A novel fuel processing platform for micro-scale solid oxide fuel cells

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Outline

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- Concept of the µSOFCs system
- Concept of the fuel processing platform for µSOFCs
- Platform fabrication
- Thermal characterization
- Fuel processing characterization
- Conclusion
- Outlooks

Concept of µ-SOFCs

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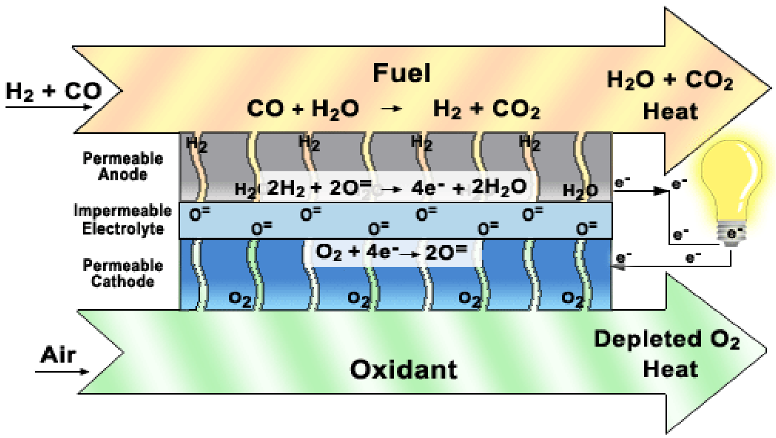
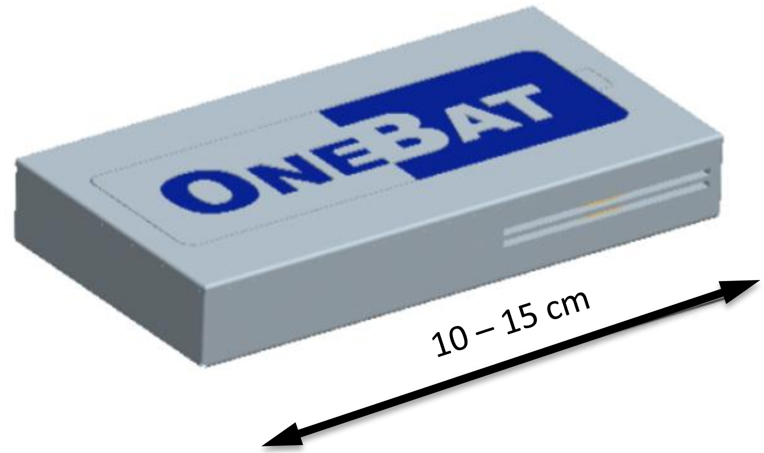
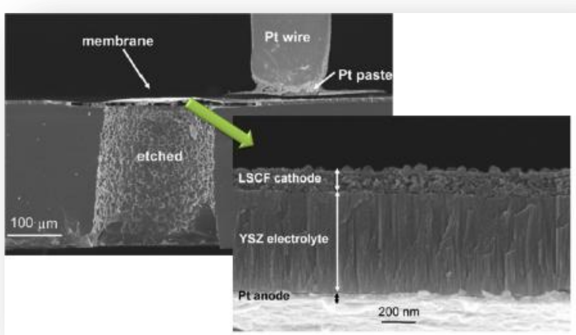
Solid oxide fuel cell



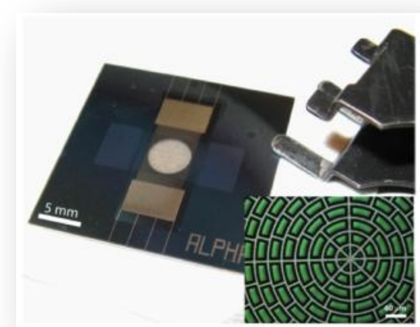
ONEBAT µ-SOFC system





Foturan or Silicon base µSOFC membrane

2008 Bieberle, J. Power Sources

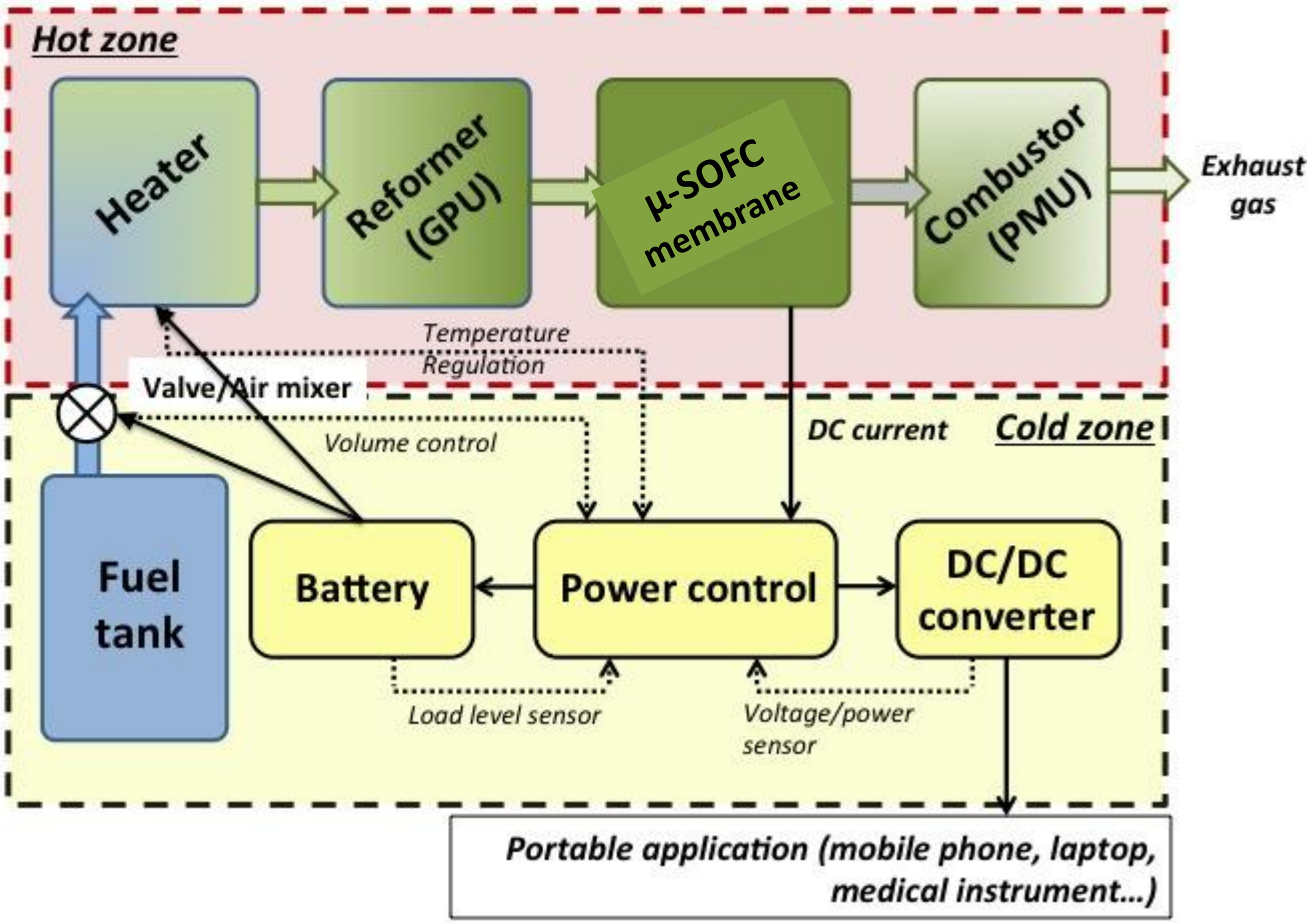


Ni grid anode supported µSOFC membrane

2008 Rey-Mermet, Solid State Ionics

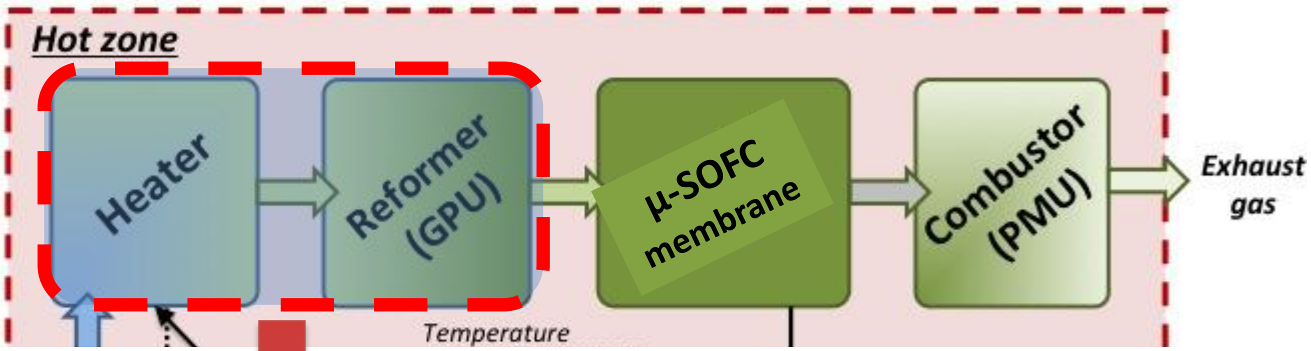
Concept of µ-SOFCs

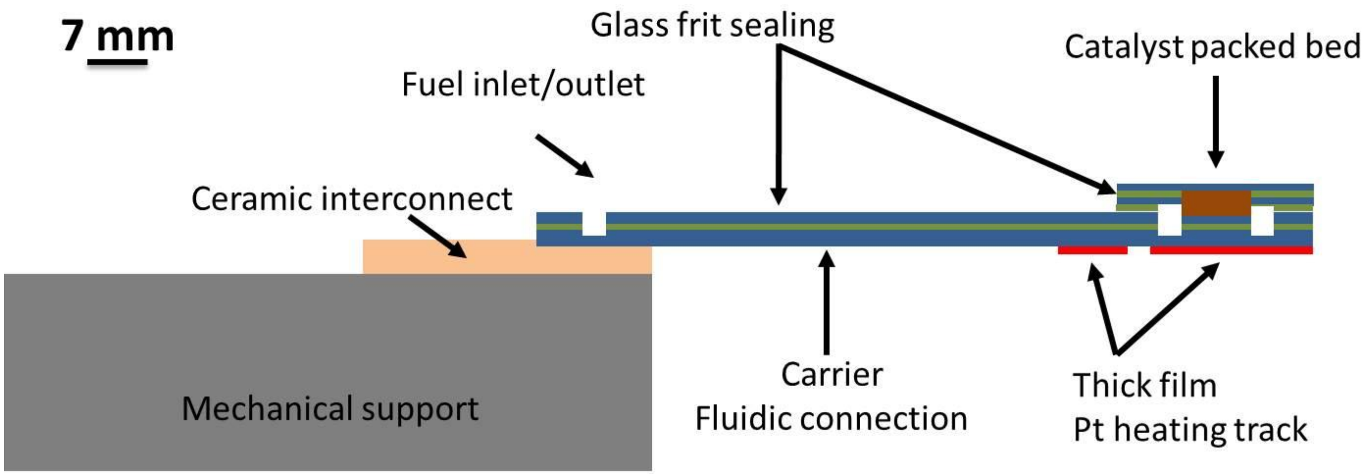
Concept of the µ-SOFC system



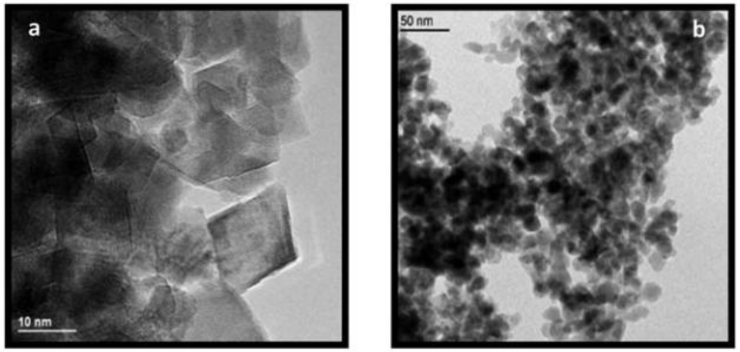
Concept of μ-SOFCs

System concept of μ-SOFCs





Catalyst – hydrocarbon reforming



Transmission electron micrographs of the as-prepared 2 wt% Rh/$Ce_{0.5}Zr_{0.5}O_2$

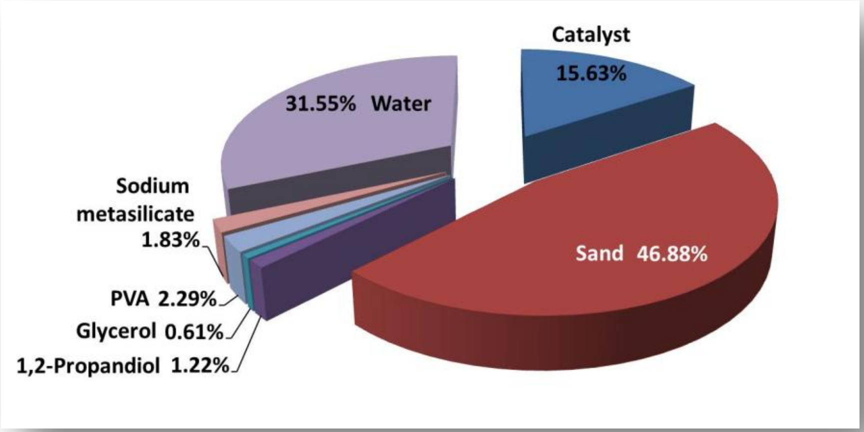
2008 Hotz, Chem. Eng. Sci.

Partial oxidation (POX) of butane

$C_4H_{10} + 2O_2 \rightarrow 5H_2 + 4CO$

- Exothermic reaction
- High syngas (CO & H_2) production by Rh-metal catalyst

Catalyst paste composition

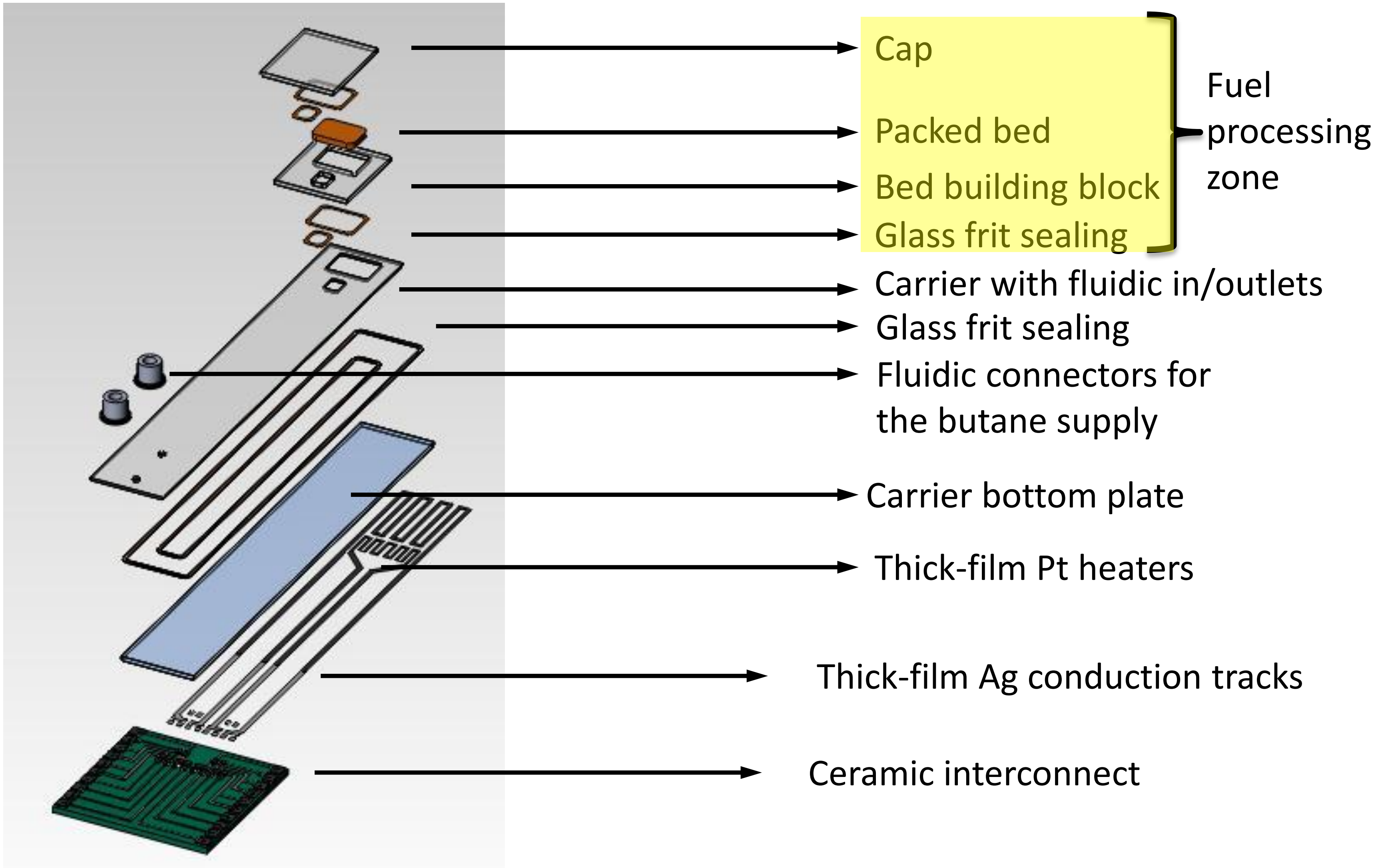


Sand: Avoiding hot spots and porosity enhancement

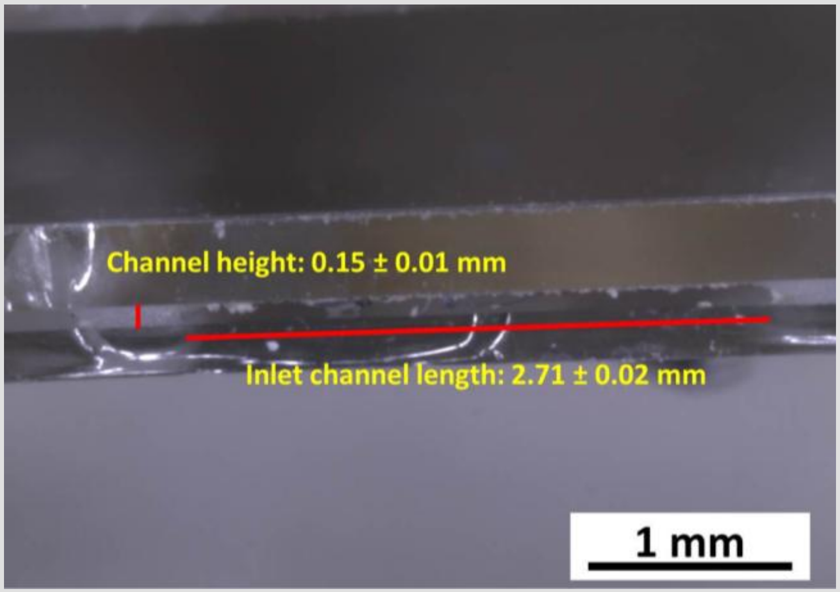
Ceramic binder: Packed bed adhesion

Polymer binder: Solid dispersion in the paste

Thick-film fuel processing platform



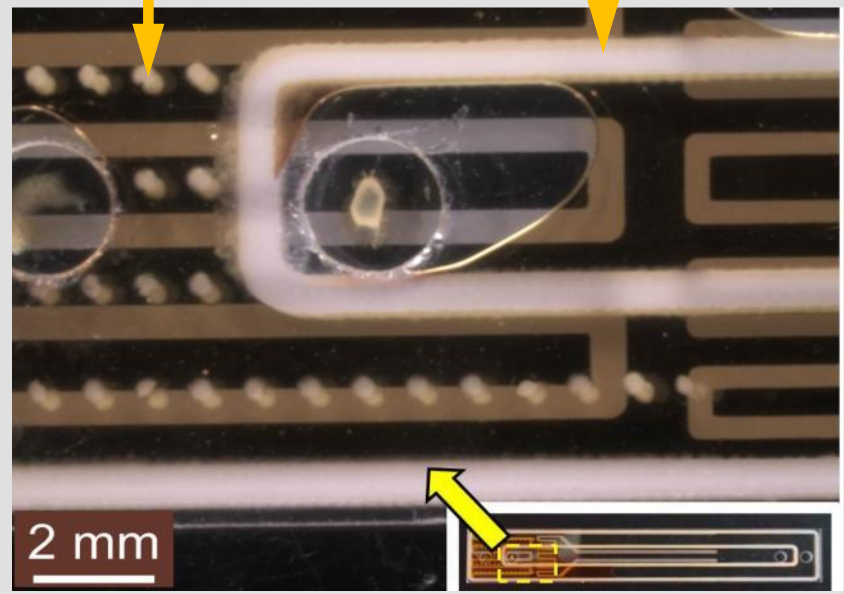
Fuel processor – structure characterization



Dimension of fluidic channels in the carrier

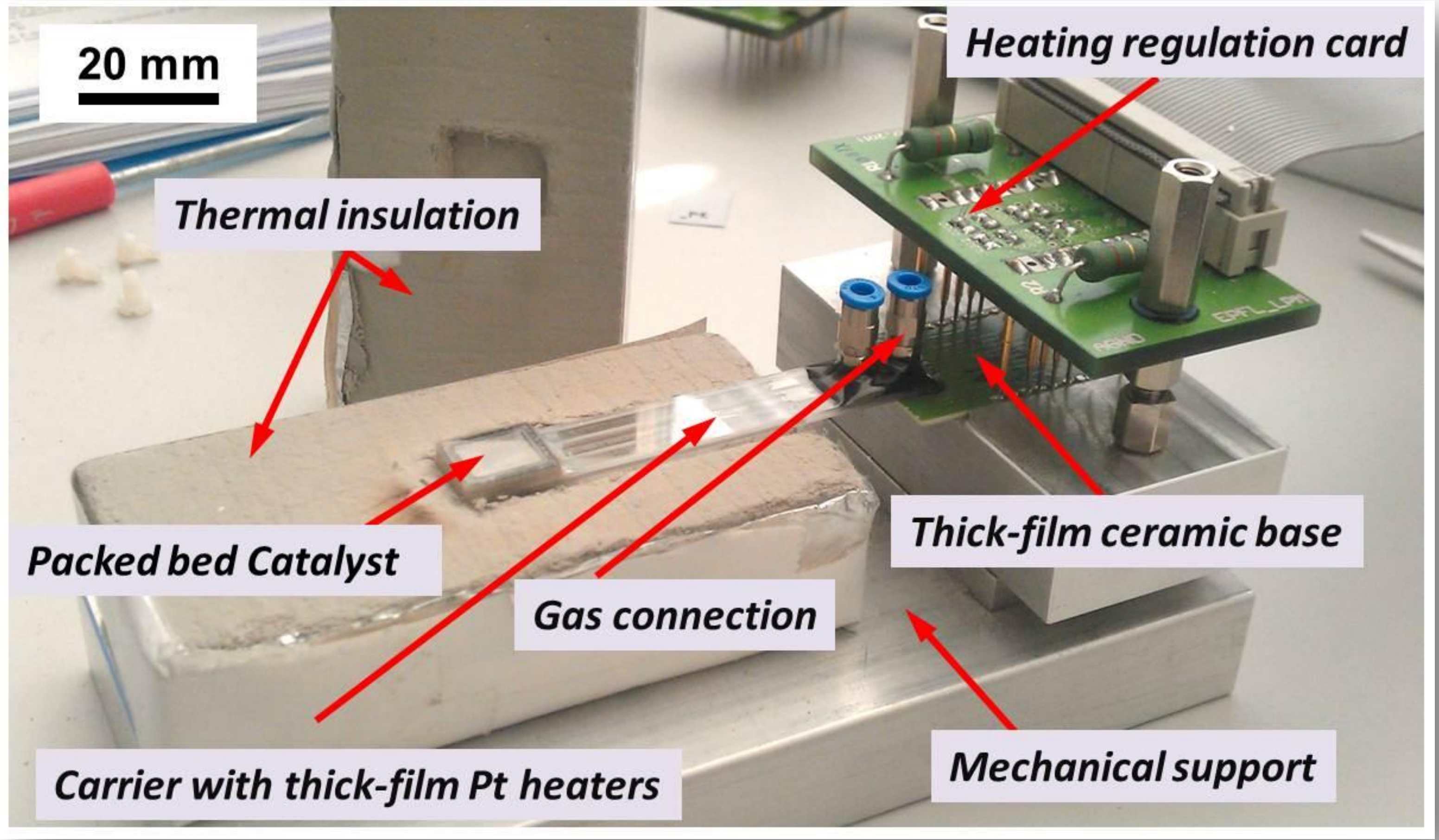
Carrier

Glass frit sealing in carrier



Hermetic glass frit sealing in the carrier confirmed by the dye penetration method

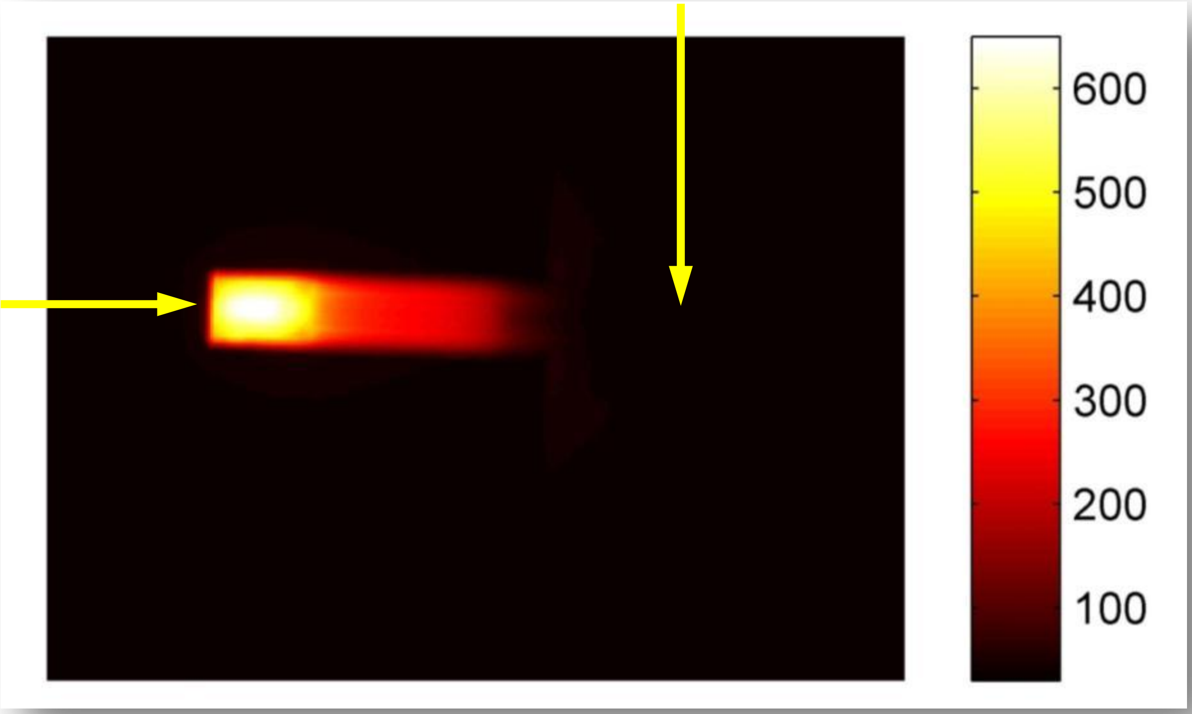
Concept of the fuel processing test platform



Thermal characterization

Electrical/fluidic connection (cold zone, < 50 ˚C)

Catalytic bed on reformer (hot zone, > 600˚C)



An infrared image of the fuel processing platform.
Voltage supply: 22 V; no gas flow

Fuel processing – POX of butane

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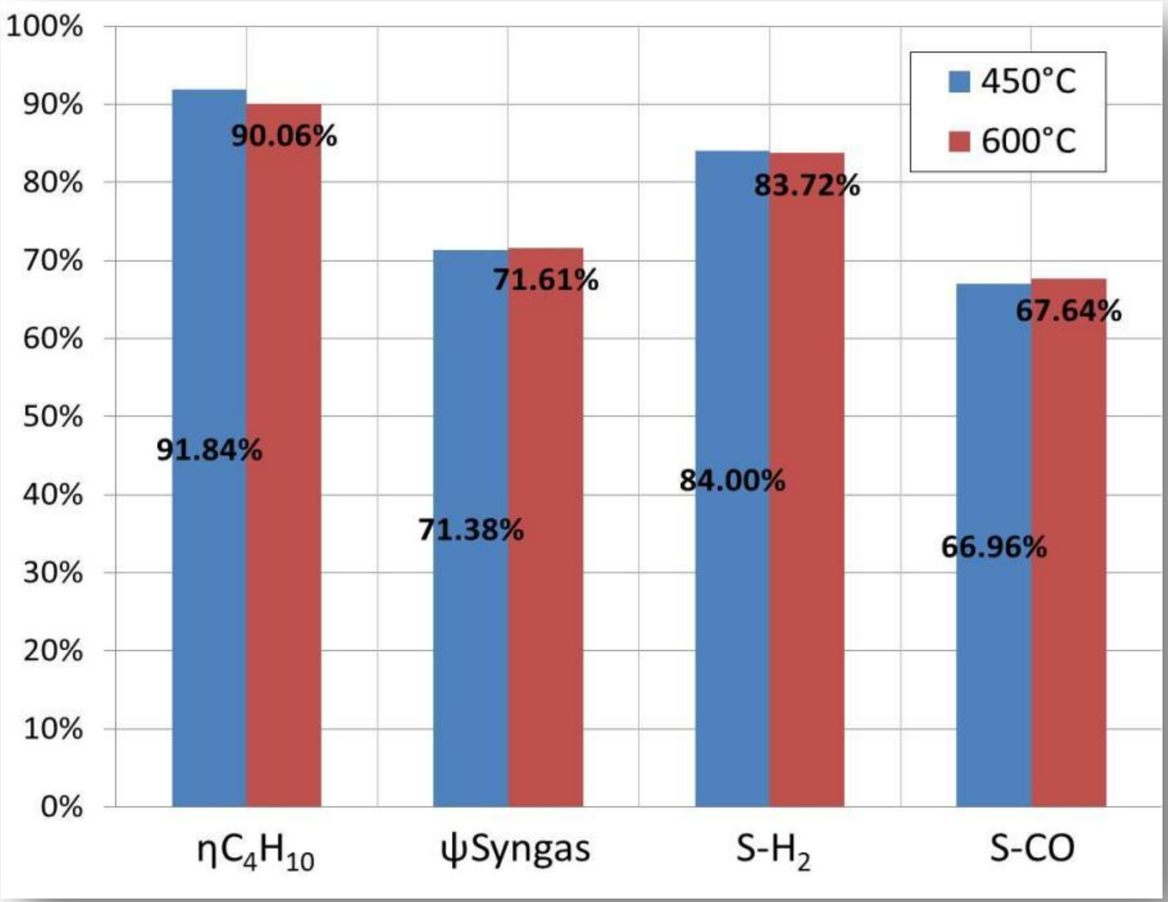
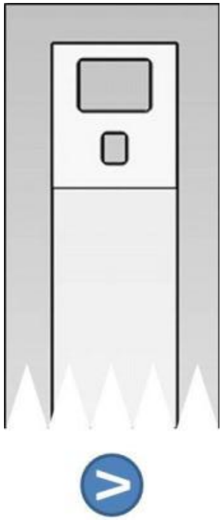
Butane reforming performance vs. reforming temperature



Pressure drop

@450˚C : 146 mbar
@600˚C : 185 mbar



Flow rate of butane/air mixture: 25 ml/min
Molar ratio of the butane /air mixture : Butane : Air = 1: 12.5

Fuel processing – POX of butane

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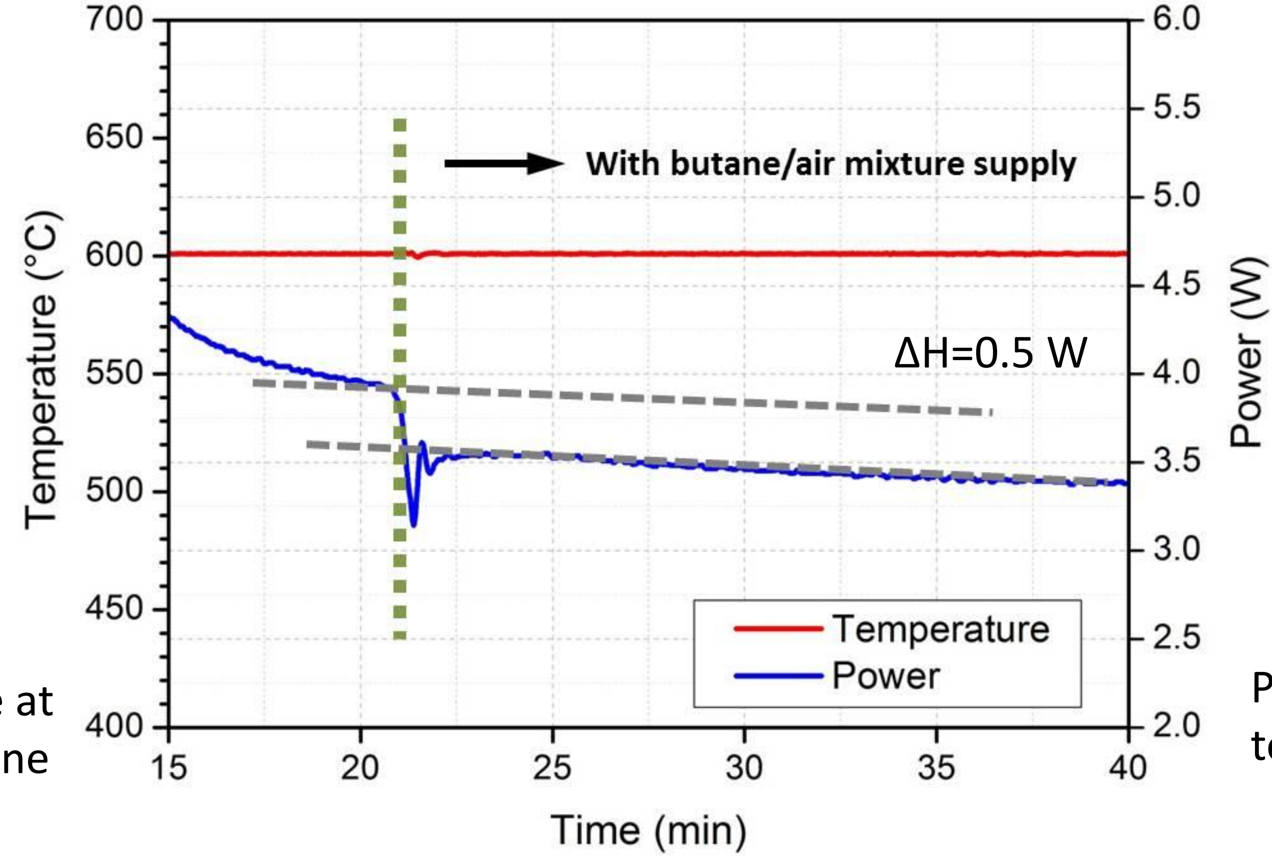
Characterization of the partial oxidation of butane



Temperature at reforming zone

Power supplied to the heaters

Conclusion

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- A meso-scale fuel (butane) processing system was developed for the μ-SOFCs testing platform
- The system integrates electrical heating, temperature sensing and fluidic function.
- The exothermic behavior of butane reforming (POX) is observed as an electrical power reduction while keeping at a constant temperature
- The butane reforming reached about 91% of conversion and 71% of syngas yield at 450˚C of starting temperature

Future work

- Detailed reforming process study (e.g. impact of different starting temperature, flow rate of butane/air mixture)
- Reduction of pressure drop in the fuel processor
- Thermal self-sustain study
- The μ-SOFC integration

Acknowledgement

EPFL
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LPM

LC EPFL

ONEBAT

csem

ETH LTNT
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

FNSNF
FONDS NATIONAL SUISSE
SCHWEIZERISCHER NATIONALFONDS
FONDO NAZIONALE SVIZZERO
SWISS NATIONAL SCIENCE FOUNDATION

Thank you!

Thick-film fuel processor

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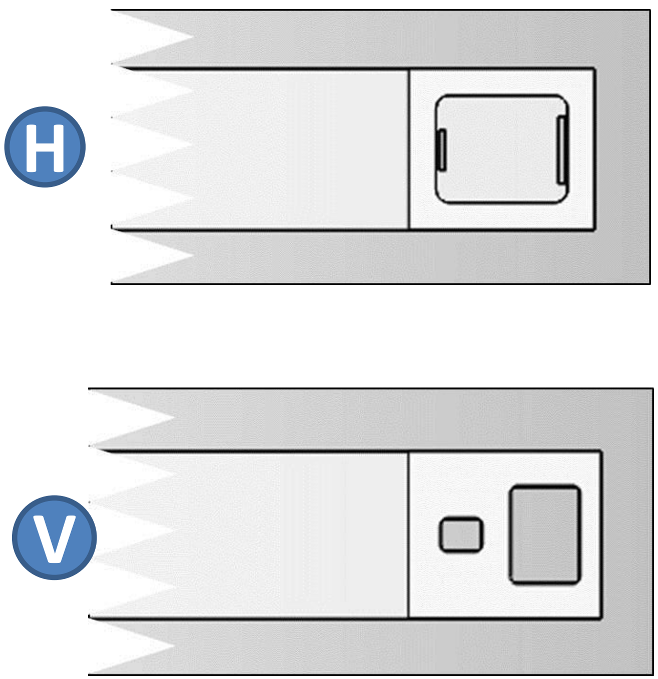
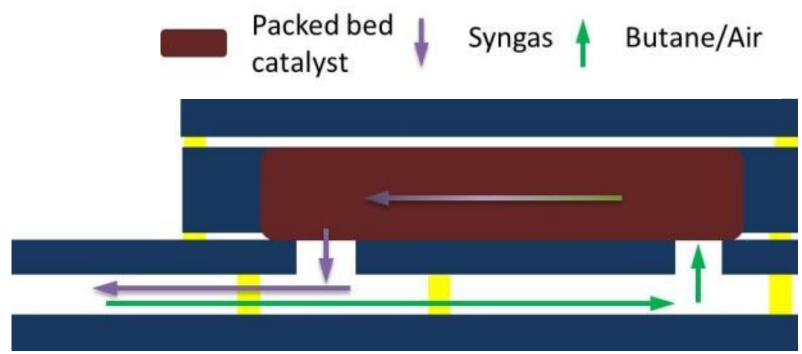
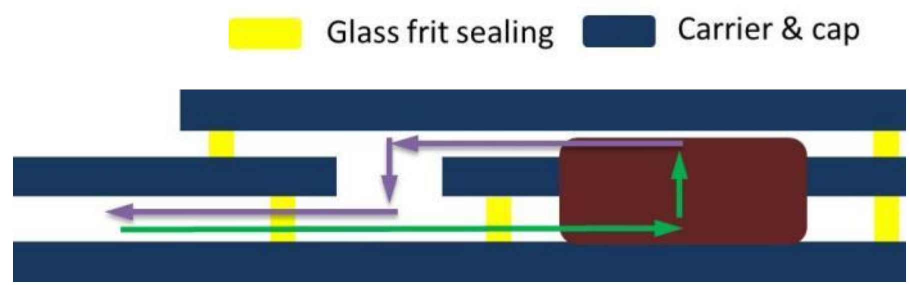
Fuel processing zone





Horizontal flow

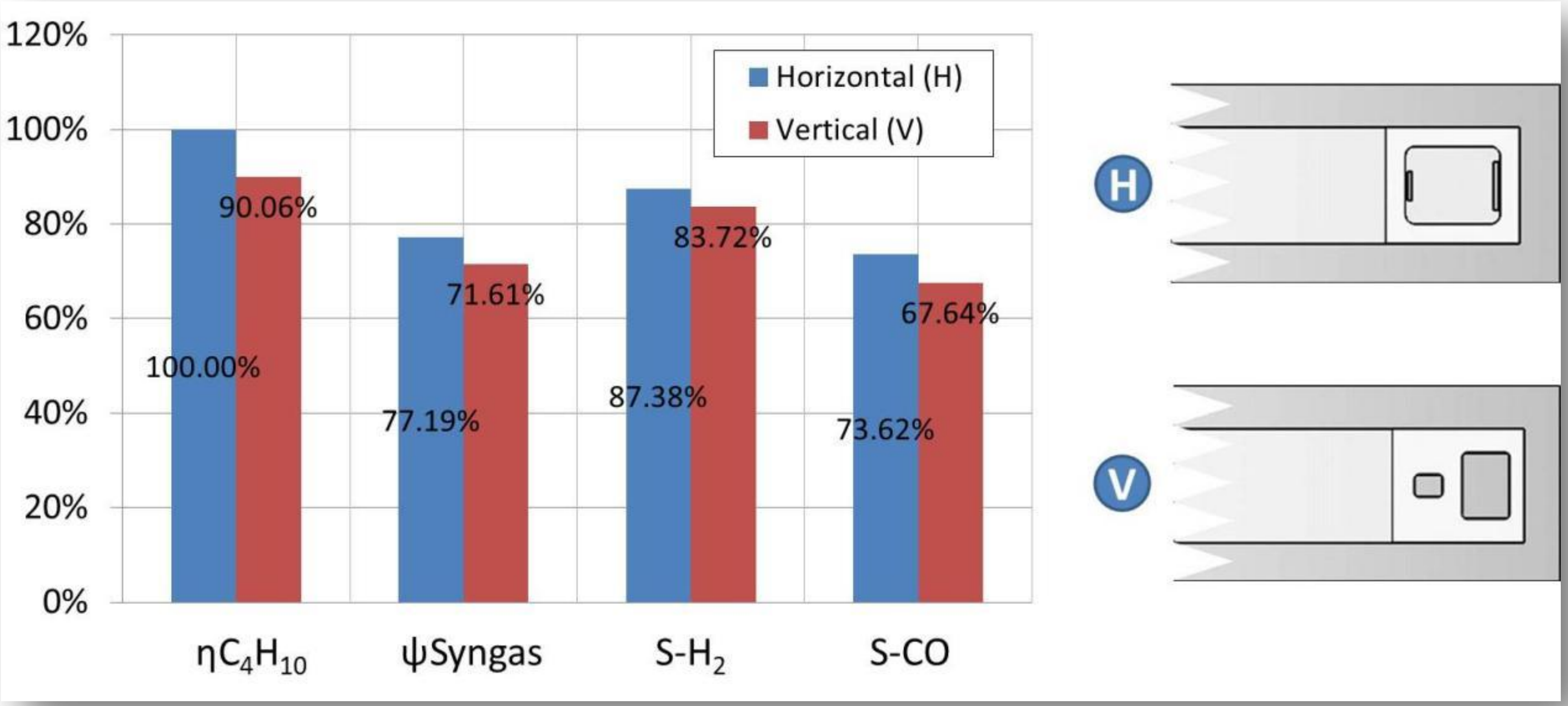


Vertical flow

Flow direction	Bed Volume	Length of gas flow through bed
	mm^3	mm
Horizontal	96.04	9.8
Vertical	75.3	2.1

Fuel processing - POX of butane

Butane reforming efficiency comparison
Horizontal flow vs. Vertical flow in catalyst packed bed



Fuel processing - POX of butane

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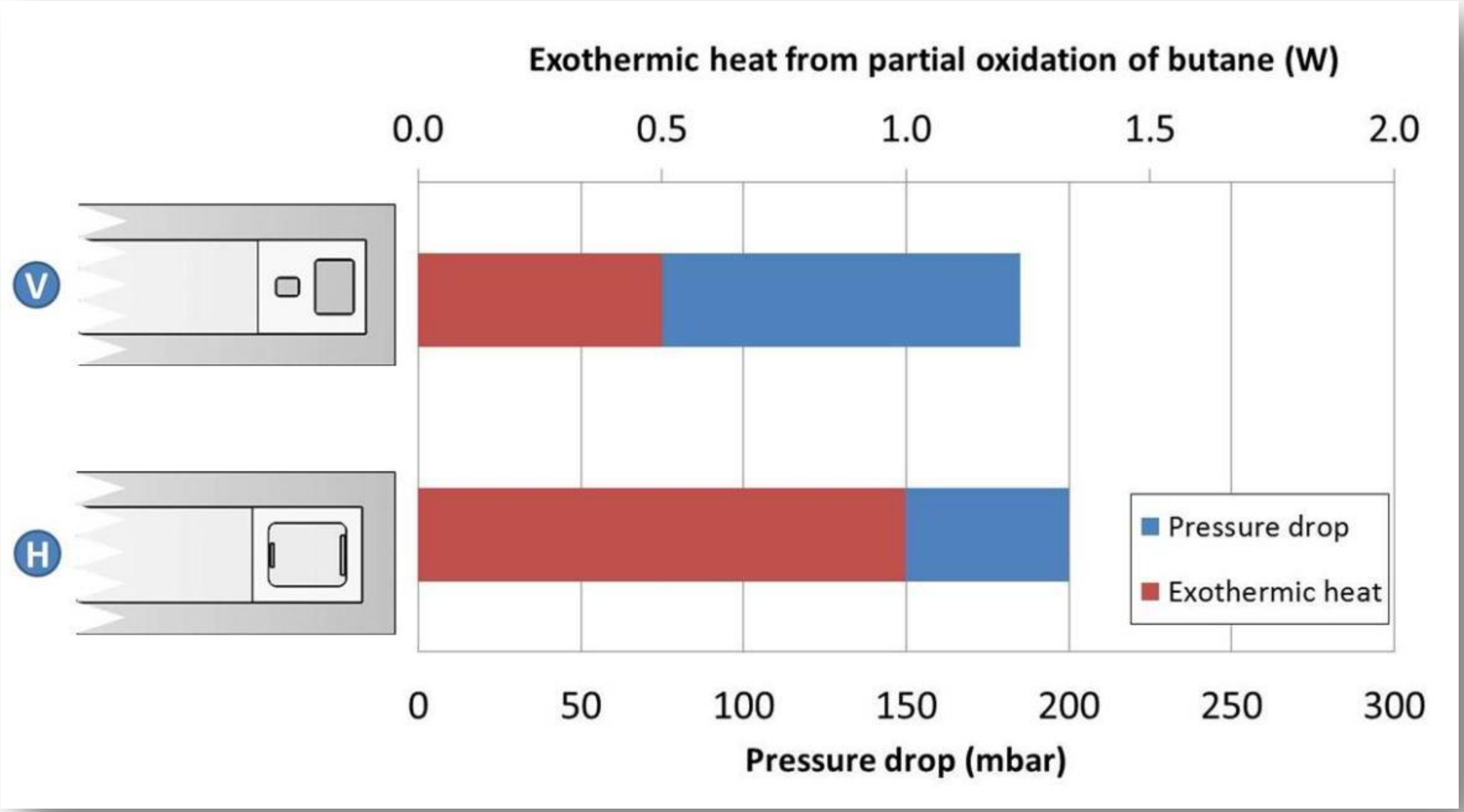

Conclusion

- A meso-scale gas (butane) reforming system is developed for the μ-SOFCs testing platform
- The system integrated electrical heating and fluidic function that is able to characterize the exothermic behavior of the chemical reaction
- The butane reforming could reach about 91% of conversion and 71% of syngas yield at 450° C in vertical flow reformer
- Overall, the performance of horizontal flow reformer is better than that of vertical flow one