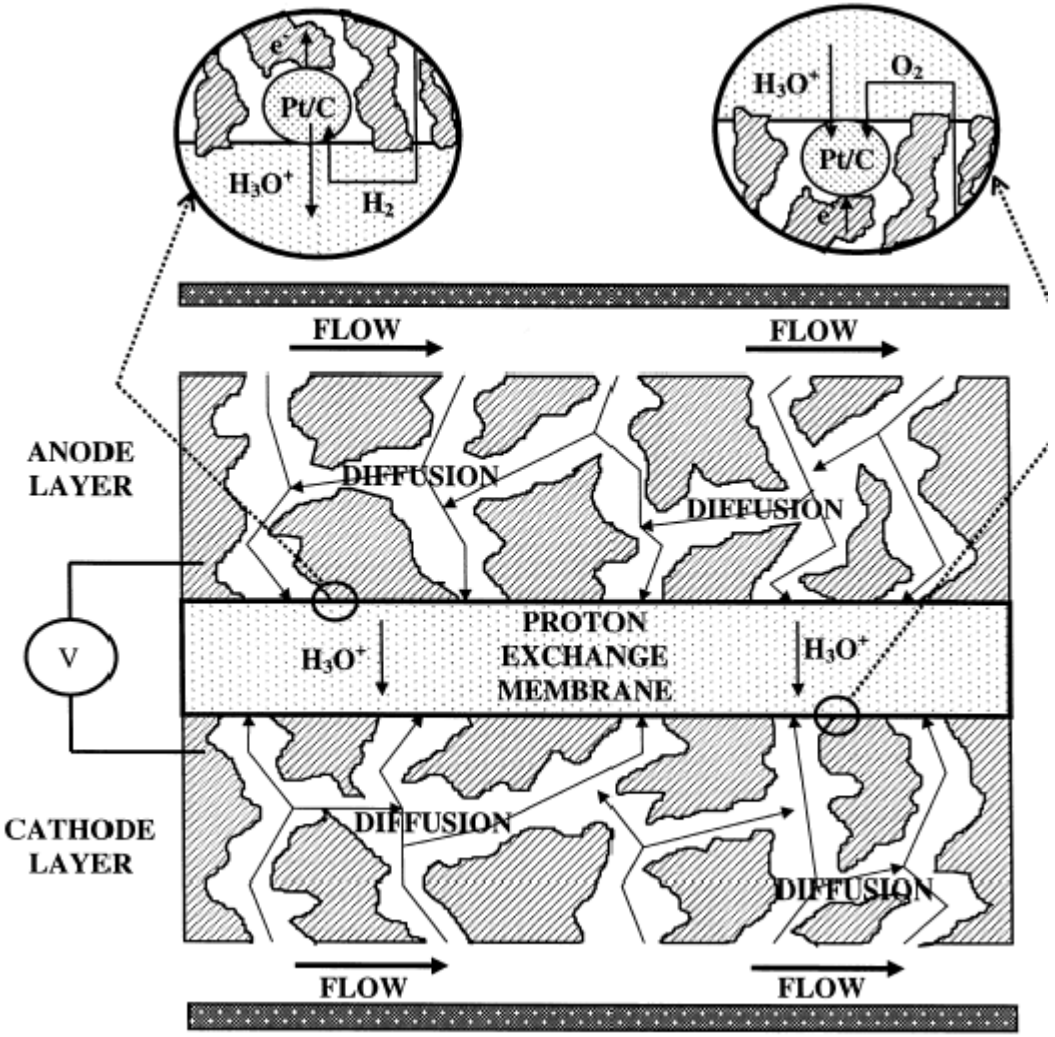
Из гофрированной листовой стали (в основном SOFC)



# Биполярные пластины

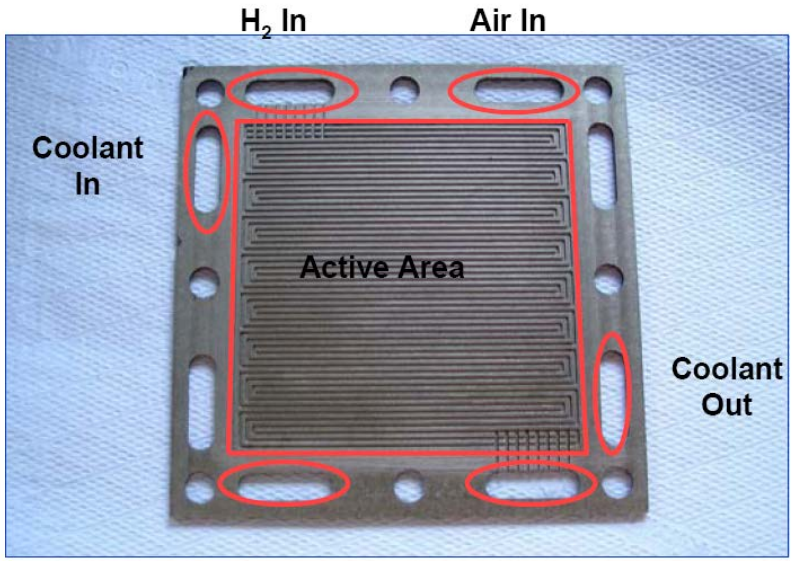
**Conventional Flow Field Design**





# Герметики и прокладки

Для функционирования одного МЭБ в составе ТЭ необходимо загерметизировать 21 соединение.

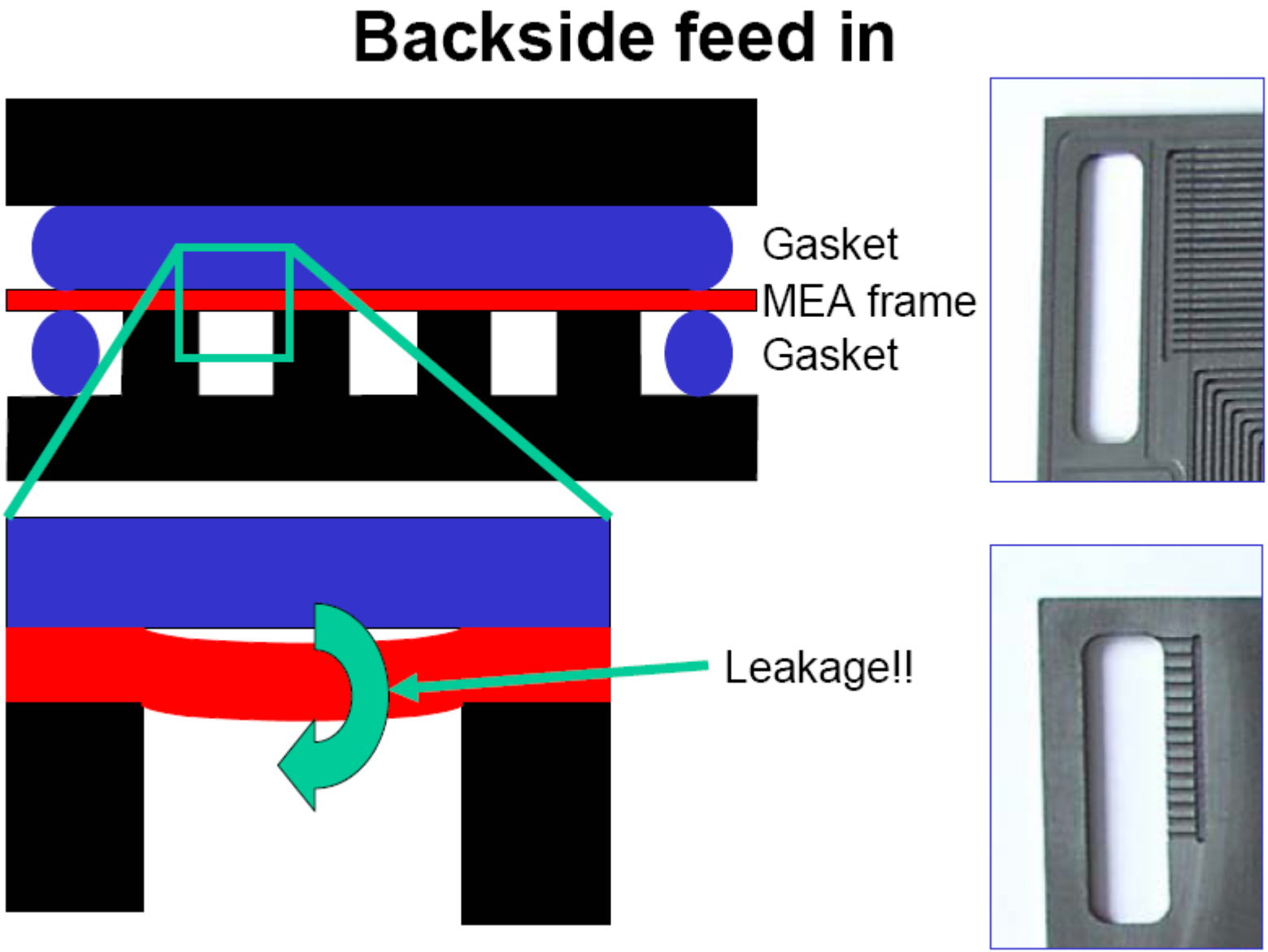



Total: 7 Different Sectors

## Classification of Gaskets

| | Rigid | Elastic | Plastic |
|---|---|---|---|
| Flat | Cylinder-Head gasket | Flat gasket | Graphite foil |
| shaped | Crimped metal | Formed elastomer | Sealing tape |
| adhesive | 2K Epoxy resin | Silicone | Sealing compound |

# Герметики и прокладки

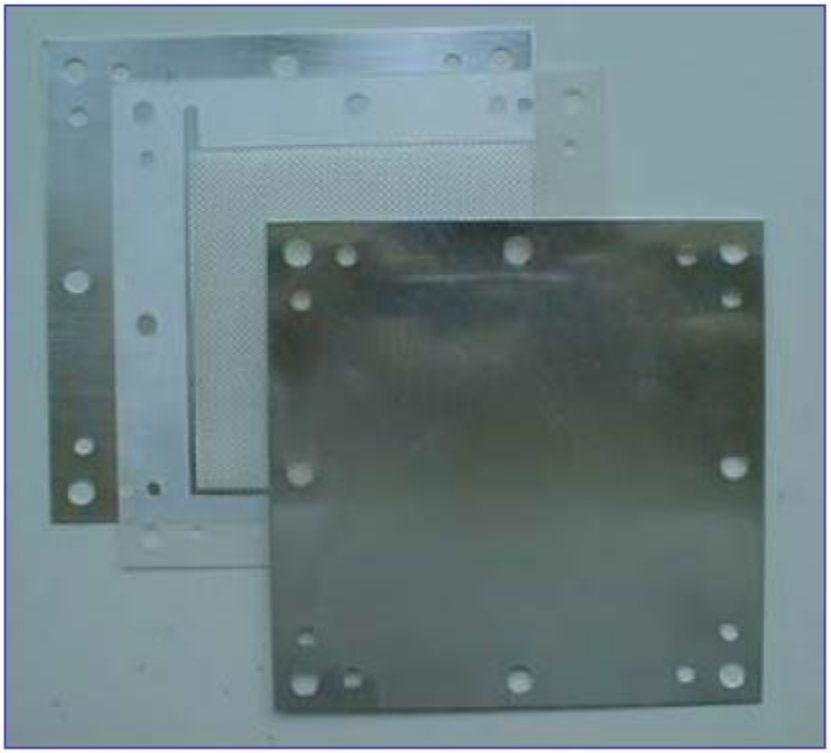


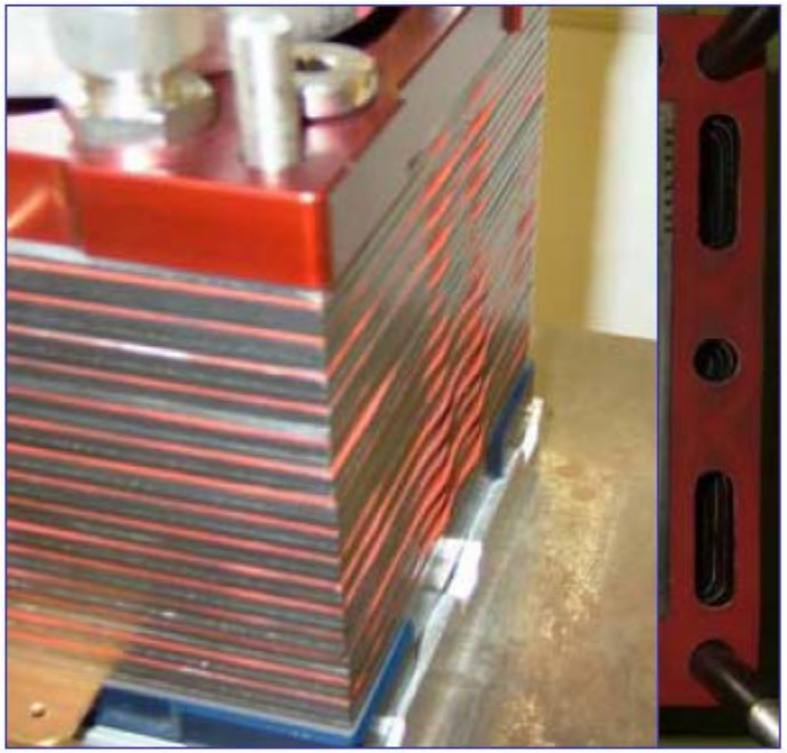
# Герметики и прокладки

## Flat gasket

+ Easy to produce

- Very high load on gasket
- Danger of bipolar plate fracture
- Unreliable sealing



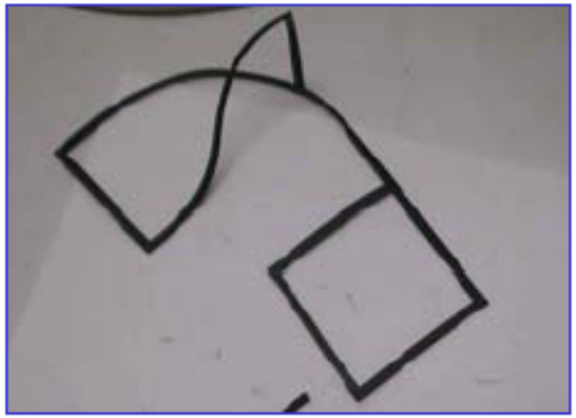


# Герметики и прокладки

## Loose gasket

+ Reliable sealing
+ High tolerance region
+ Practical for small quantities

- Difficult to handle
- High notch stress in bipolar plate





# Герметики и прокладки

## Screen printed gasket

+ Good handling
+ Bipolar plate + gasket
  is one component
+ Practical for higher quantities

- Small tolerance region

Usual screen print thickness:
250µm
Max. compression:
60µm (≈25%)
GDL Tolerance Range
Up to ± 50µm



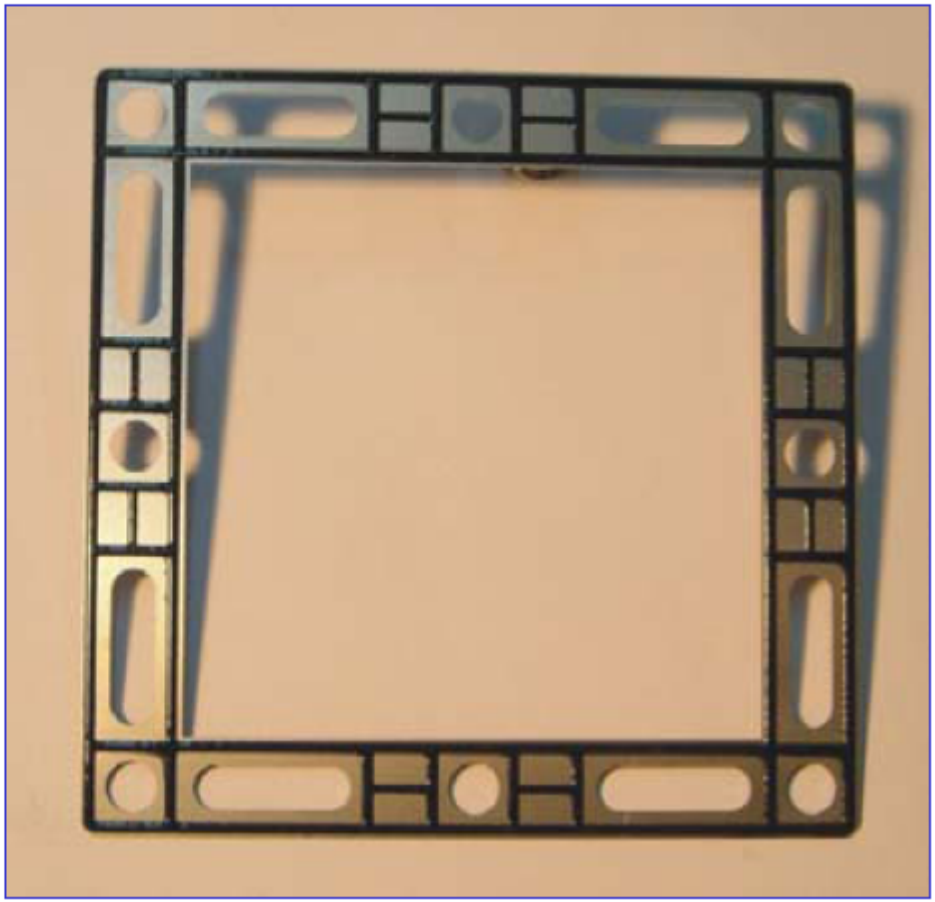
# Герметики и прокладки

## Carrier gasket

+ Good handling
+ Practical for higher quantities
+ Better tolerance region

- Extra weight/parts
- Expensive

Screen print version
Max. compression:
2x60µm



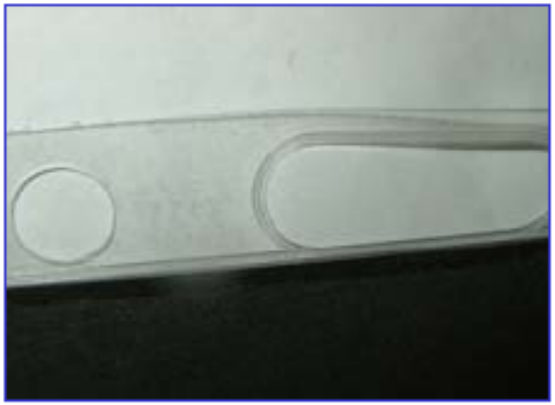
# Герметики и прокладки

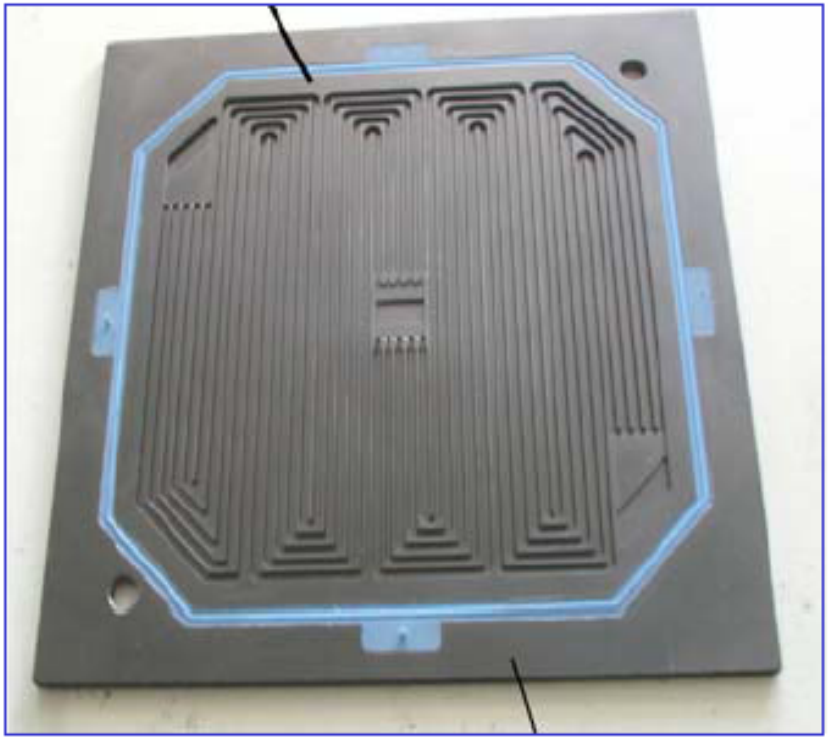
## Integrated gasket

+ Good handling
+ Practical for higher quantities
+ Good tolerance region
+ High reliability

- Production costs

Applicable to:
- Bipolar plate
- Membrane unit





Quelle: Freudenberg

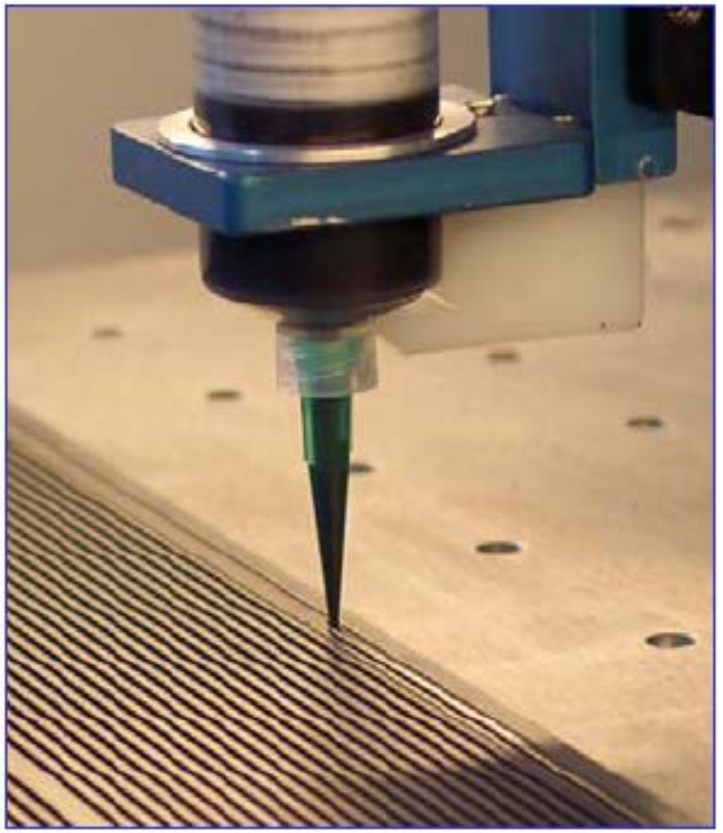
# Герметики и прокладки

## Adhesive elastomer bonding

+ Good handling
+ Practical for higher quantities (screen printing)
+ Very high reliability

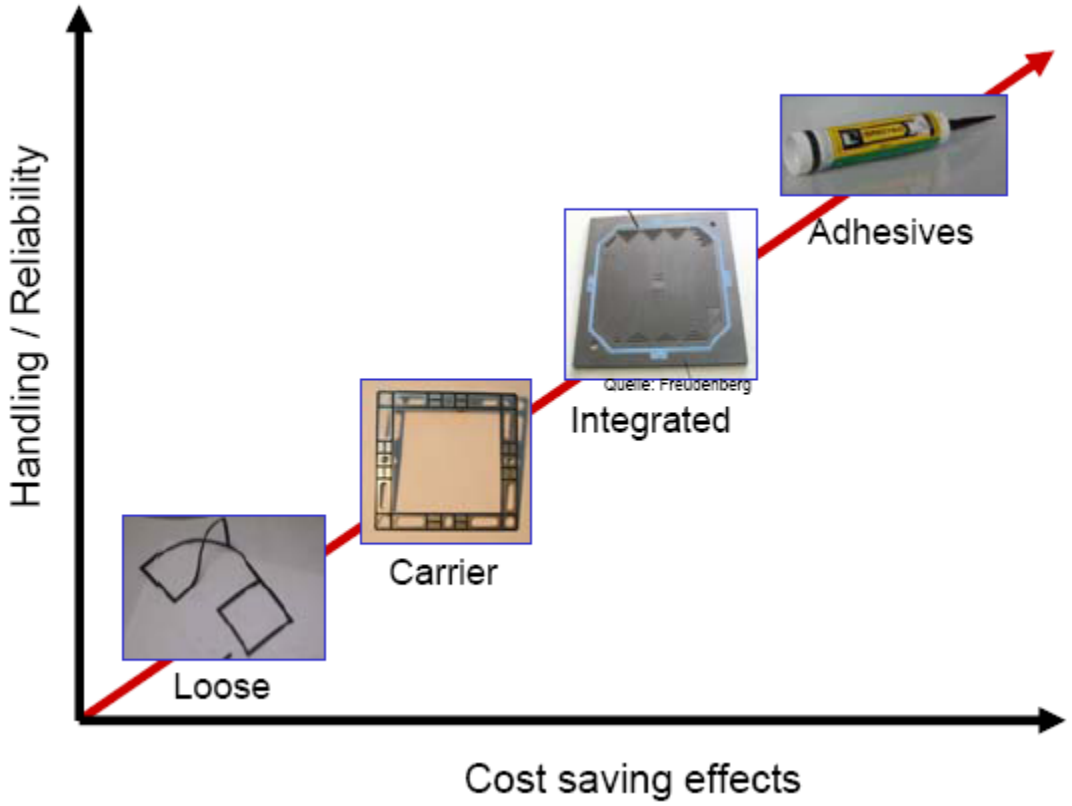
- Slow process (dispensing)
- High adhesive requirements





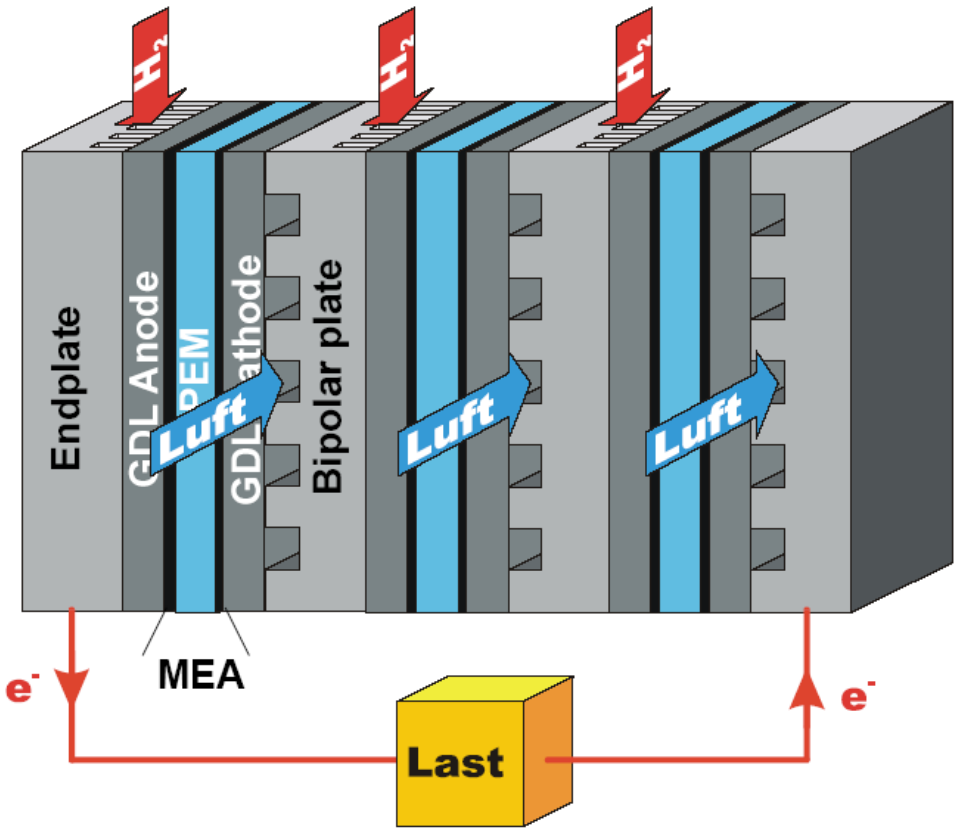
# Герметики и прокладки

Один из основных факторов при выборе – простота в использовании



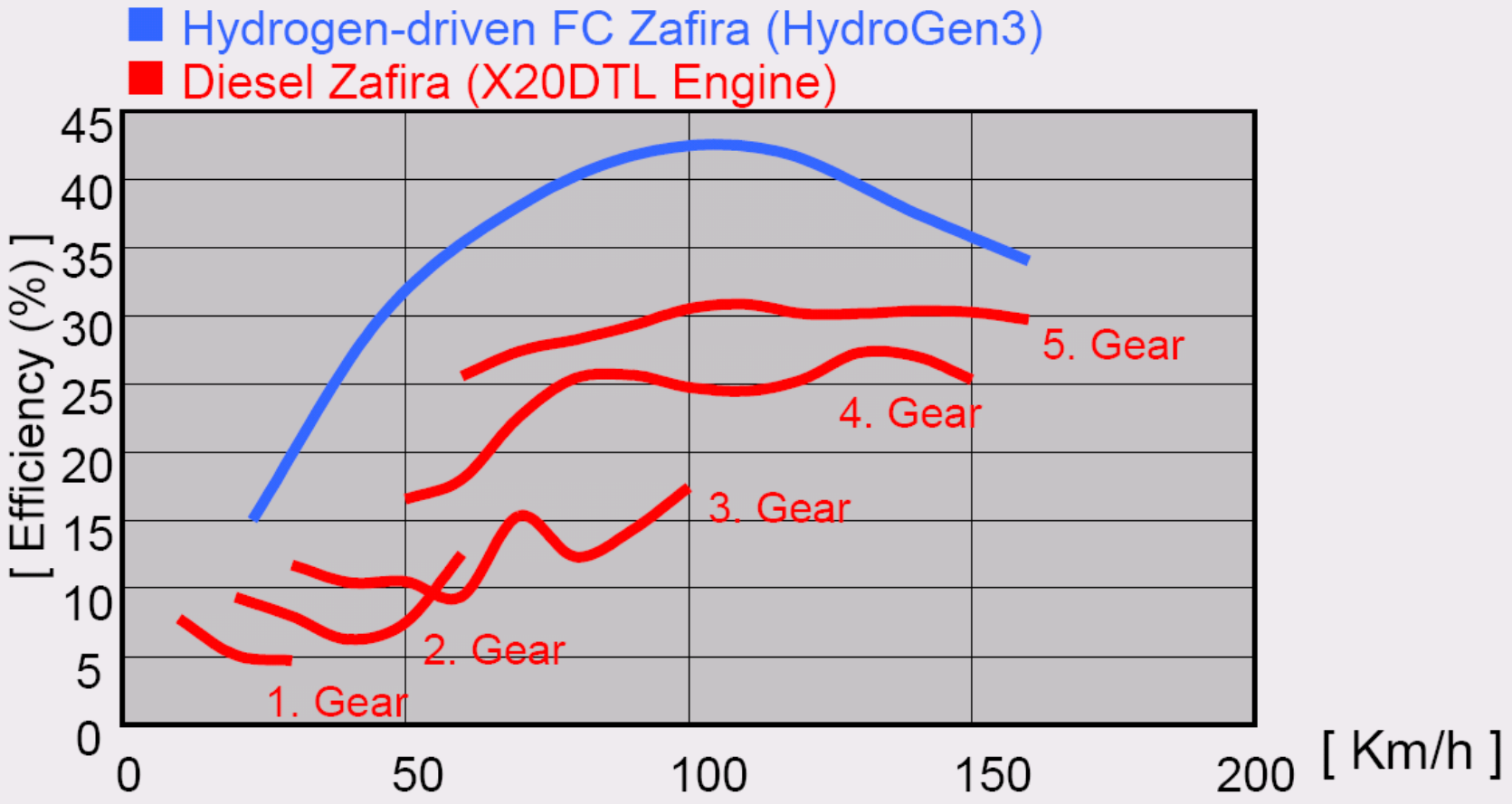
# Охлаждение батареи

1. Свободнодышашие МЭБ
2. Воздушное охлаждение
3. Жидкостное охлаждение






# Сравнение дизеля и ТЭ в автомобиле

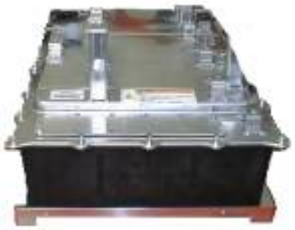



→ **Average efficiency (European Drive Cycle):**

Efficiencies: **36 %** / **22 %**

$CO_2$-Emissions (direct): **0 g/km** / **177 g/km**

# Пример современного автомобиля на ТЭ: NISSAN X-TRAIL FCV

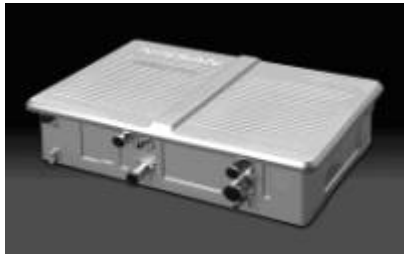






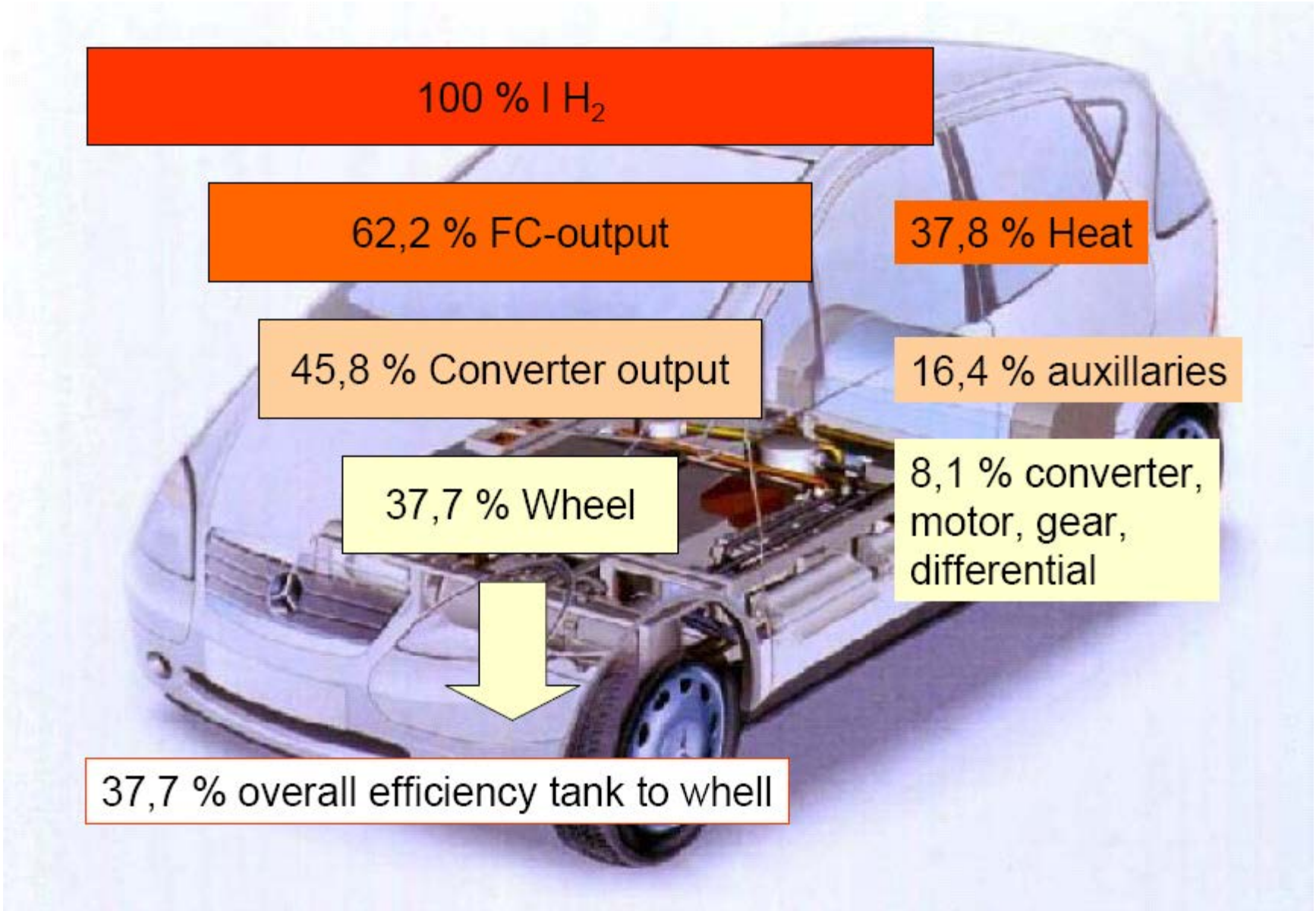




| | |
|---|---|
| **Curve Weight** | **1790** |
| **Seating capacity** | **5** |
| **Top speed (km/h)** | **150** |
| **Cruising range ( km )** | **370** |
| **Max. power ( kW )** | **90** |

# КПД энергоустановки на ТЭ в автомобиле



# 2015 год: первый серийный автомобиль Toyota Mirai




Toyota CEO Akio Toyoda said: “Today, we are at a turning point in automotive history. A turning point where a four-door sedan can travel 300 miles on a single tank of hydrogen, can be refuelled in under five minutes and emit only water vapour.”

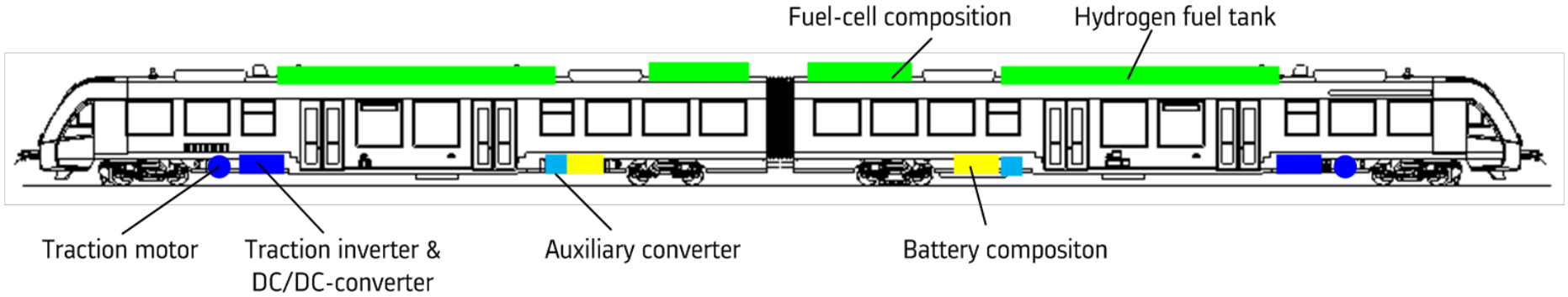
480 км пробега
100 км/ч за 9 с
50 т.долл.



# 2016 год: первый серийный поезд на топливных элементах Coradia iLint



ALSTOM




В Германии в 2017 году начнет регулярно курсировать на больших дистанциях первый пассажирский поезд, использующий водород в качестве топлива