Zentrum für BrennstoffzellenTechnik GmbH

Development of multi-layered coating and method for the aluminum bipolar plates of a direct methanol fuel cell

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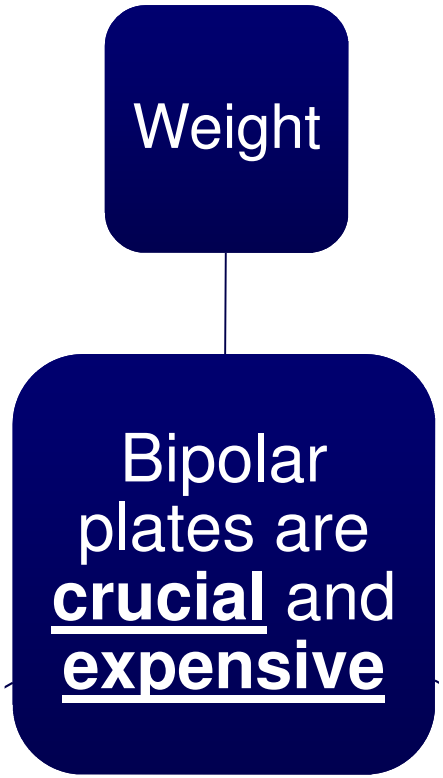
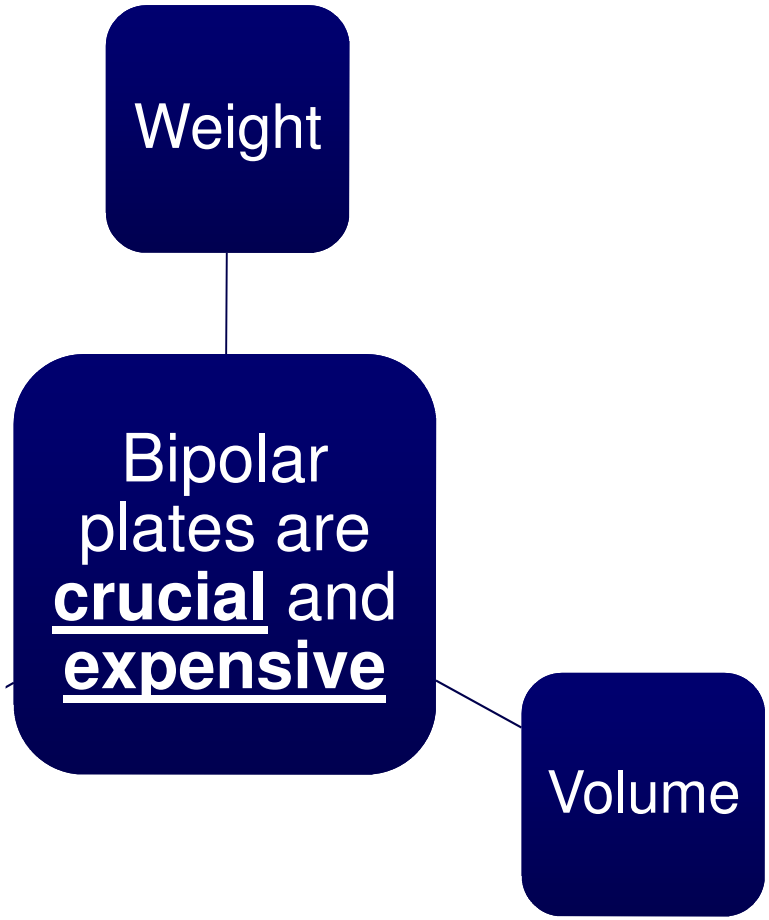
Bipolar plates

Bipolar plates are **crucial** and **expensive**

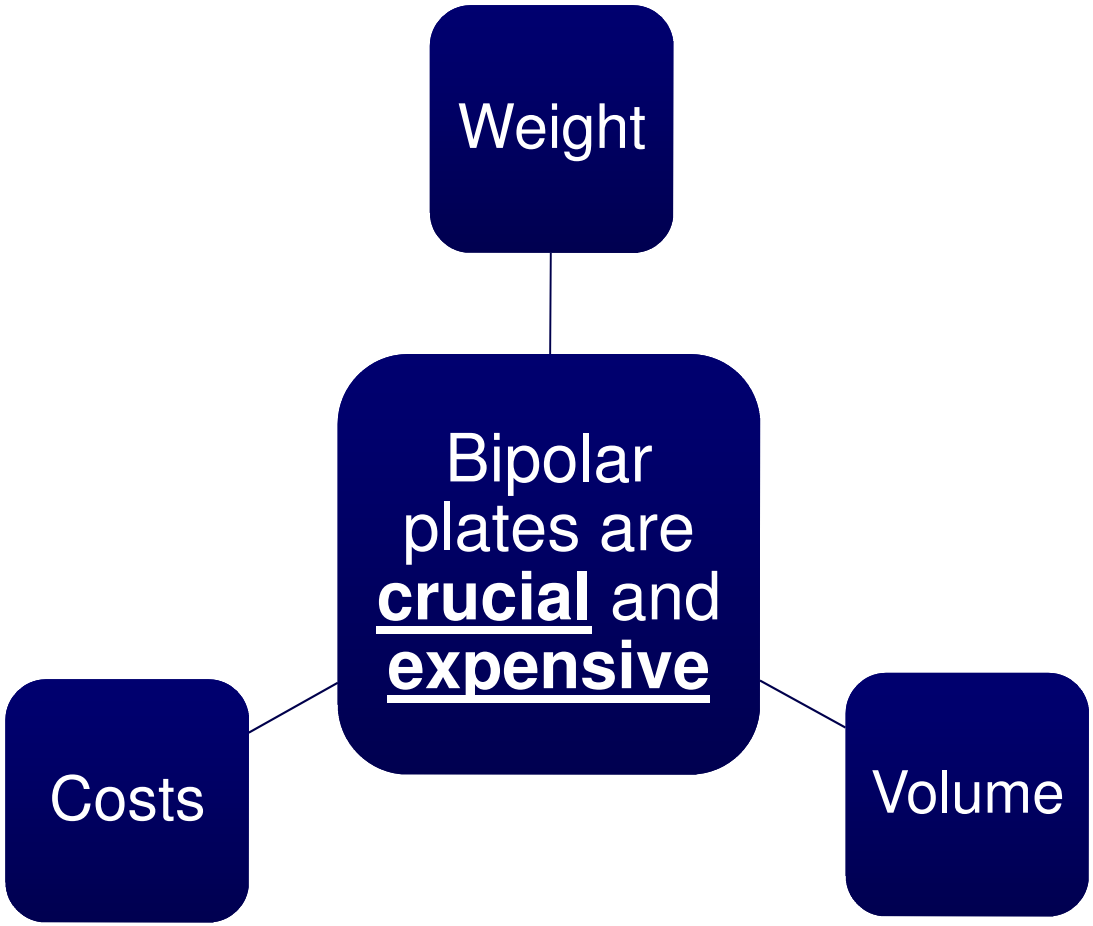
Bipolar plates



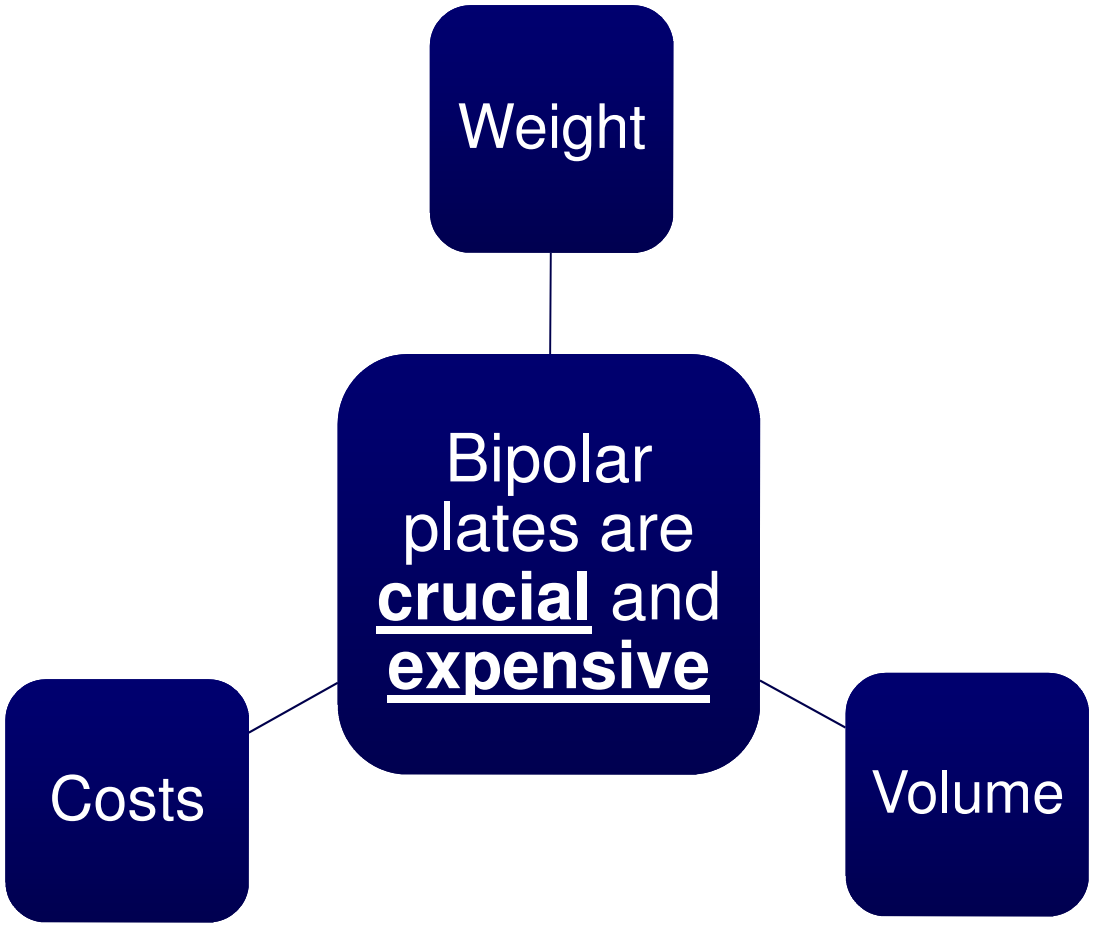
Bipolar plates



Bipolar plates

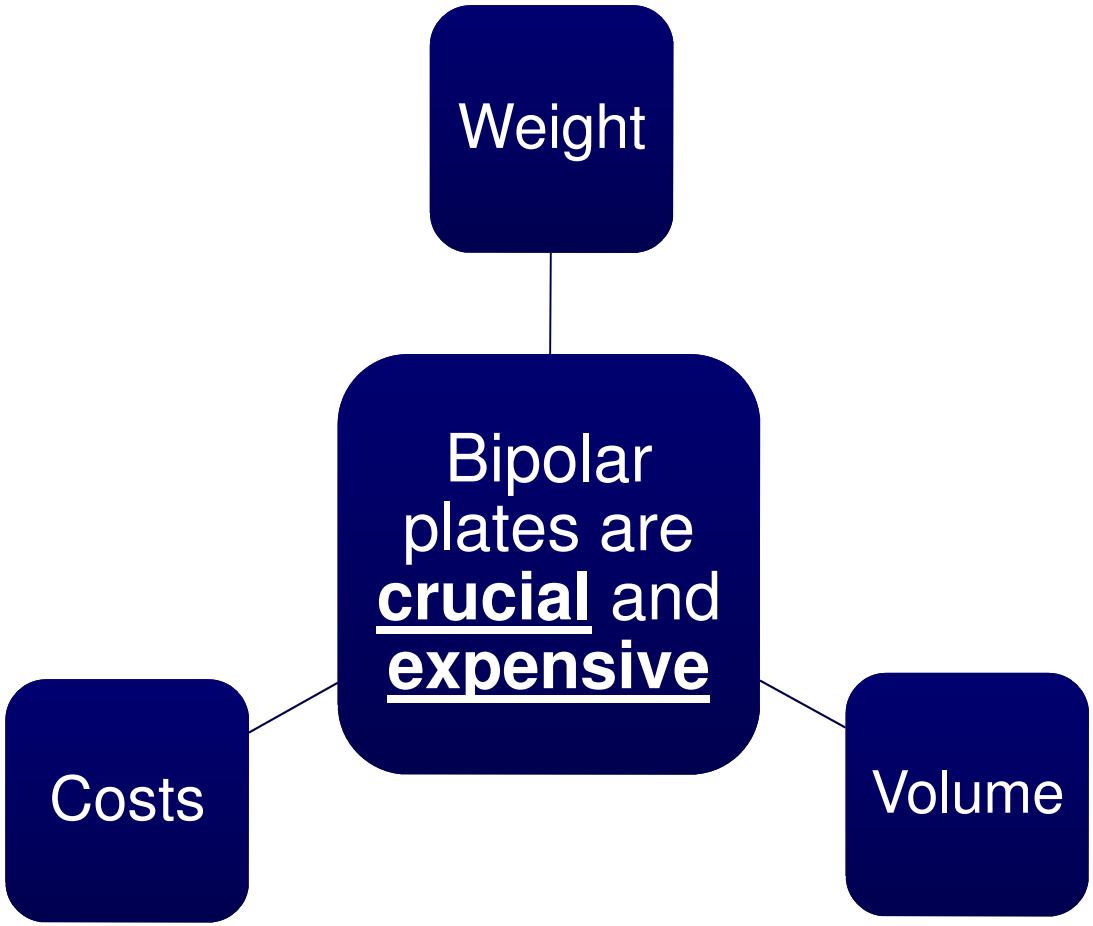


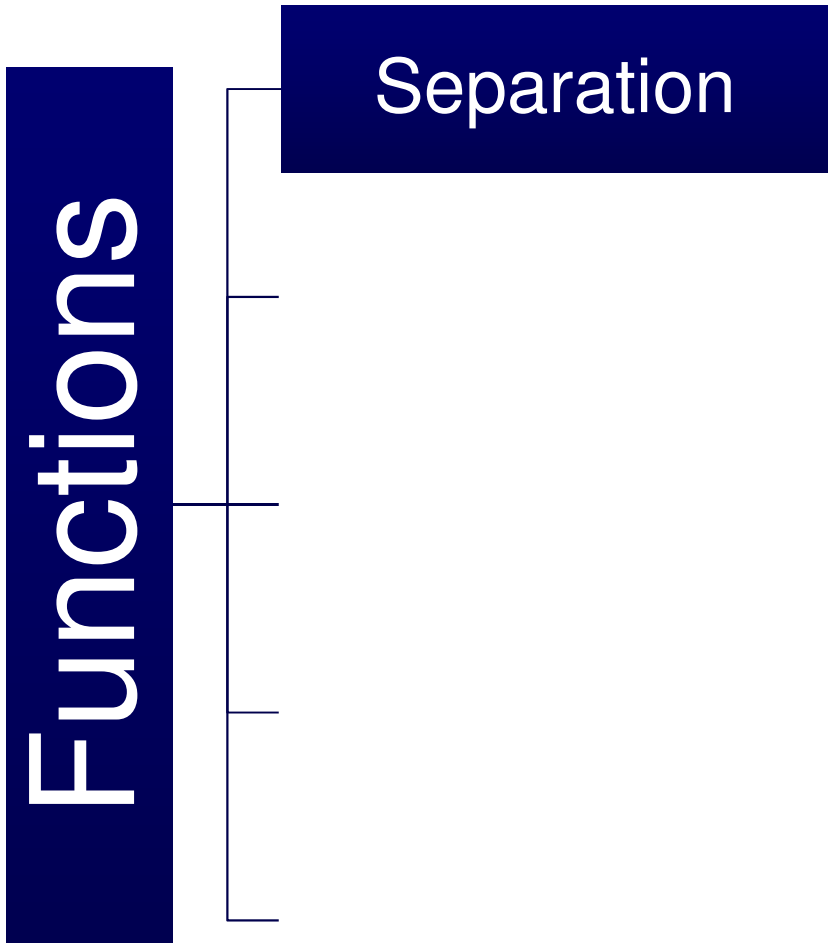
Bipolar plates



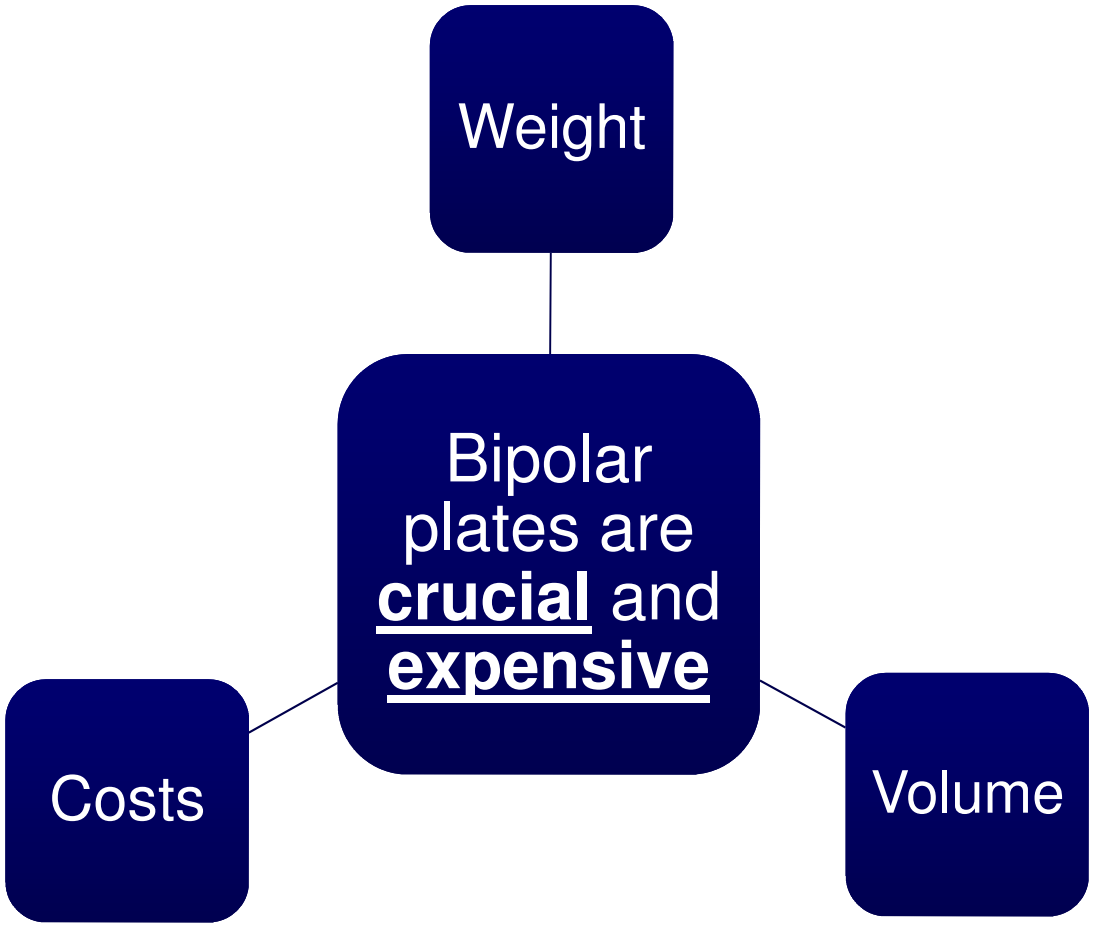
Functions

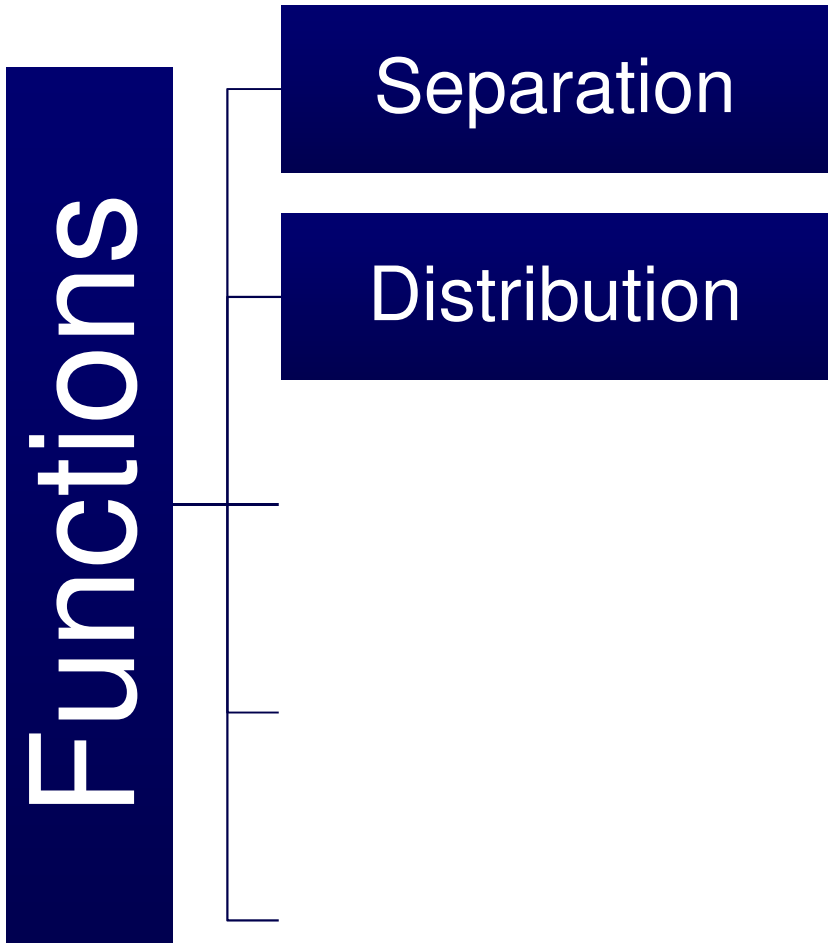
Bipolar plates



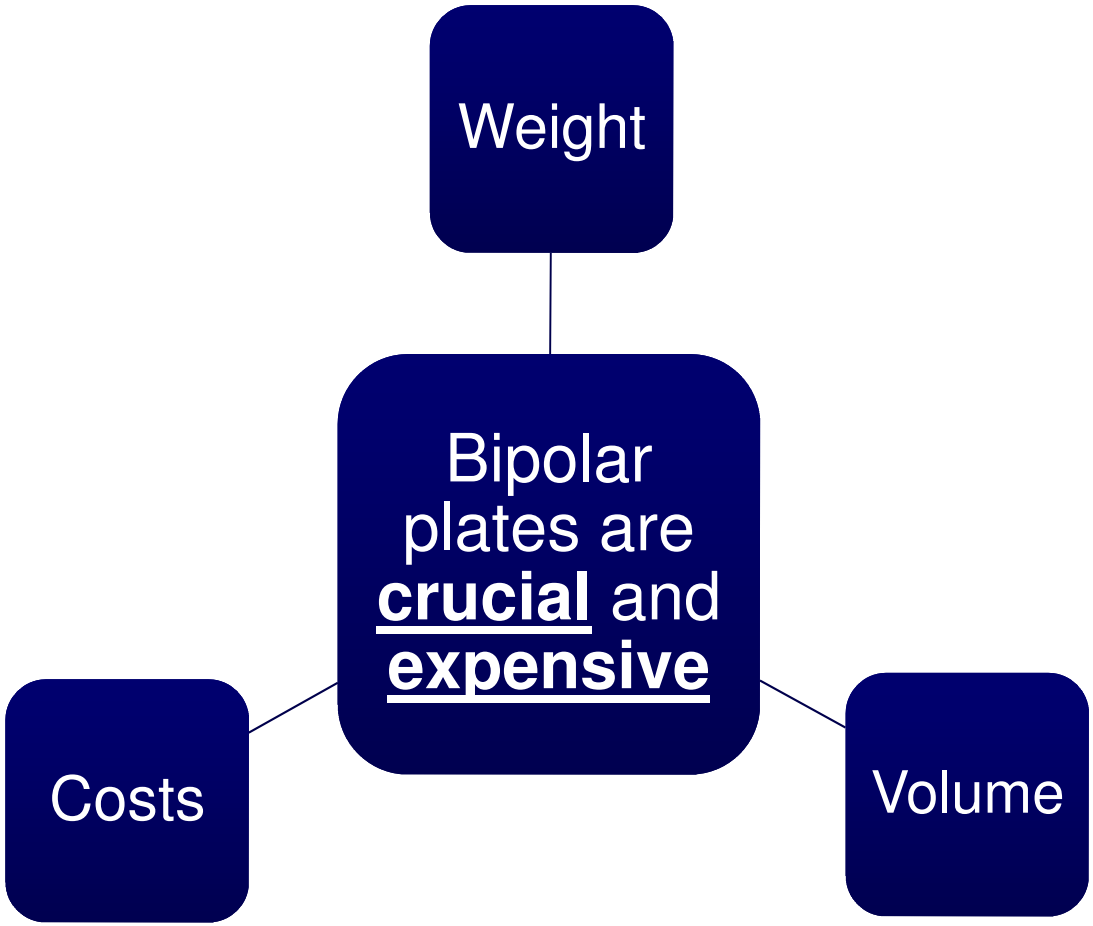


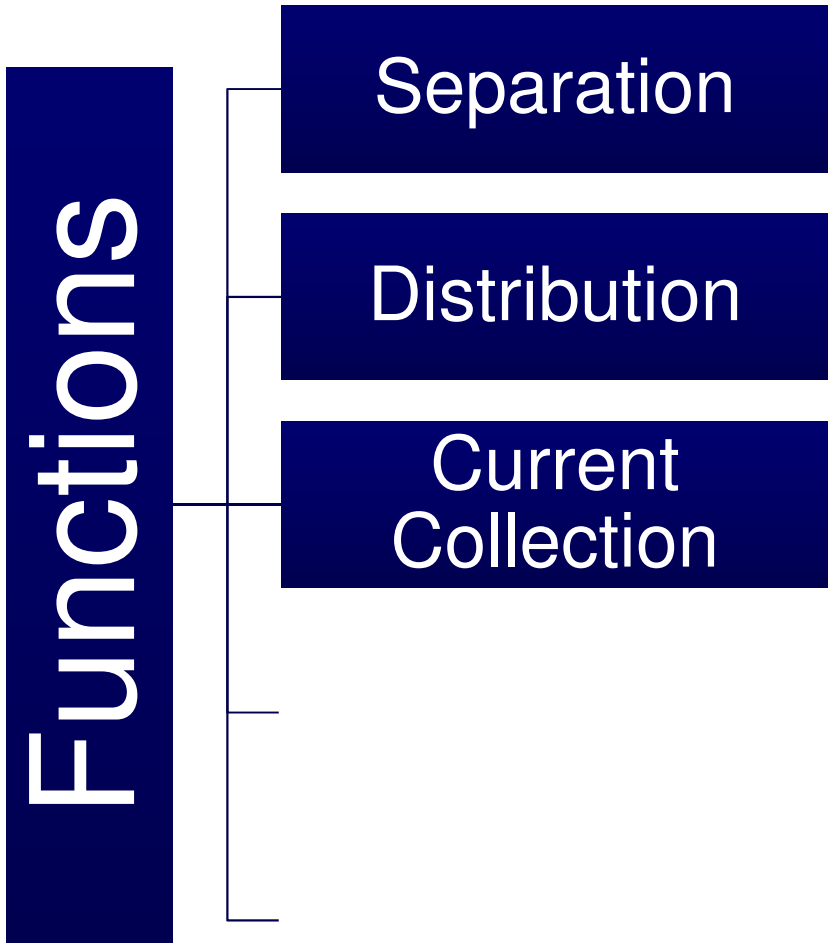
Bipolar plates



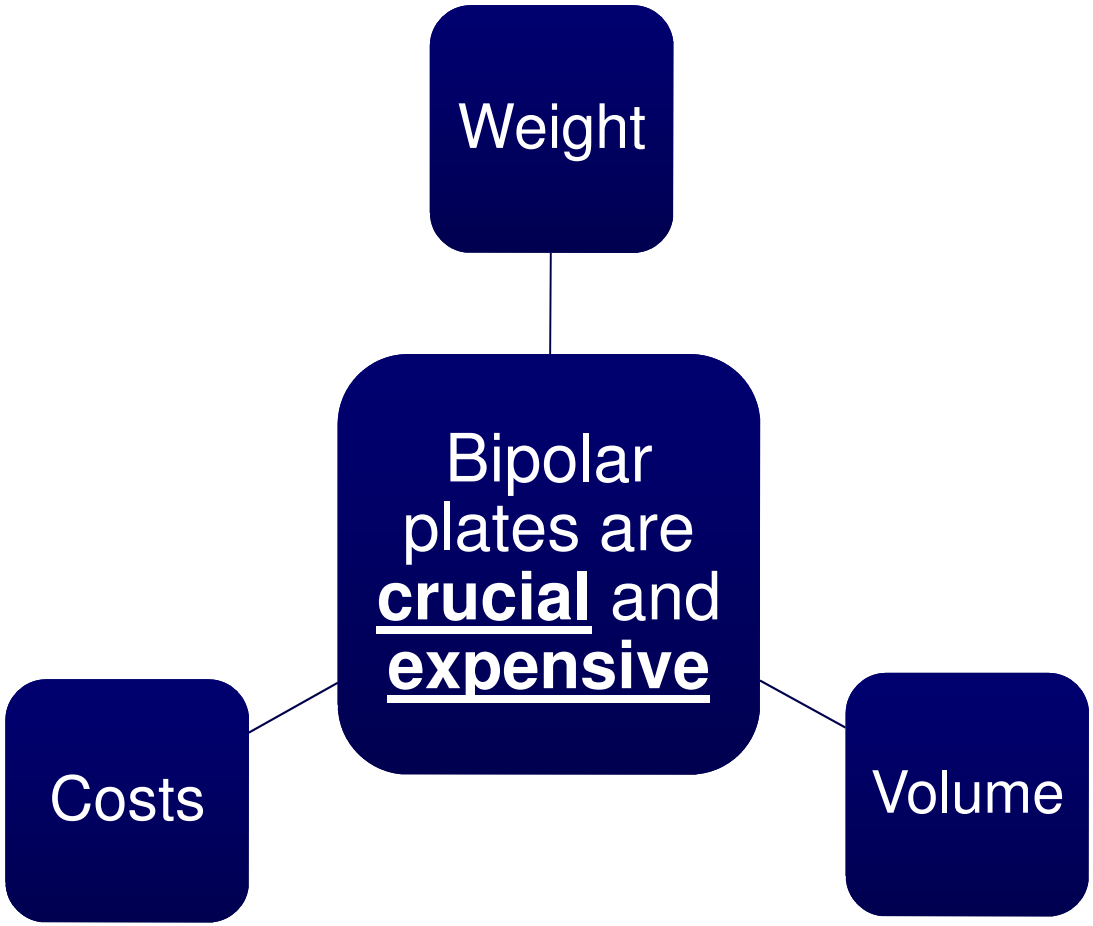


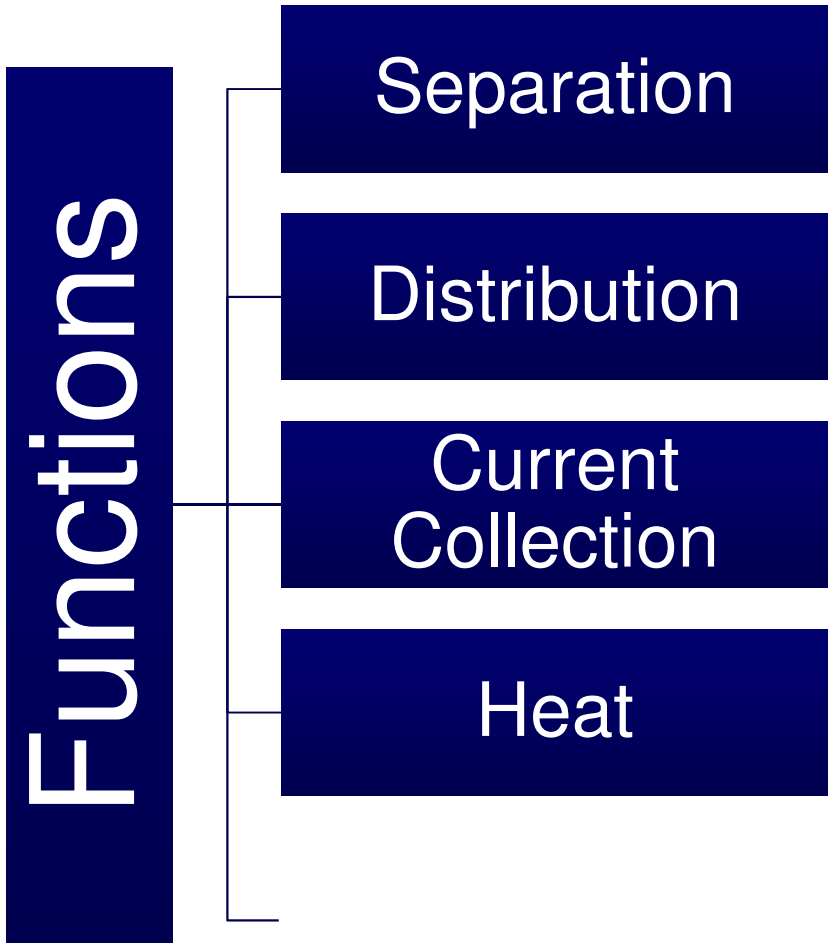
Bipolar plates



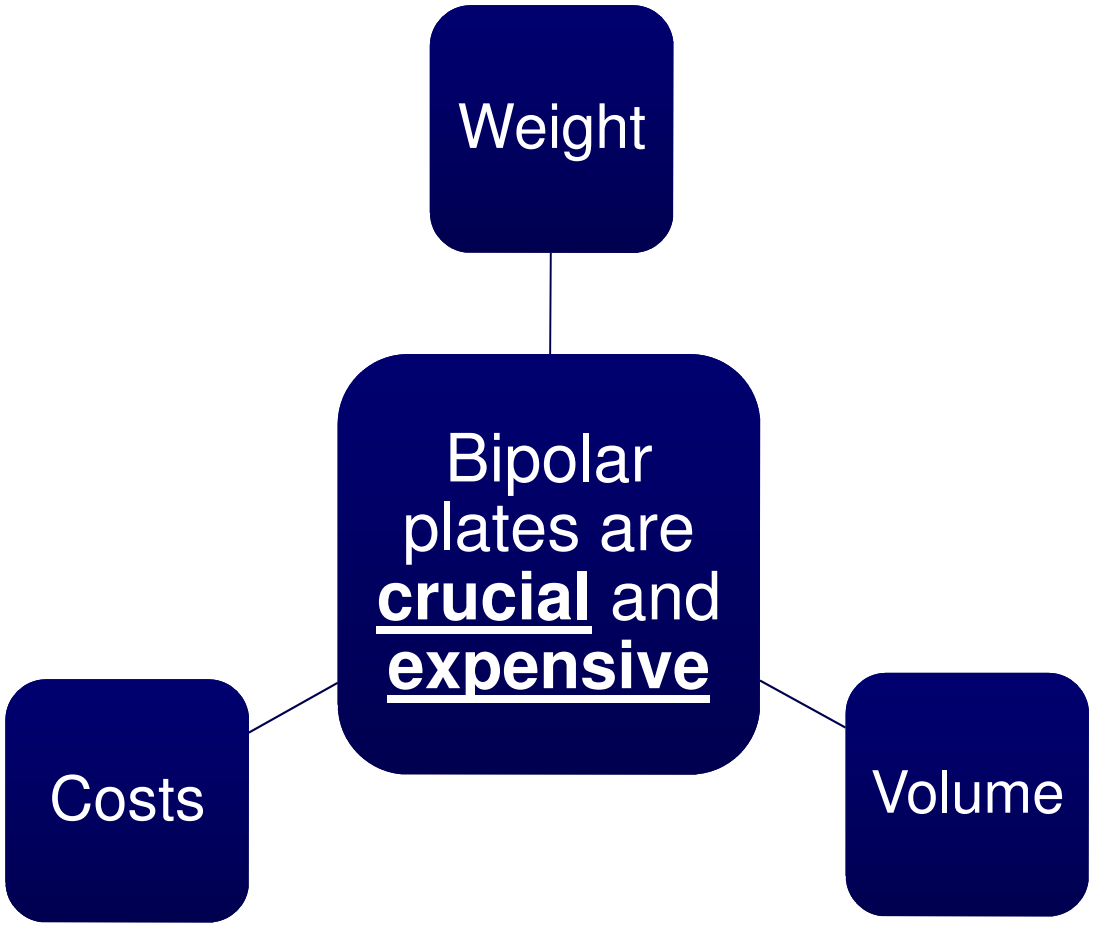


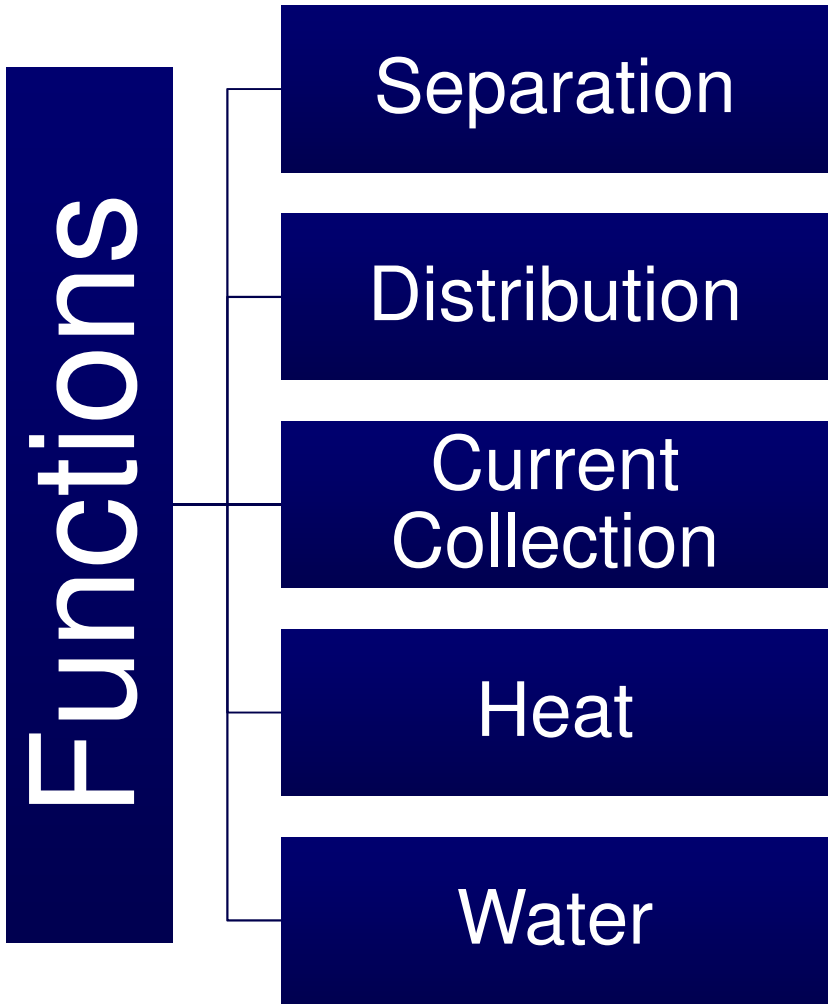
Bipolar plates





Bipolar plates





Ideal bipolar plate material?

Ideal bipolar plate material?

Compressive strength

Ideal bipolar plate material?

Compressive strength

Electrical conductivity

Ideal bipolar plate material?

Compressive strength

Electrical conductivity

Thermal conductivity

Ideal bipolar plate material?

Compressive strength

Electrical conductivity

Thermal conductivity

Electrochemical stability

Ideal bipolar plate material?

Compressive strength

Electrical conductivity

Machinability

Thermal conductivity

Electrochemical stability

Ideal bipolar plate material?

Compressive strength

Low costs

Electrical conductivity

Machinability

Thermal conductivity

Electrochemical stability

Aluminum as bipolar plate material

Aluminum as bipolar plate material

Aluminum as bipolar plate material

+

Weight

Aluminum as bipolar plate material

+

Weight

Mechanic strength

Aluminum as bipolar plate material

+

Weight

Mechanic strength

Bulk resistance

Aluminum as bipolar plate material

+

Weight

Mechanic strength

Bulk resistance

−

Aluminum as bipolar plate material

+

Weight

Mechanic strength

Bulk resistance

−

Corrosion resistance

Aluminum as bipolar plate material

+

Weight

Mechanic strength

Bulk resistance

−

Corrosion resistance

Coating mandatory

Aluminum as bipolar plate material

1050A
Aluminum alloy

+

- **Weight**
- **Mechanic strength**
- **Bulk resistance**

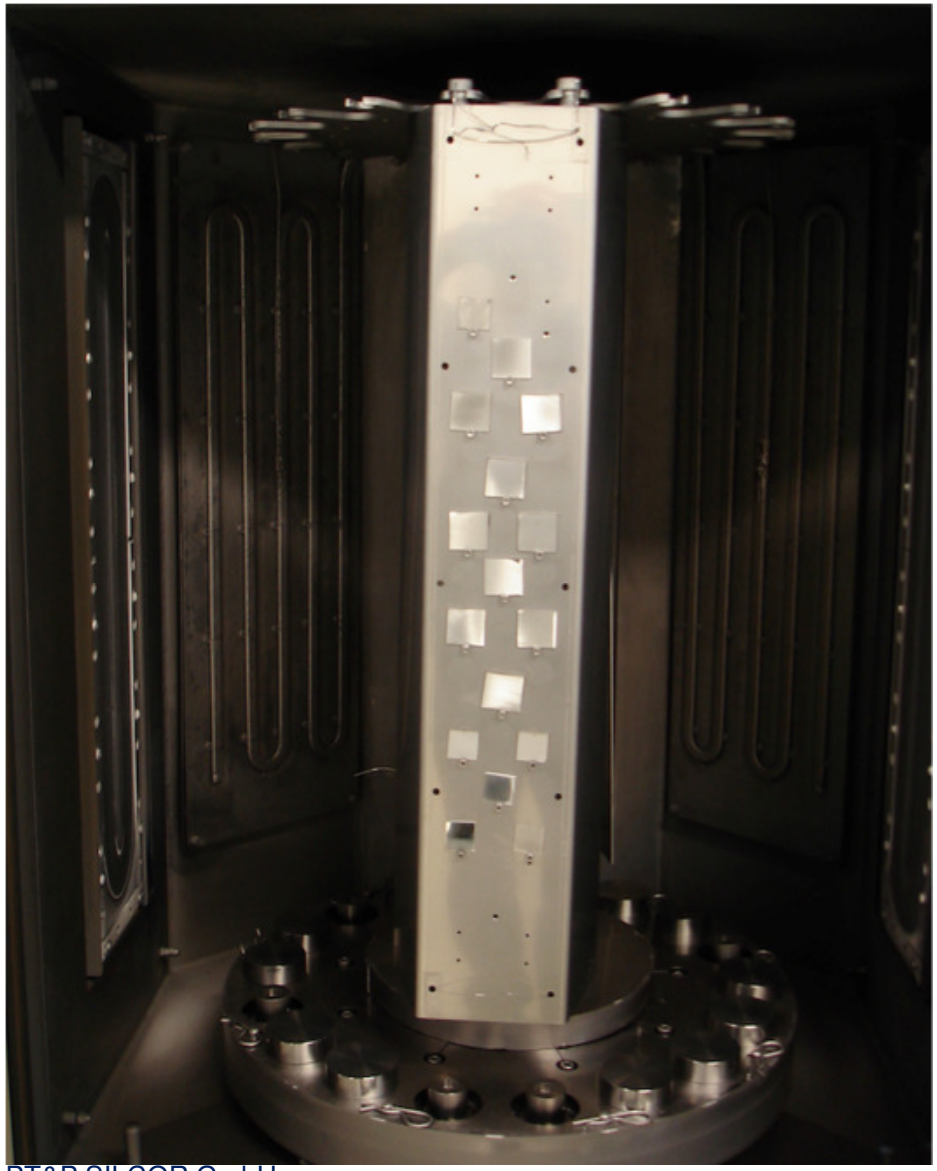
–

- **Corrosion resistance**

Coating mandatory

CrN-layers deposited by PVD (Physical Vapour Deposition)

CrN-coatings are one of the most promising candidates for corrosion resistive coatings



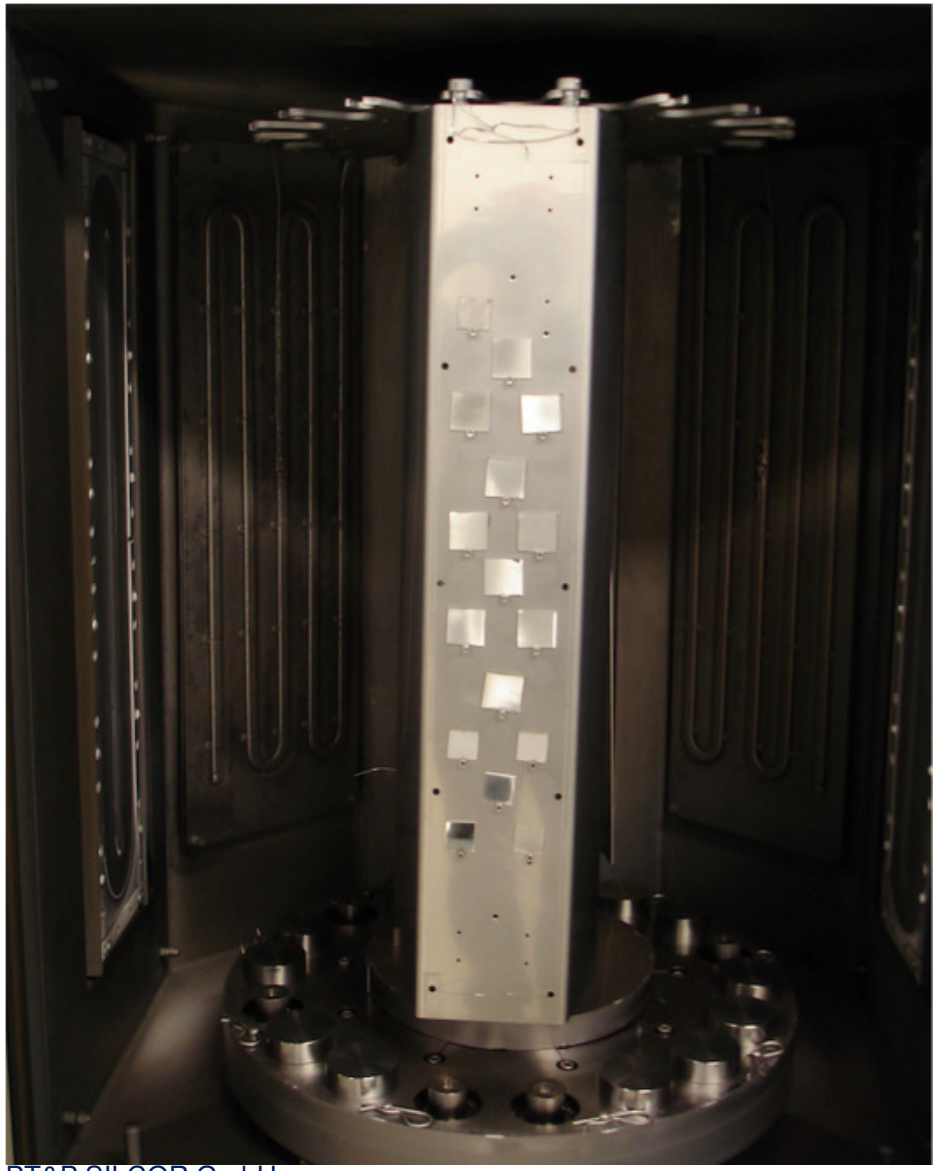
PT&B SILCOR GmbH

CrN-layers deposited by PVD (Physical Vapour Deposition)

CrN-coatings are one of the most promising candidates for corrosion resistive coatings

Problem

Surface defects



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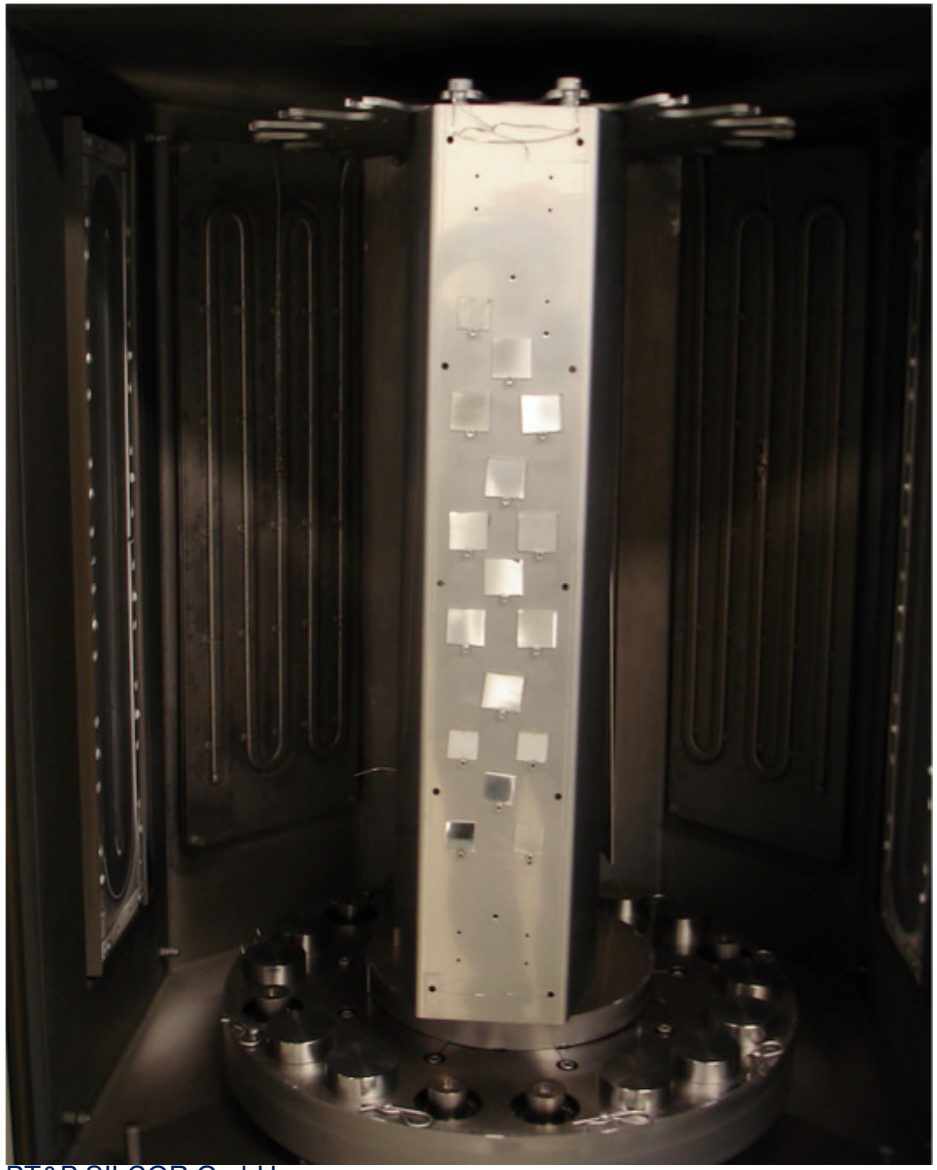
Surface defects

Solution

CrN-based multi-layer coating



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CrN/aC-based multi-layer coating

CrN-layer

CrN/aC-based multi-layer coating

CrN-layer

CrN/aC-based multi-layer coating

CrN-layer

Intermediate layer

Amorphous carbon (aC)

CrN/aC-based multi-layer coating

CrN-layer

Intermediate layer

Amorphous carbon (aC)

High corrosive resistance

CrN/aC-based multi-layer coating

CrN-layer

Intermediate layer

Amorphous carbon (aC)

- **High corrosive resistance**
- **Excellent compactness**

CrN/aC-based multi-layer coating

CrN-layer

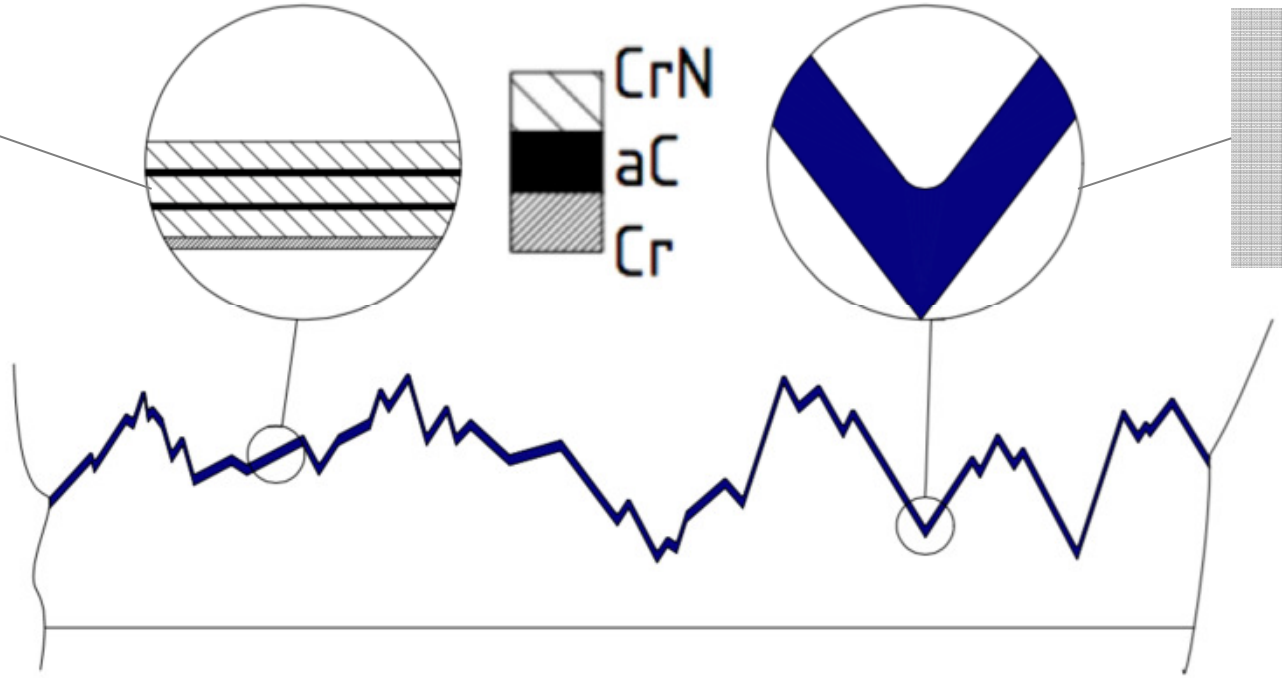
Intermediate layer

Amorphous carbon (aC)

- **High corrosive resistance**
- **Excellent compactness**
- **Good adhesion to CrN**

CrN/aC-based multi-layer coating

Alternating CrN and aC layers



Roughness modification through the coating

CrN-layer

Intermediate layer

Amorphous carbon (aC)

- **High corrosive resistance**
- **Excellent compactness**
- **Good adhesion to CrN**

Ideal surface properties of a bipolar plate?

Uniformity

Adjustable structure

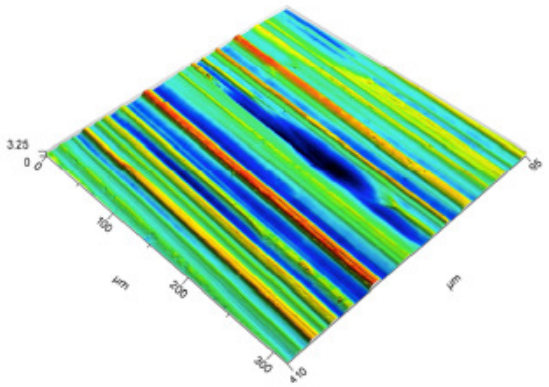
Bipolar plate

Surface

No defects

Contact resistance

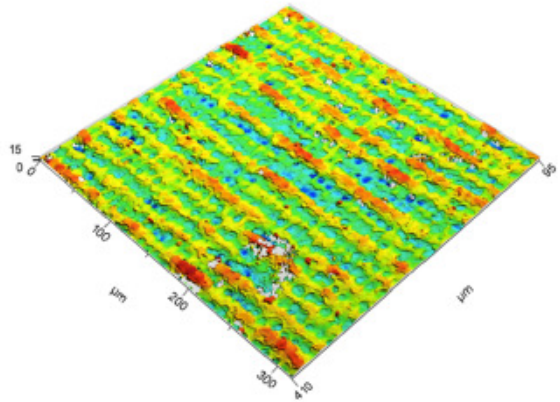
uncoated modified



Approach

Pretreatment

Laser-modification



uncoated modified

Measurement of corrosion current density

Three-electrode system:

Auxiliary electrode: **platinum sheet**

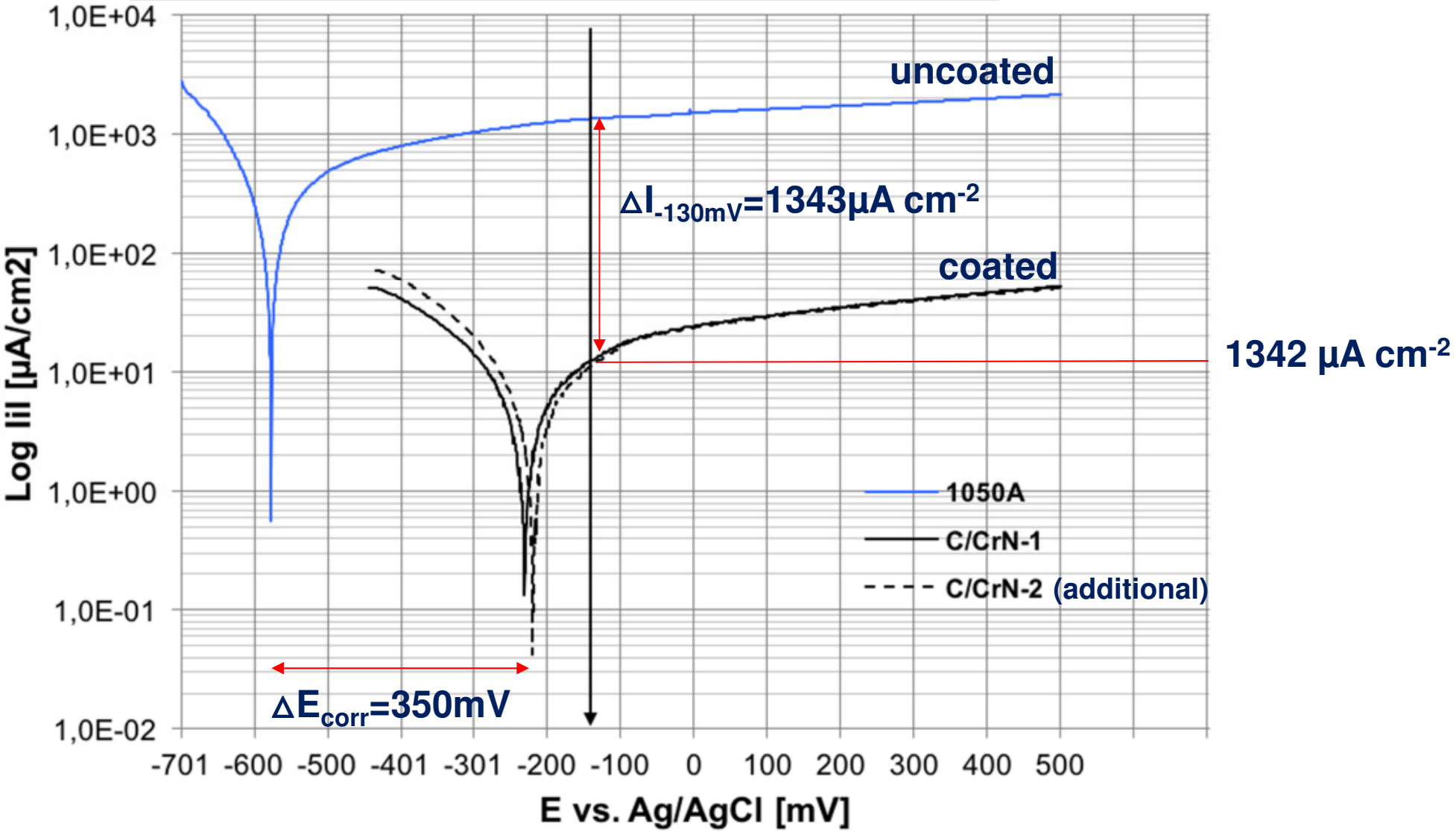
Working electrode: **1050A sample**

Reference electrode: **Al/AlCl electrode**

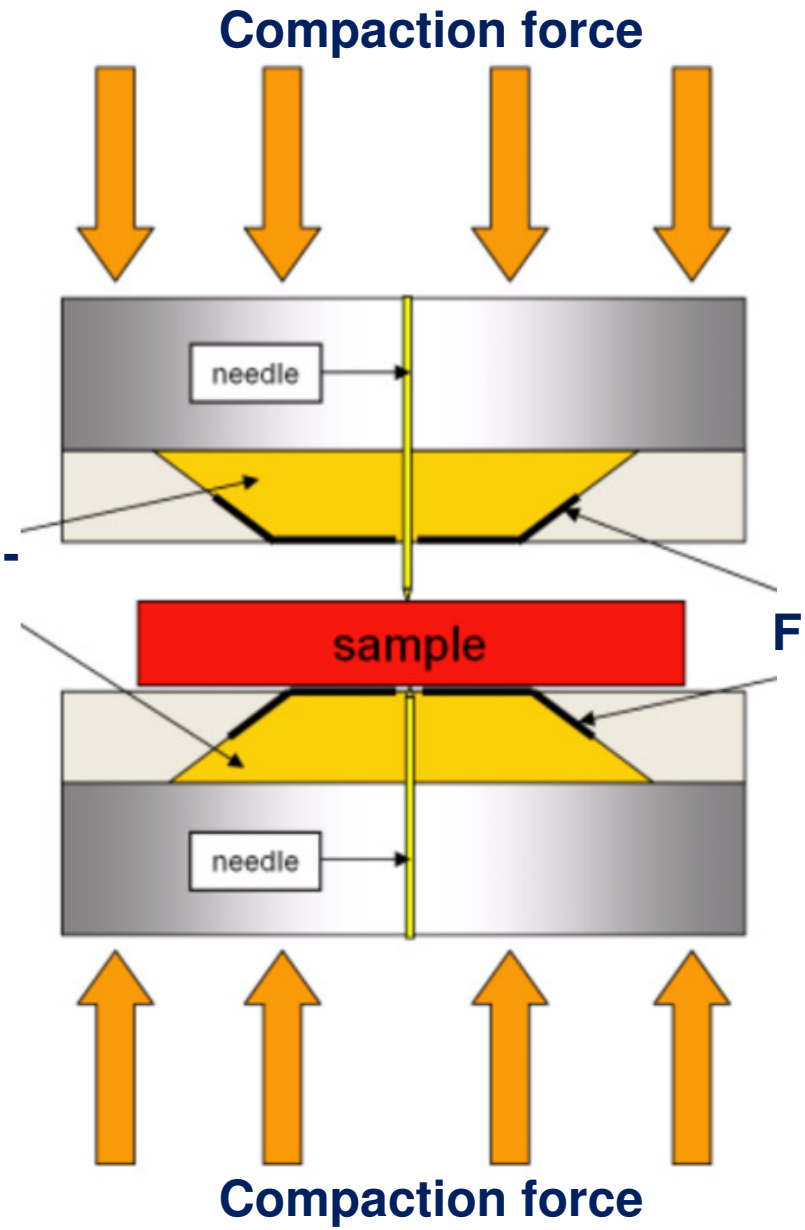
Electrolyte:0.5 M H_2SO_4 + 10 vol.-% CH_3OH

Electrochemical measurements

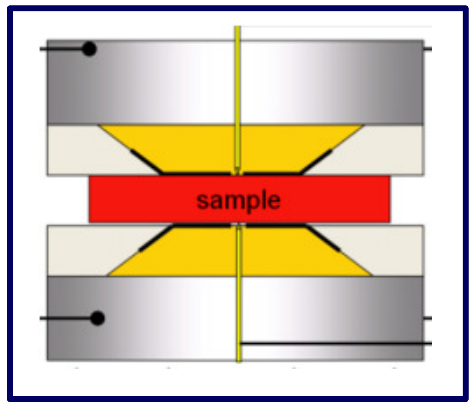
Electrolyte:0.5 M H_2SO_4 + 10 vol.-% CH_3OH **T= 60 °C**



Interfacial Contact Resistance (ICR)



Gold coated frustum-pyramids (poles)



Fixed gas diffusion layer (GDL)

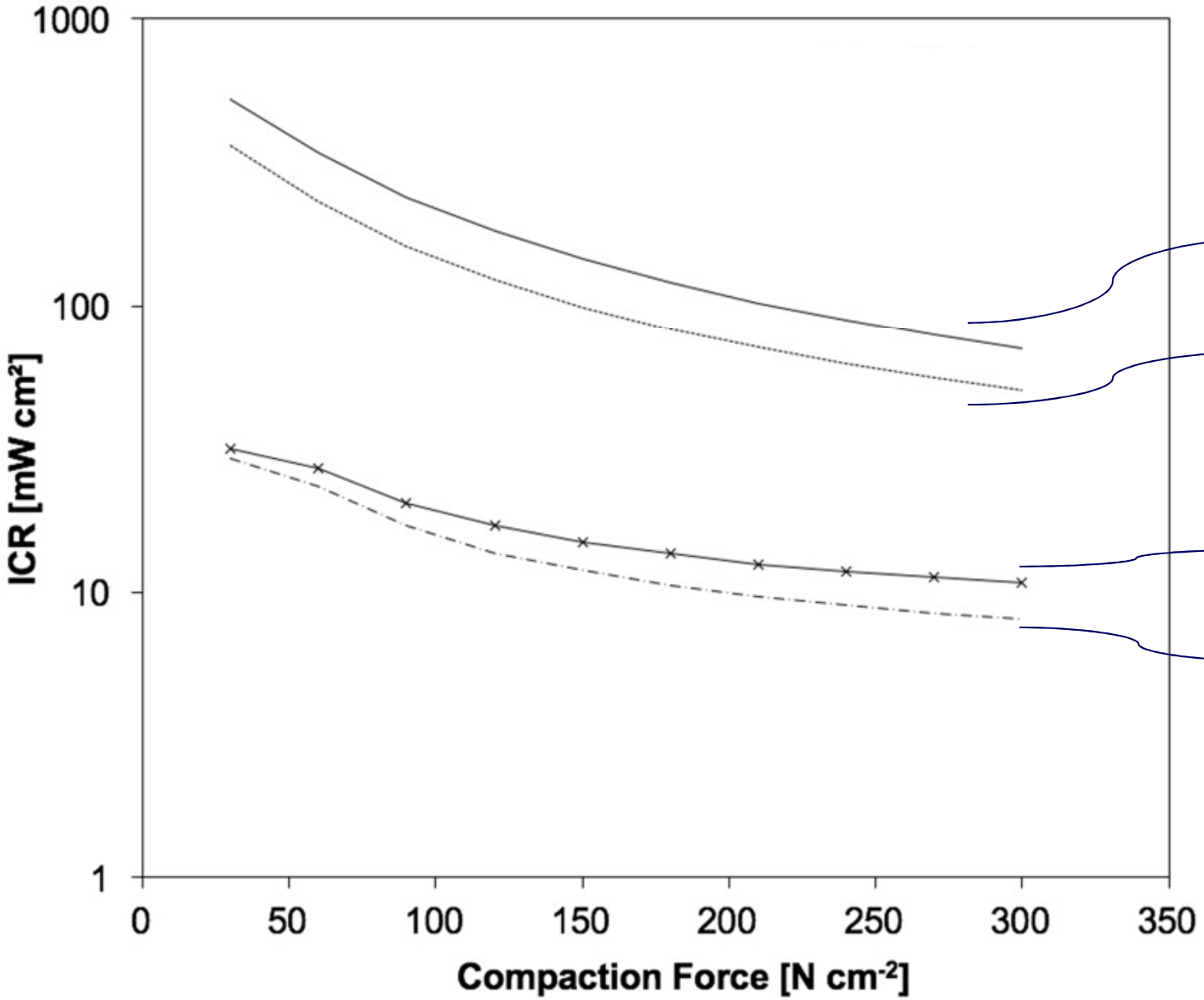
Different values of electrical current:

0.5 A; 1.0 A; 1.5 A; 2.0 A

Compaction force:

from 30 to 300 Ncm^{-2}

ICR measurements



coated not modified

coated modified

uncoated not modified

uncoated modified

Better match to GDL

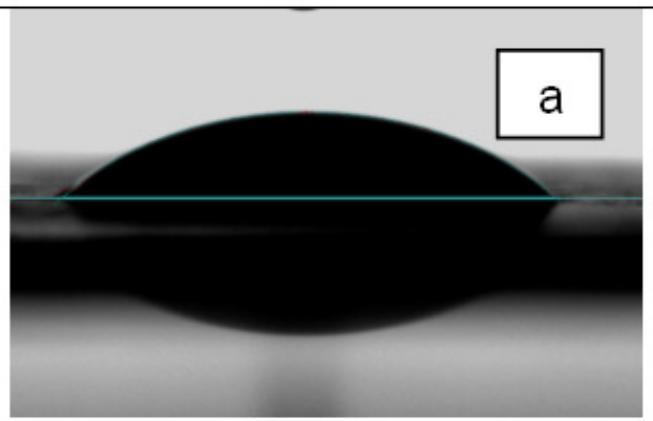
Gas Diffusion Layer

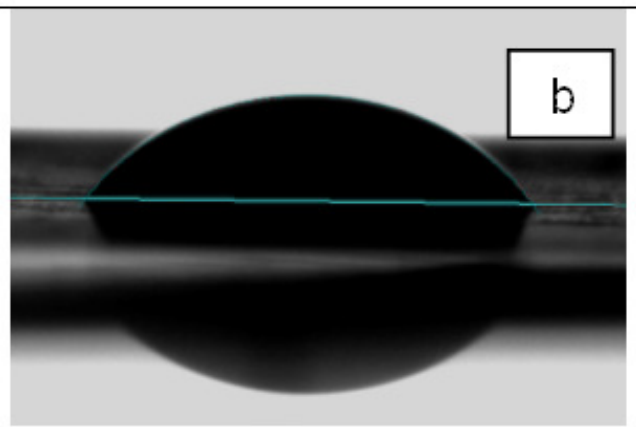
Static contact angle measurements

uncoated modified

coated modified

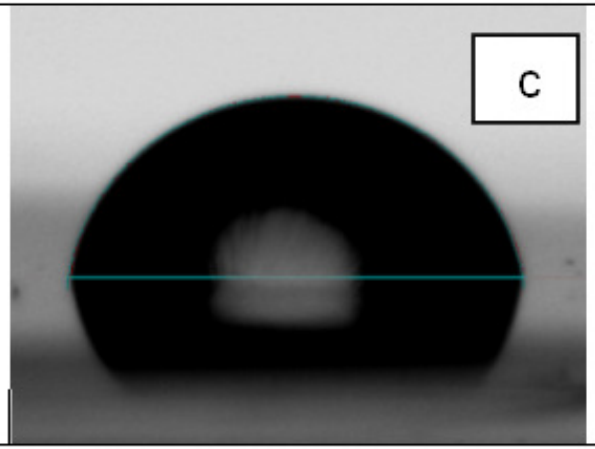
39.3°

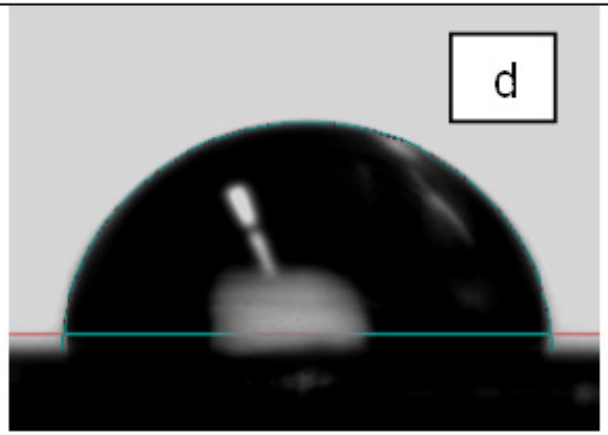




56.7°

81.1°





79.6°

uncoated not modified

coated not modified

Conclusion and outlook

Corrosion resistive multi-layer coating for 1050A

- Alternating corrosion resistive CrN/aC coating for aluminum
- Improvement of the corrosion resistance of the 1050A aluminum alloy

ICR measurements

- Require an Improvement
- Thickness of the amorphous carbon layer

Laser-modification

- Better match to the surface of the GDL
- Reduce the hydrophobicity for different sections of the bipolar plates

Thank you for your attention!

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www.zbt-duisburg.de