

Anders Hallbro, Stefan Skrabs, Innovation Services – ISWB, 29th November 2016

Metallic High Performance Components for SOFC

Energiforsk - Fuel Cell Conference 2016

Westmanska Palatset, Holländargatan 17, Stockholm

- **Plansee - Company overview**
- **Department ISWB – Growth option SOFC**
- **Products and services for the SOFC industry**
- **Summary**

- **Plansee - Company overview**
- Department ISWB – Growth option SOFC
- Products and services for the SOFC industry
- Summary

Properties:

- High melting point
- High density
- Low vapor pressure
- High temperature strength
- High thermal conductivity
- High corrosion resistance



From the powder to the final product



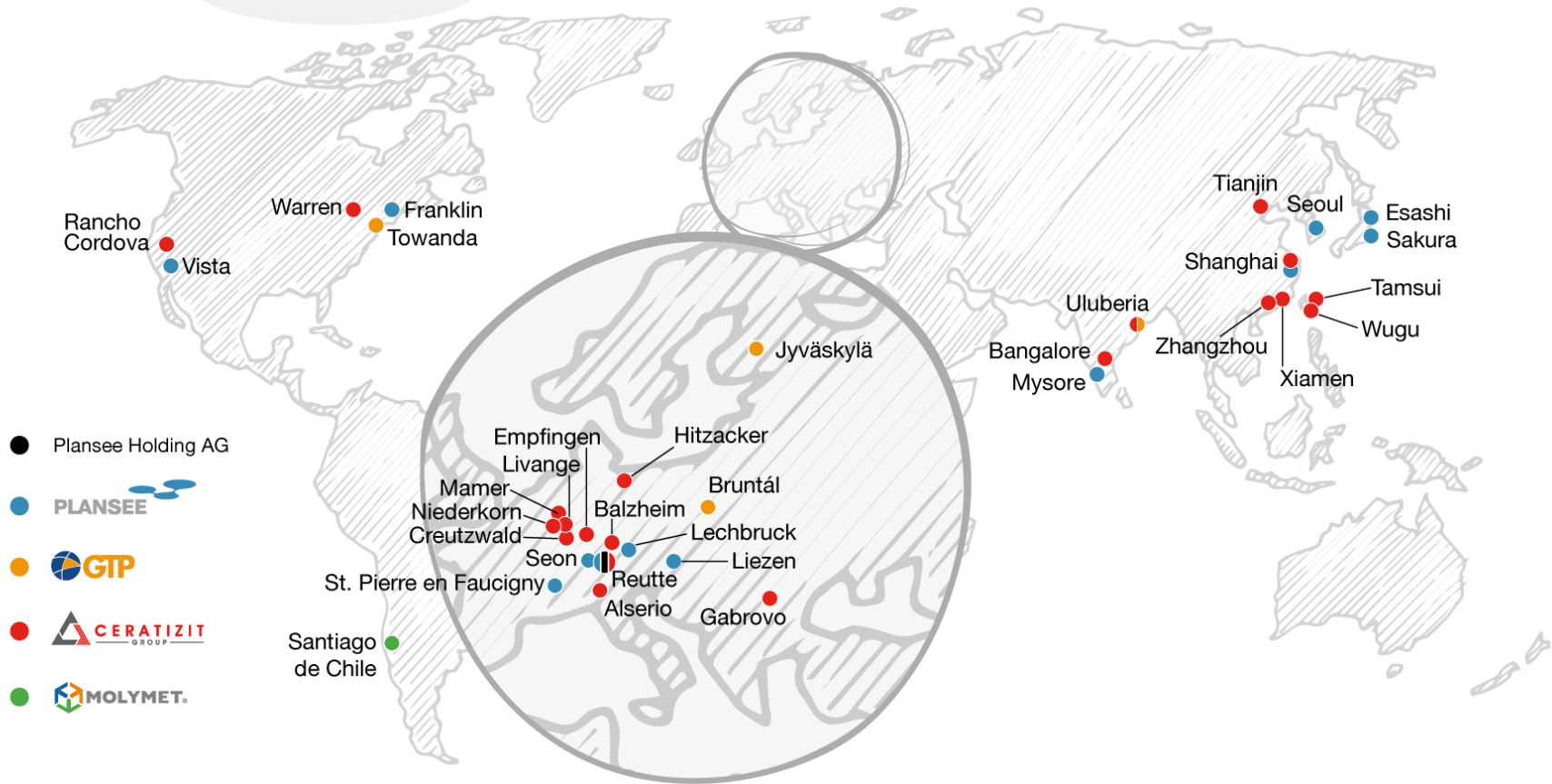
The Plansee Group, with its divisions, covers the entire value-added chain: From the powder to the final product.

Group portfolio and industrial logic

plansee GROUP

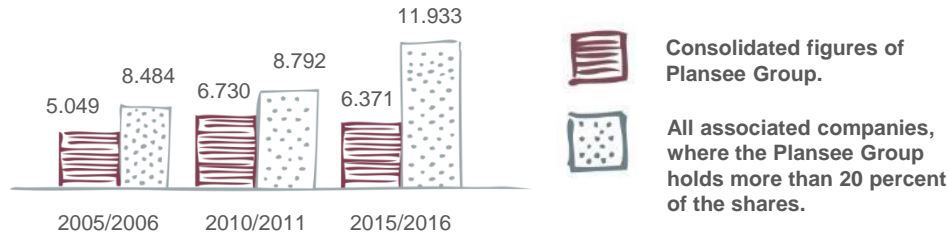


The Plansee Group worldwide

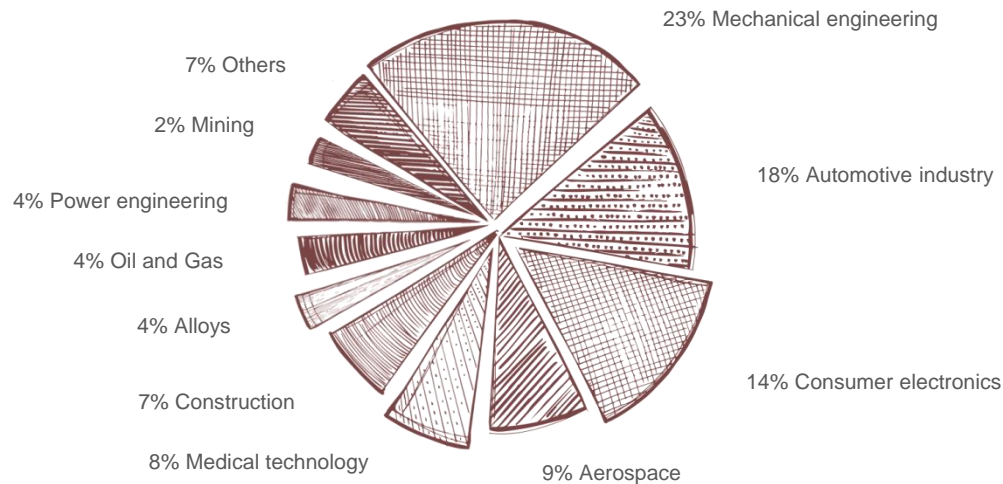


Facts and Figures

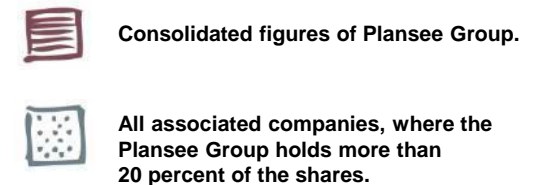
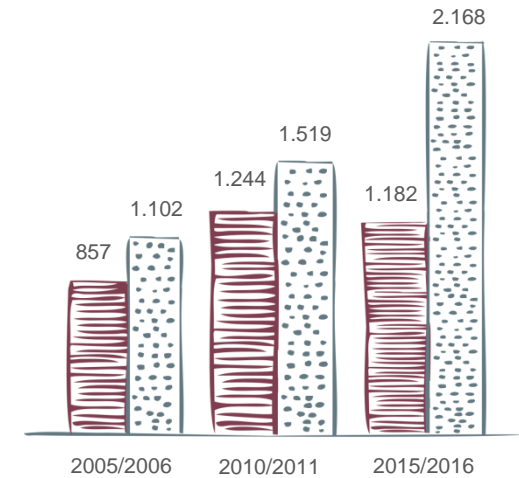
Employees



Attractive growth markets



Sales in million euros

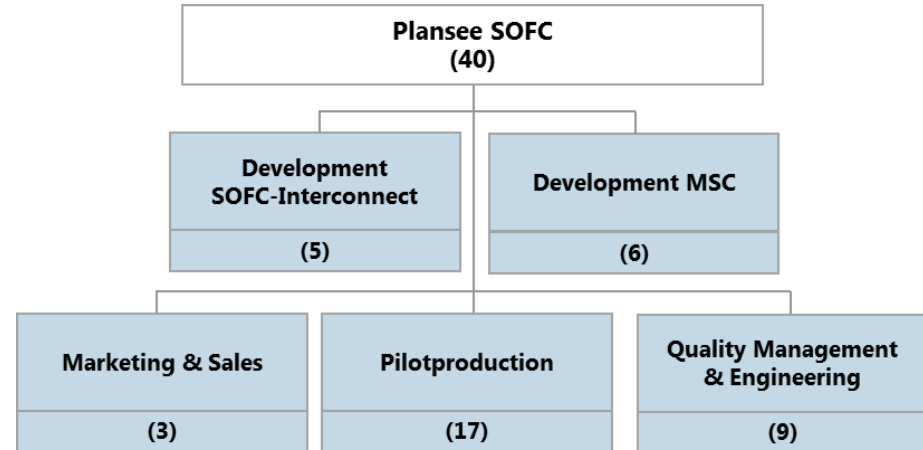


Some of our customers. You can rely on us!



- Plansee - Company overview
- **Department ISWB – Growth option SOFC**
- Products and services for the SOFC industry
- Summary

Growth Option "SOFC"

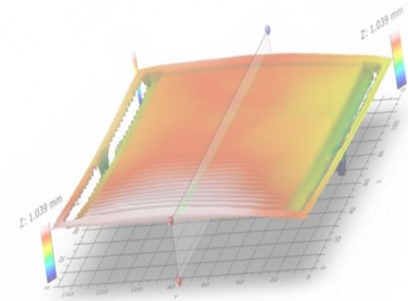
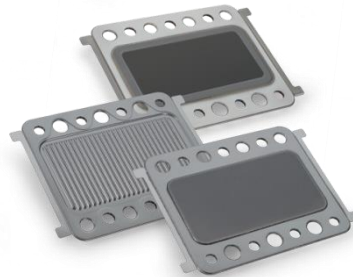
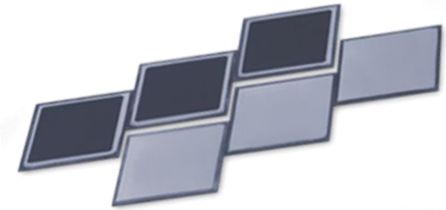


Pilot line for SOFC Interconnect production
at the Plansee headquarters in Reutte (Austria)

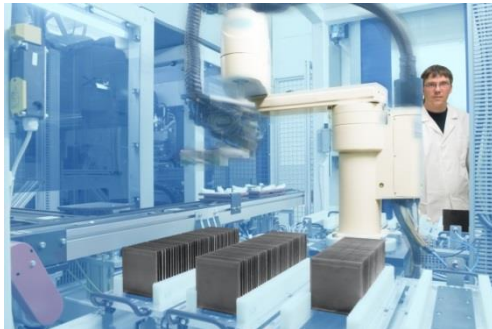
Close to the customer

Plansee SOFC competence

- > 20 years of SOFC experience
- Broad application know-how
- Continuous investment in technical equipment
- Long-term, close and stable cooperation
- International experience in SOFC business



P/M net shape technology based on Automotive Industry processes



- Process derived from fabrication of P/M steel automotive components
- Highest material yield
- Secured process stability and component consistency from part to part and from batch to batch
- Maximum precision
- Industrial scalable process

Plansee/GTP: Two industrial lines in operation for series production of P/M SOFC components



Pilot line for SOFC Interconnect production at the Plansee headquarters in Reutte (Austria)



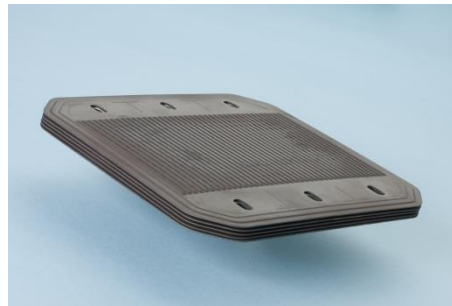
Industrial lines for SOFC Interconnect production at GTP Towanda (USA)

- Plansee - Company overview
- Department ISWB – Growth option SOFC
- **Products and services for the SOFC industry**
- Summary

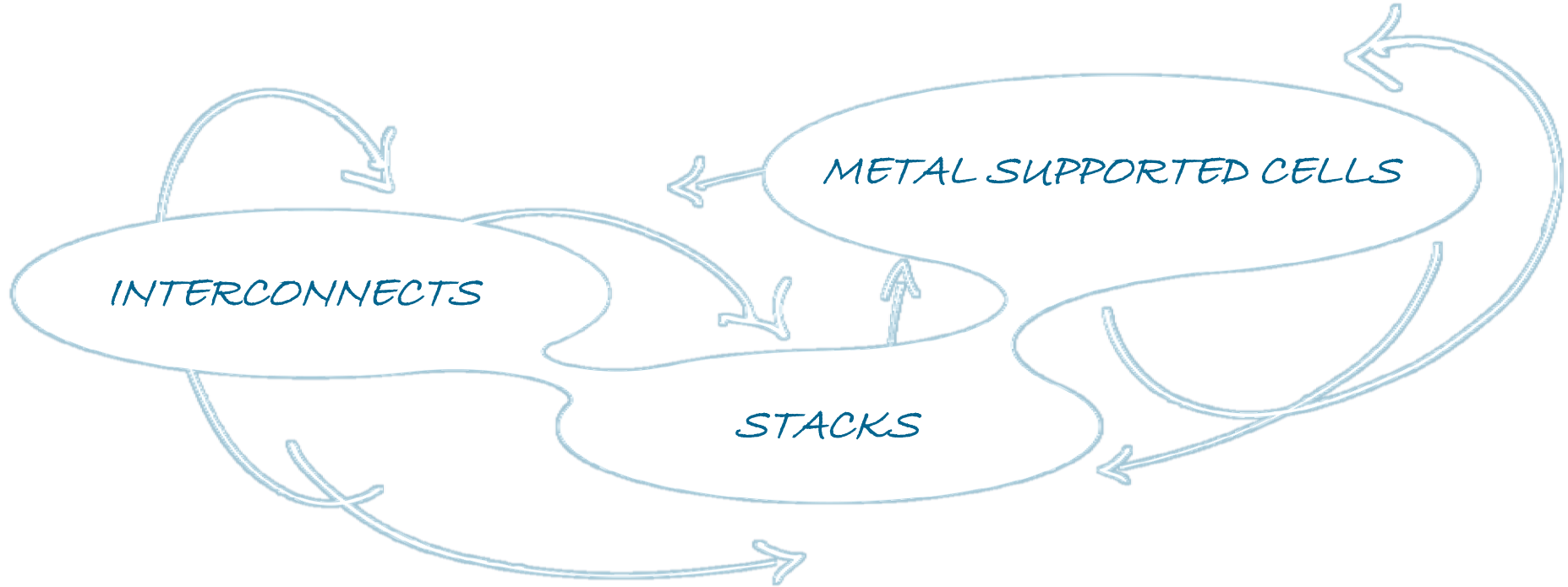
Cr- and FeCr-based Interconnects

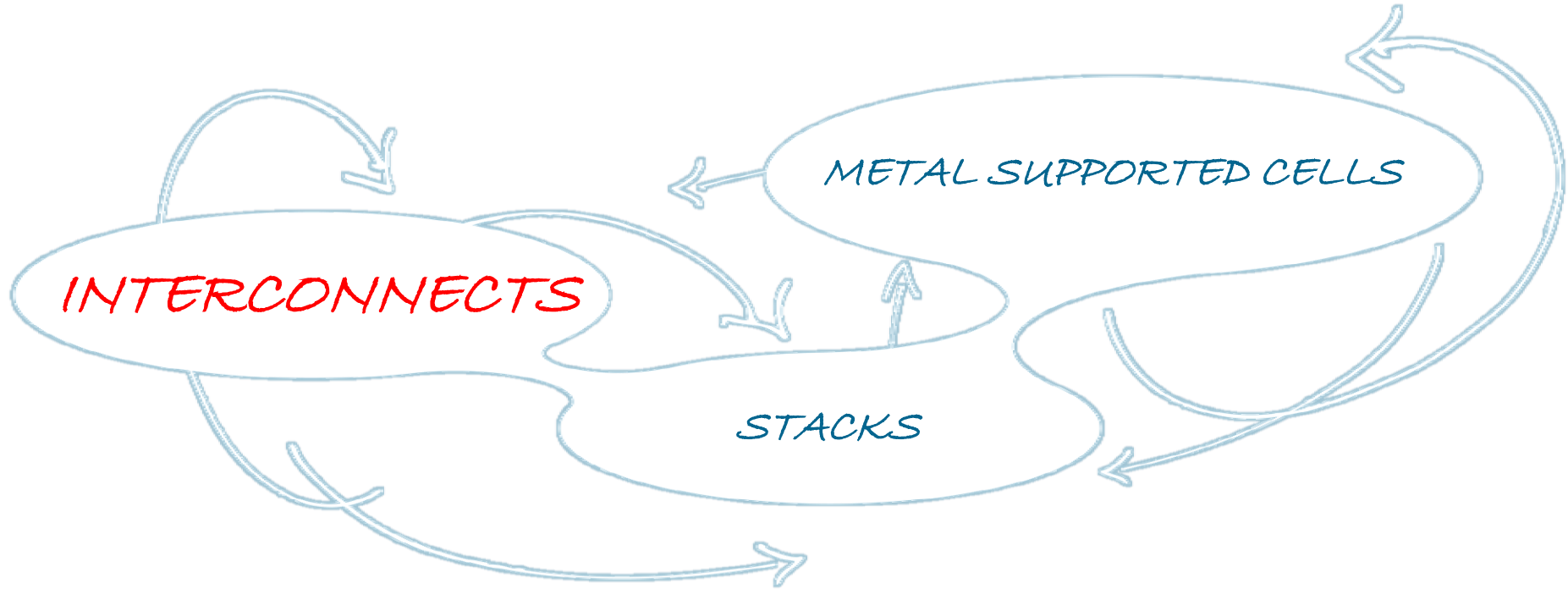
Metal-supported SOFC

Hydrogen Separation Membranes

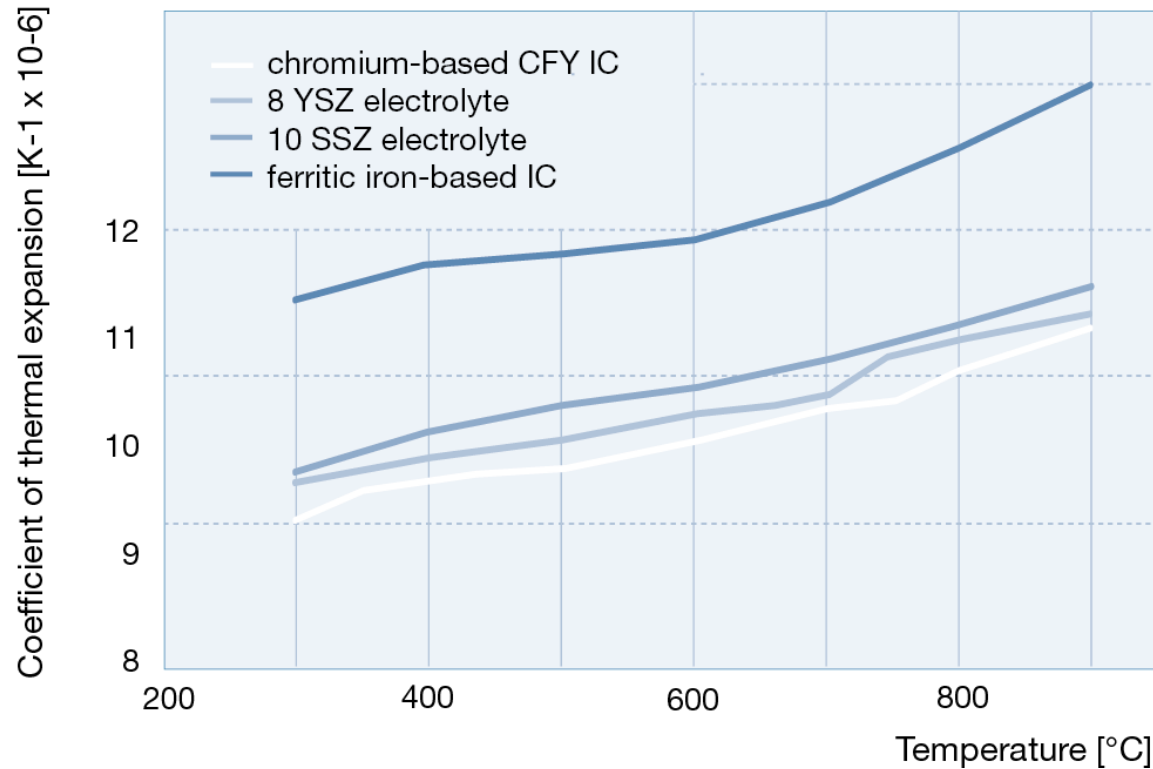


Our support for your success





Coefficient of thermal expansion



Powder metallurgically produced stack components for SOFC made by Plansee

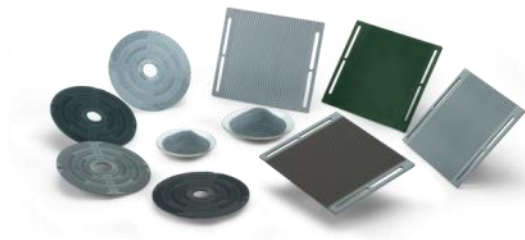
As a leading supplier of powder metallurgical high performance materials, we develop and manufacture customized, coated ready-to-stack metallic SOFC components

CFY-Interconnects for ESC

- 150 x 130 mm²
- Alloy adapted to CTE of electrolyte
- Operation temperature up to 1,000 C°

FeCr-Interconnects for ASC

- 180 x 180 mm²
- Alloy adapted to CTE of anode
- Operation temperature up to 850 C°



Cr- and Fe- base alloys for SOFC interconnects.

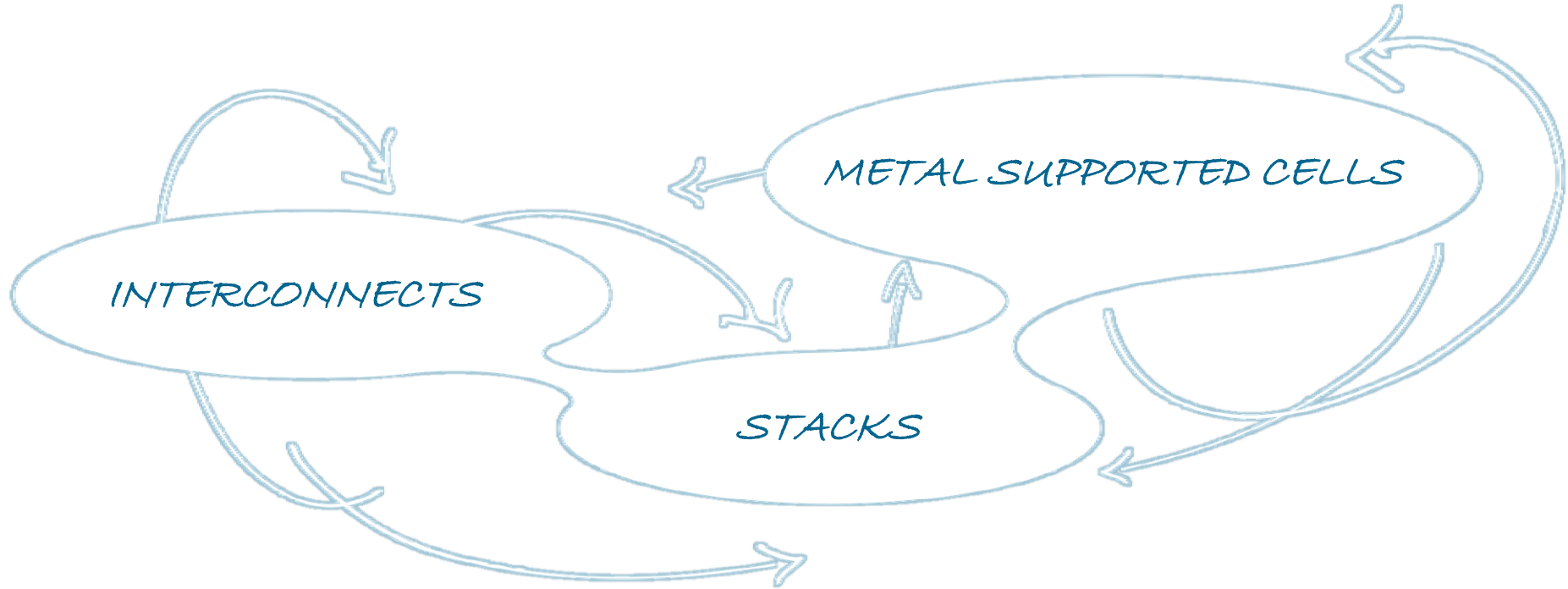
Suitable for ESC- ASC- or MSC- applications

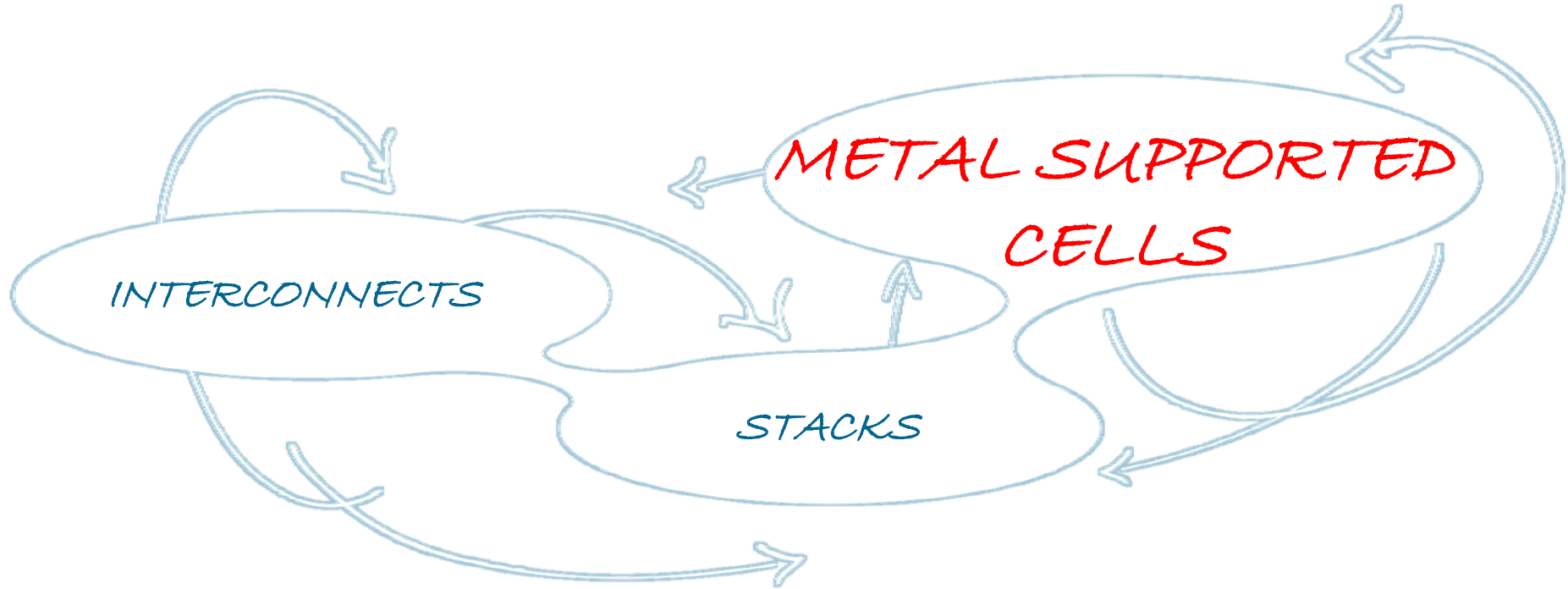
What we are able to offer:

- Prototyping, Pilot production, industrial production of customer specific design
- Independent anode and cathode structure due to pressing process, e.g. cross flow
- Dimensional accuracy, in particular for large-scale production
- High material yield, low costs



Our support for your success

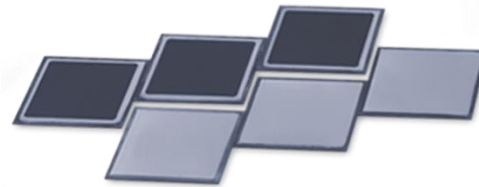
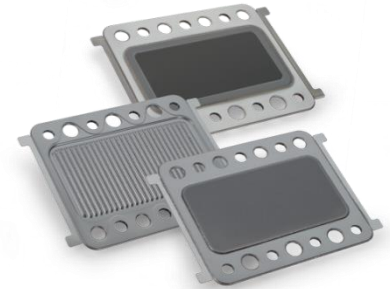




ITM-parts for mobile applications

Oxide Dispersion Strengthened alloy

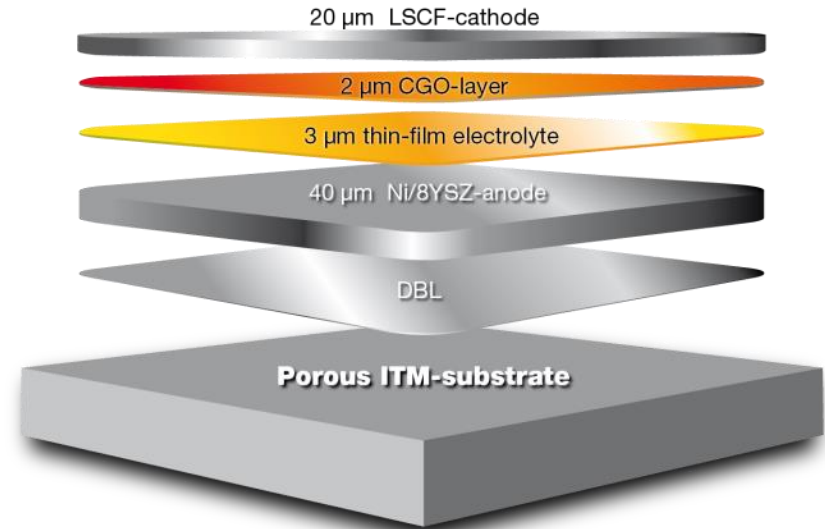
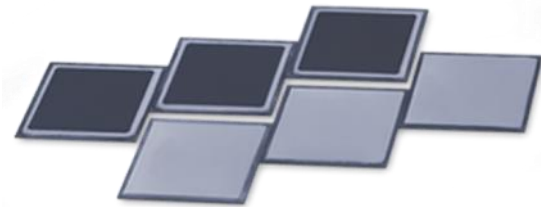
- Porous ITM substrates for development and pilot production of Metal Supported SOFC Cells (MSC)
- In cooperation with Linde: development and production of tubular porous substrates for Pd-membrane modules for H₂ separation
- Dense ITM sheets for interconnects and other stack components



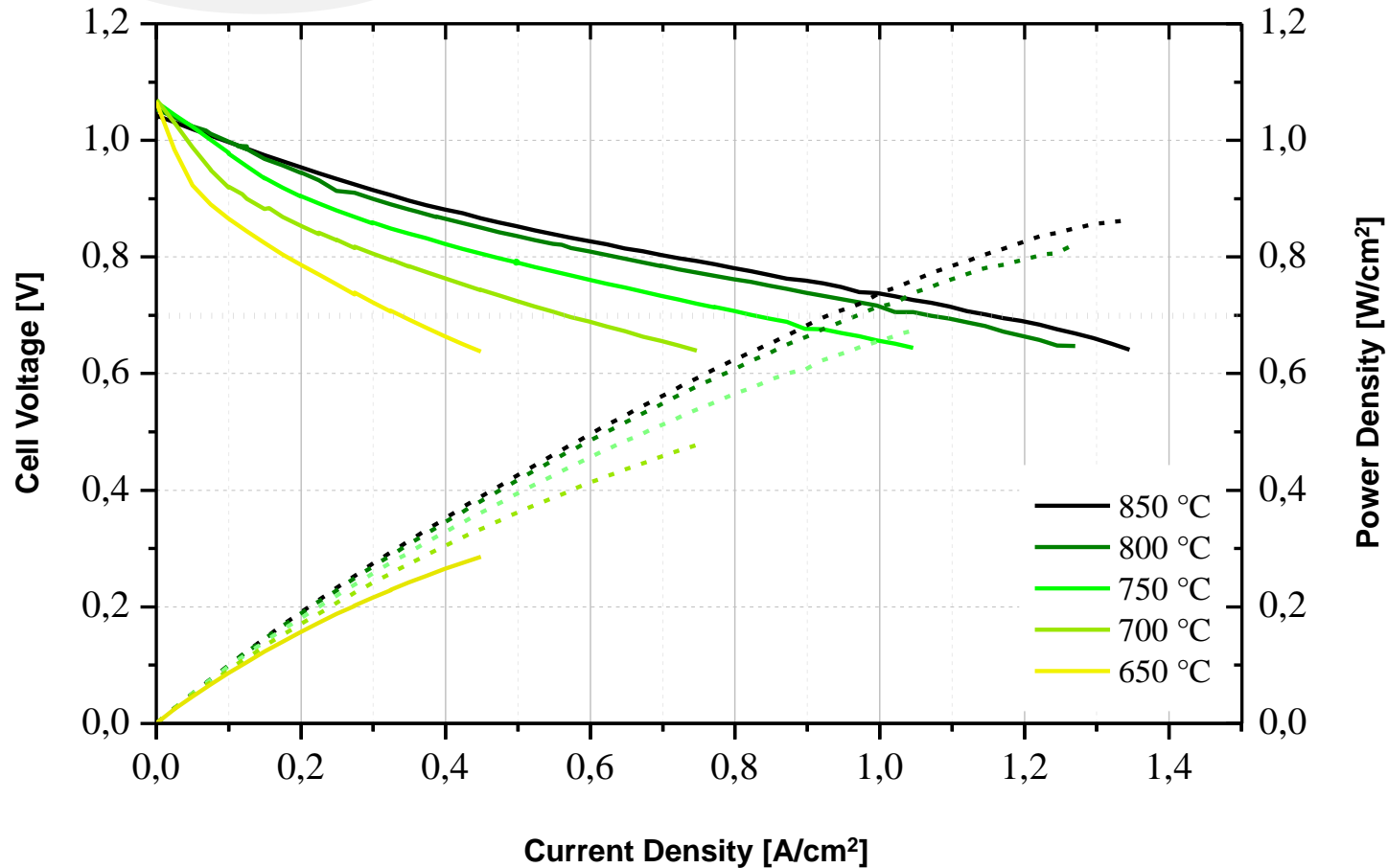
The next generation of SOFC MSC for lightweight-design applications

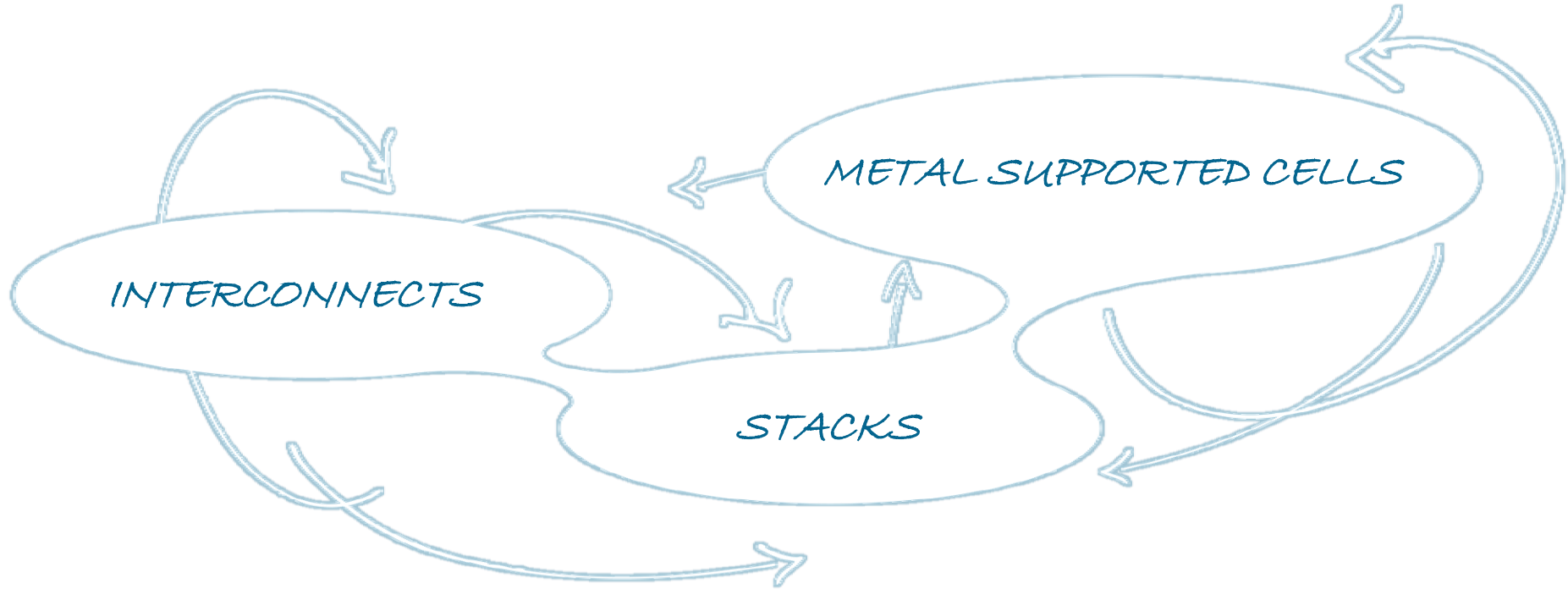
- + high power performance
- + resistant to frequent redox and thermo-cycles
- + fast start-up time
- + operation between 650-850 °C

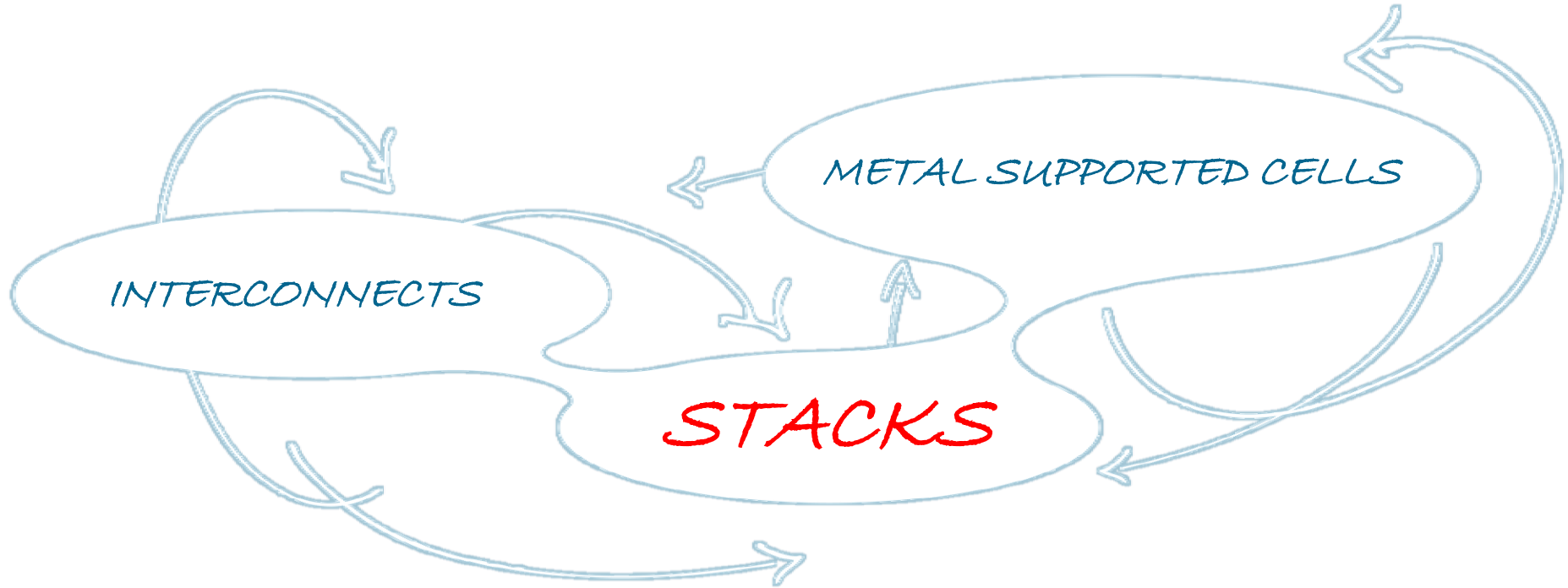
= MSC made by Plansee



Metal Supported Cell (MSC) Electrochemical Performance



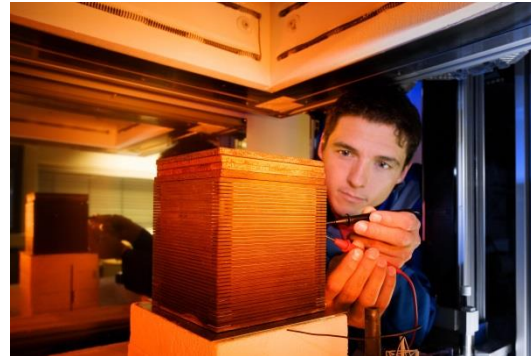




... for stationary applications

CFY/ESC Stack-Development type MK351/MK352

Cooperation with Fraunhofer IKTS



Development & Promotion

- The team Fraunhofer IKTS and Plansee are cooperating since more than a decade to advance the SOFC technology via a so-called CFY/ESC type stack called Mk351 and MK352
- Cr-Fe-Y (CFY) interconnects as main stack components produced by Plansee
- Stack design and stack assembly in a pilot manufacturing realized by Fraunhofer IKTS
- Plansee and Fraunhofer IKTS together offer prototype stacks to interested industrial companies for evaluation issues and small demonstration series
- Stack design is licensable

MK352 ESC / CFY Stacks

30-layer stack in hot box operation

ESC type: 10 Sc1CeSZ Electrolyte

Power: typ. 800 W
($H_2/N_2 = 40/60$,
 $\eta_{fu} = 75\%$, $T_{max} < 850\text{ }^\circ\text{C}$)

Dimensions: 150 x 130 x 110 mm³

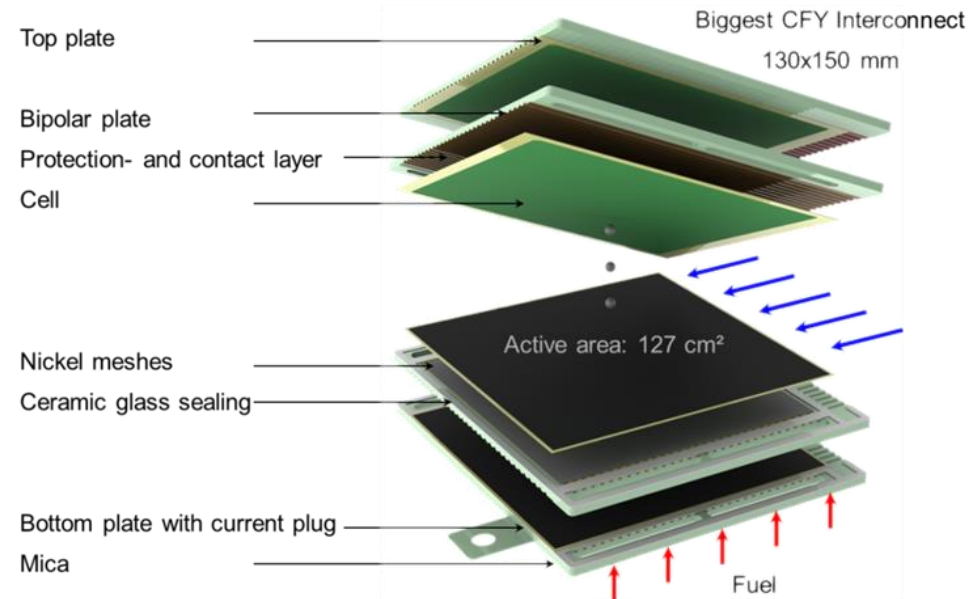
Weight: 10.75 kg

Specific Power: 75 W/kg or 372 W/l

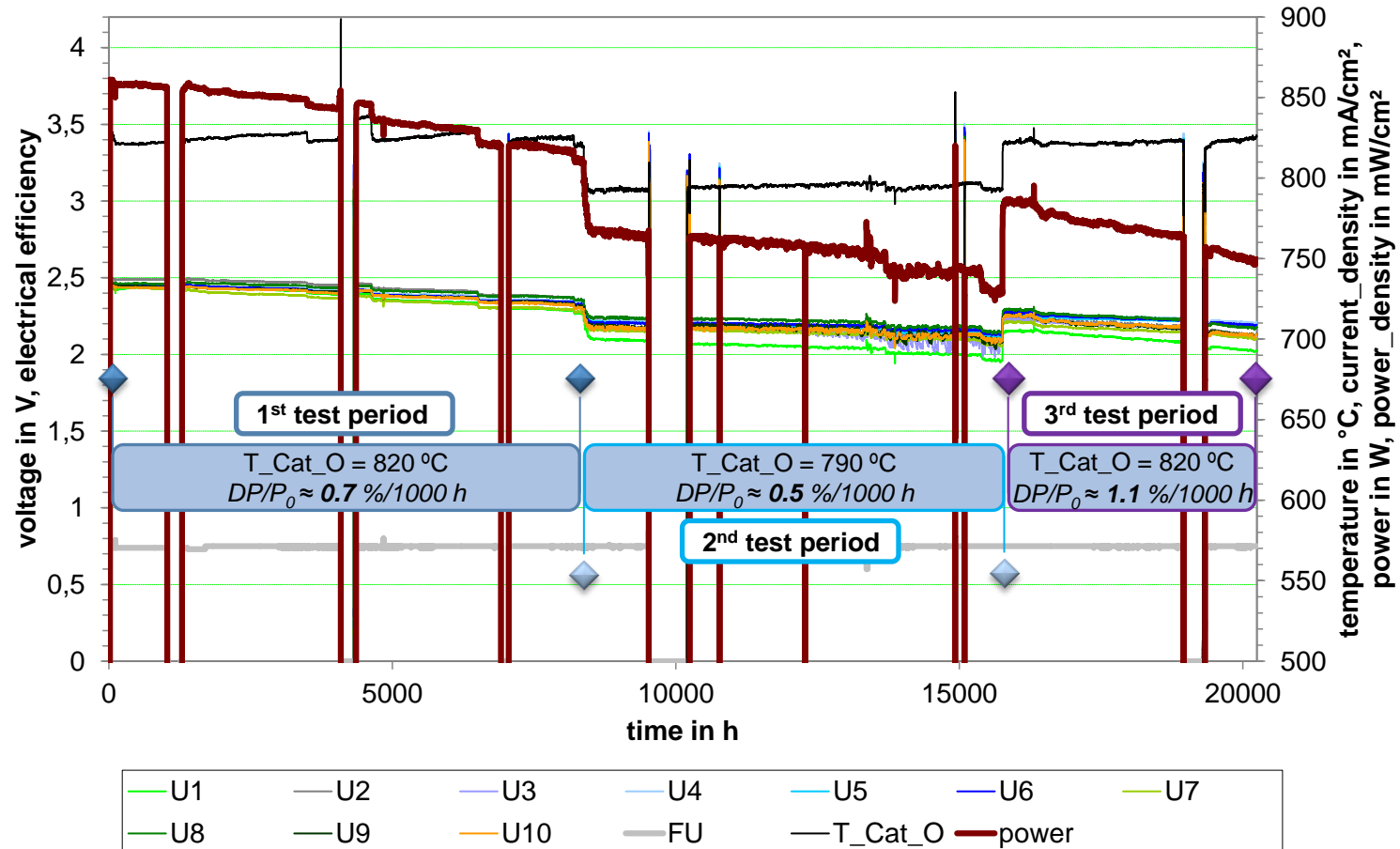
Operational Range: 800 – 900 °C

Long term stability: $\Delta P/P_0 < 1\%/1.000\text{h}$

Fraunhofer
IKTS



Long-term hot box test of MK351 stack – 30 layers



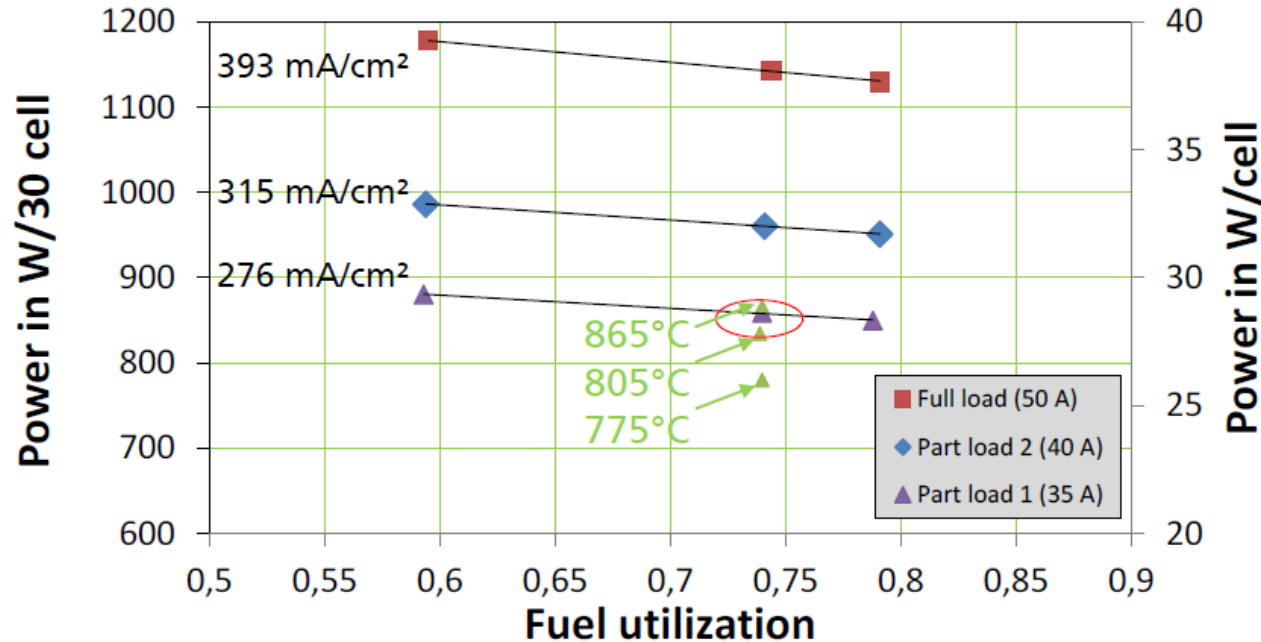
Performance Map of MK352 stack – 30 layers

30-cell stack in a hotbox: constant power point

Fuel: 40 % H₂ in 5% H₂O and N₂

Air: 100 sl/min

T_{Cat_o}=830°C – 840°C



→ At reference point 850 W/30 cell stack

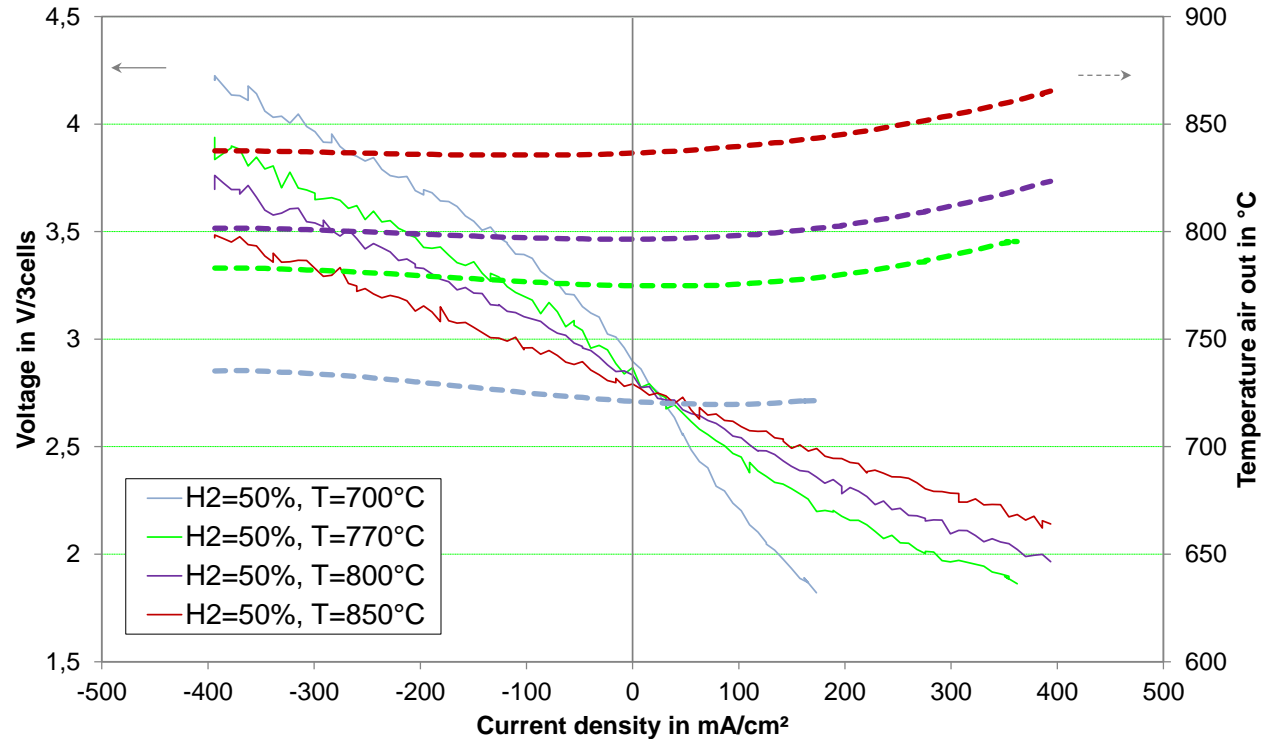
→ Up to 1200W/30 cell stack possible

Stack results MK351

SOEC/SOFC performance map

30-cell stack furnace operation

- $T_{\text{furnace}} = \text{const}$
- Fuel: 50% H₂ in 50% H₂O
- Air: 100 sl/min

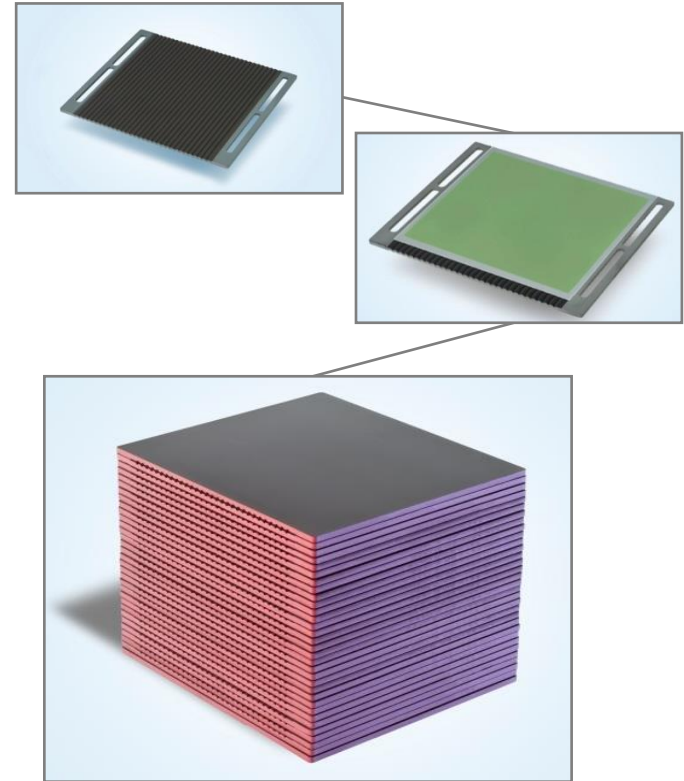


➔ Stable behavior in SOEC/SOFC operation mode in a wide temperature range (700 – 850°C)

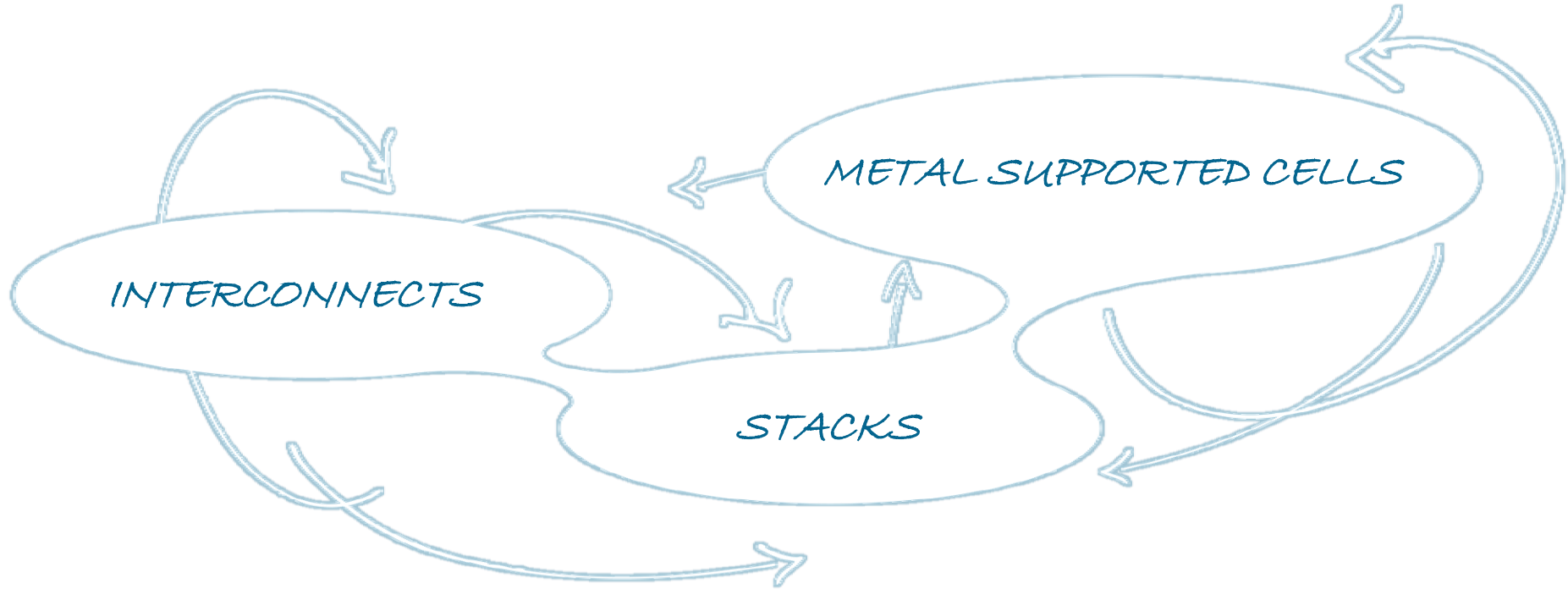
Licensing option of a SOFC stack technology offers a proven cutting-edge technology at low risk

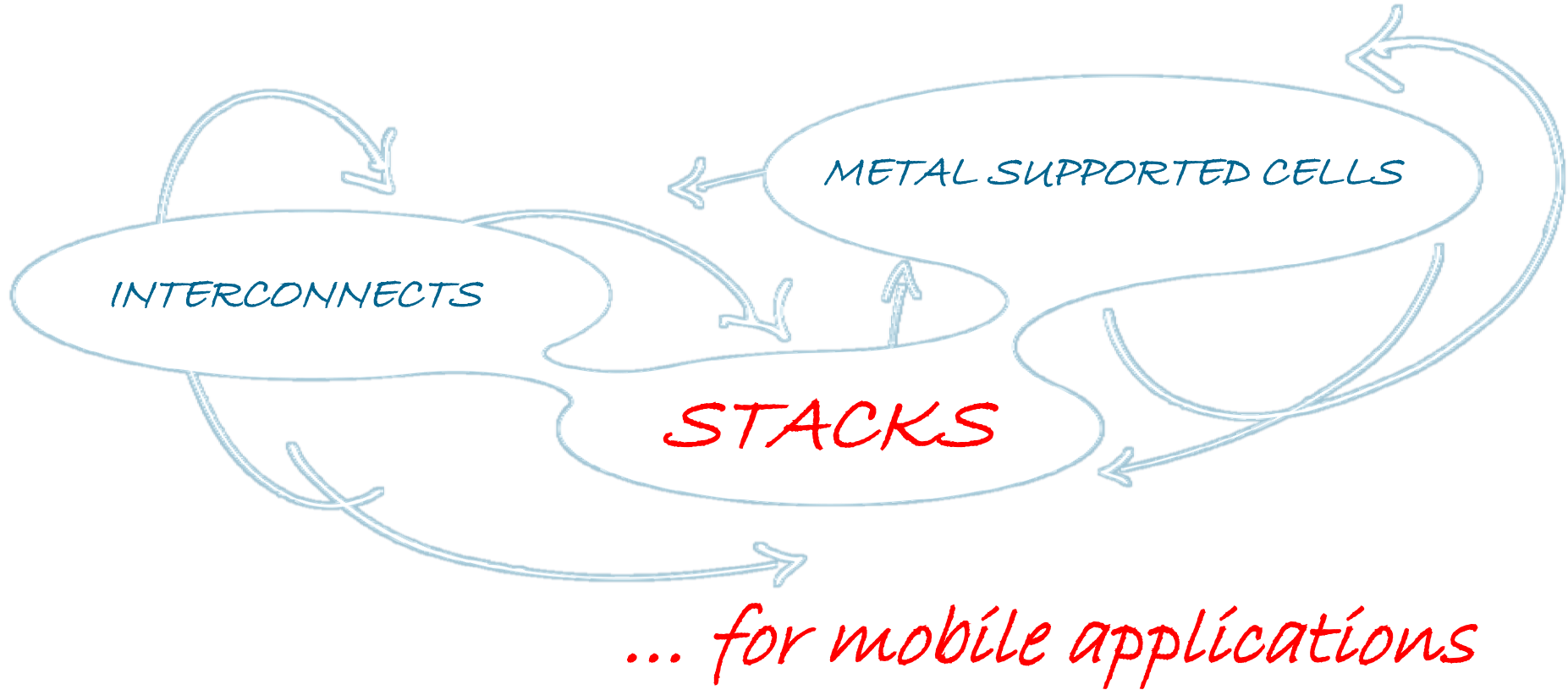
Key Facts

- SOFC stack technology with an Electrolyte Supported Cell (ESC) concept called “**CFY Stack**”
- CFY stack and cell technology is based on more than 10 years of continuous R&D efforts by Fraunhofer IKTS and Plansee SE leading to a broad range of experience, know-how and IP
- CFY stack has already proven its unique superiority in a wide scope of applications
- CFY stack technology is supported by an established stack pilot line and a reliable and scalable supply chain for components
- Flexible models are available for licensing and technology transfer



Our support for your success





MSC Technology for Mobile Applications



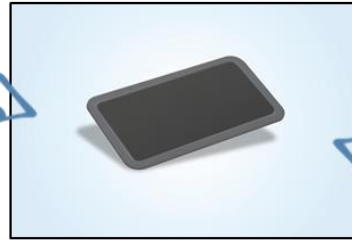
APU Systems



Range Extender



Marine Applications



Leisure

→ **MSCs enable robust light-weight designs and high performance**

Metal Supported Stack Development „MeStREx“ – Metallic Stack for Range Extender

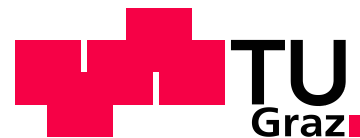
Presented work is funded in the FFG program „Mobilität der Zukunft“
under Grant Agreement 850356 „MeStREx“, an initiative of
Bundesministerium für Verkehr, Innovation und Technologie (bmvit) Austria



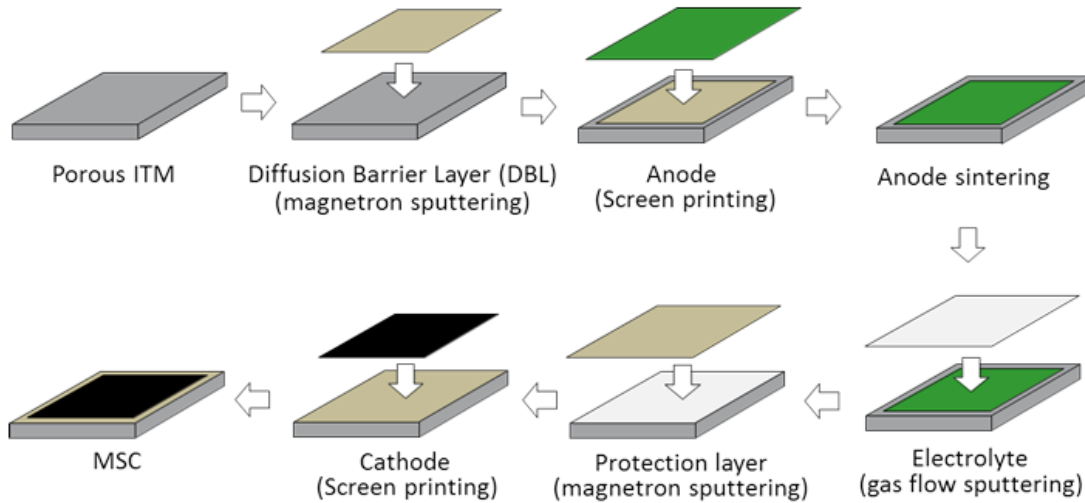
FFG



NISSAN GROUP
OF EUROPE

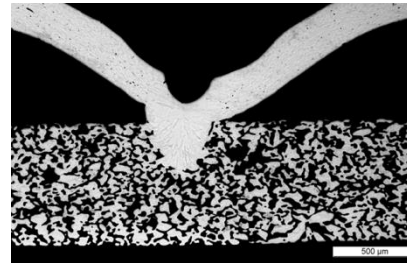
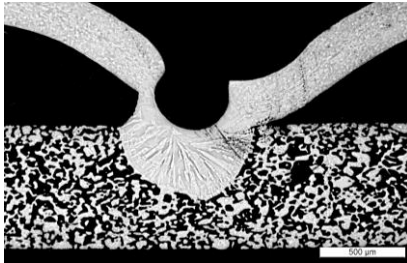


Processing of Plansee MSCs

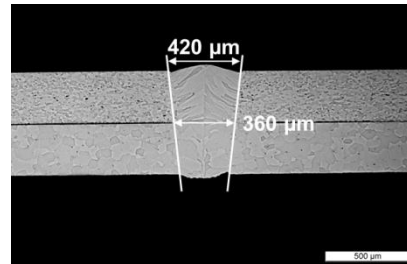
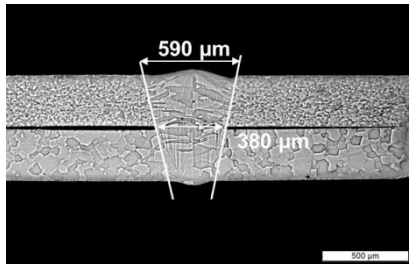


Repeat Unit Manufacturing – Process Development

■ Anode side contacting



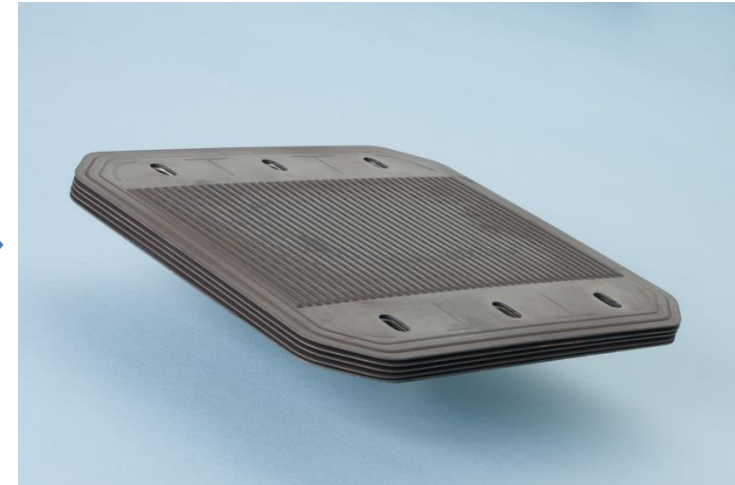
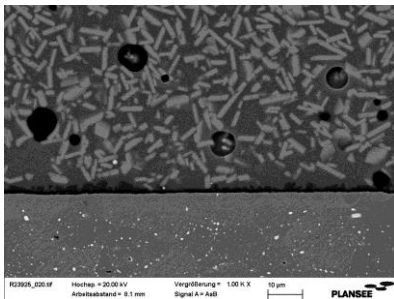
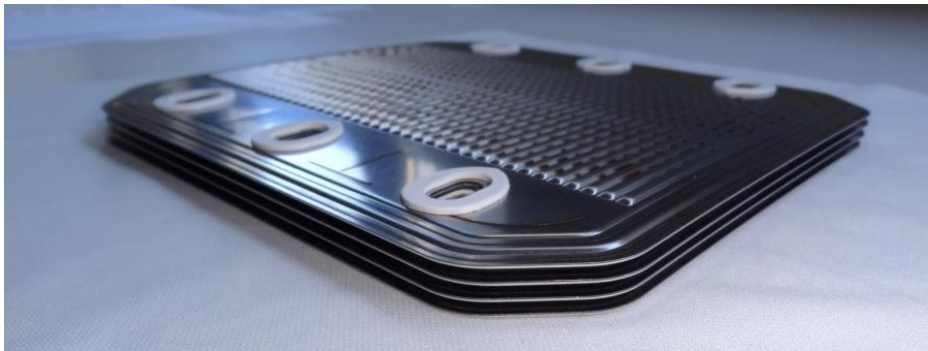
■ Interconnect – frame welding



→ **Laser welding allows reduced energy input for minimum distortion**

MSC Stack Development

- Sealing development – stack building



→ **Glass sealing as best choice for gas-tight repeat unit connection**

- Plansee - Company overview
- Department ISWB – Growth option SOFC
- Products and services for the SOFC industry
- **Summary**

Summary

- Plansee is international experienced in the SOFC business for more than 20 years.
- Plansee is able to support customers in the development and evaluation phase with fast prototyping iterations.
- Plansee offers subsequent pilot scale production and transfer to industrial lines
- Pilot line for interconnects (P/M CFY-alloy or P/M FeCr-alloy) with a capacity of approx. 500.000 parts/year available.
- Two industrial lines for interconnects (P/M CFY-alloy) in operation.
- Pilot production for Metal Supported Cells (MSC) established.
- Stack development activities with partners.



The logo for PLANSEE, featuring the word "PLANSEE" in a bold, grey, sans-serif font. To the right of the text is a graphic element consisting of three overlapping, rounded blue shapes that resemble a stylized molecule or a cluster of atoms.

PLANSEE

The words "STRONG METALS" are written in a large, bold, blue, hand-drawn style font. The letters are thick and have a slightly irregular, sketchy appearance. The text is positioned in the lower-middle part of the slide, with "STRONG" on the left and "METALS" on the right, separated by a wide space.

STRONG METALS