Durable and Sustainable component supply chain for high performance fuel cells and electrolysers

MAIN FOCUS: Development of materials, components and cells, significantly less reliant on critical raw materials (CRM) and PFAS, with lower environmental footprint and costs, and higher performance and durability than existing technologies.

Partners:

SINTEF · HI ERN Helmholtz Institute Erlangen-Nürnberg part of Forschungszentrum Jülich · cea · tecnalia MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE · DLR · cnrs · DTU · VTT · EPFL · Hes·so

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Clean Hydrogen Partnership

The project is supported by the Clean Hydrogen Partnership and its members Hydrogen Europe and Hydrogen Europe Research under Grant Agreement No 101101479.

EU budget: 10 M€

Duration: 6 years (2023-2028)

LinkedIn

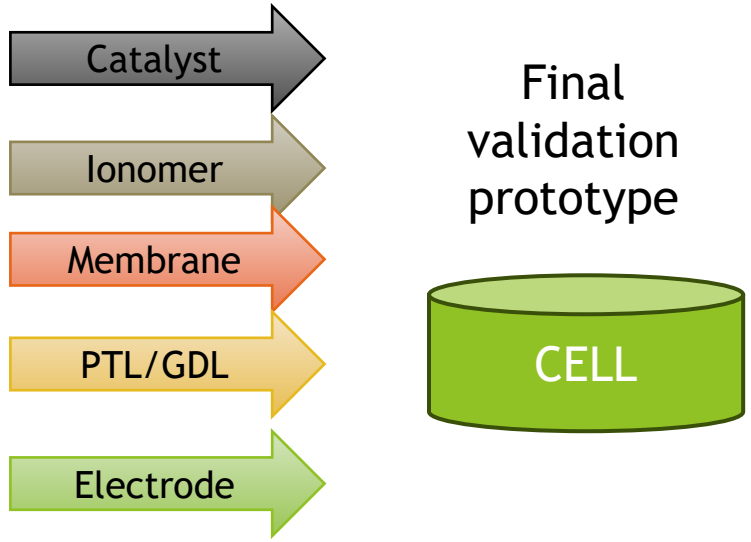
linkedin.com/company/sustaincell/

https://sustaincell.eu

SUSTAINCELL

Technologies

- Alkaline Electrolyser (AEL)
- Anion Exchange Membrane Electrolyser (AEMEL)
- Anion Exchange Membrane Fuel Cell (AEMFC)
- Proton Exchange Membrane Electrolyser (PEMEL)
- Proton Exchange Membrane Fuel Cell (PEMFC)
- Solid Oxide Electrolyser (SOEL)
- Proton Conducting Ceramic Electrolyser (PCCEL)



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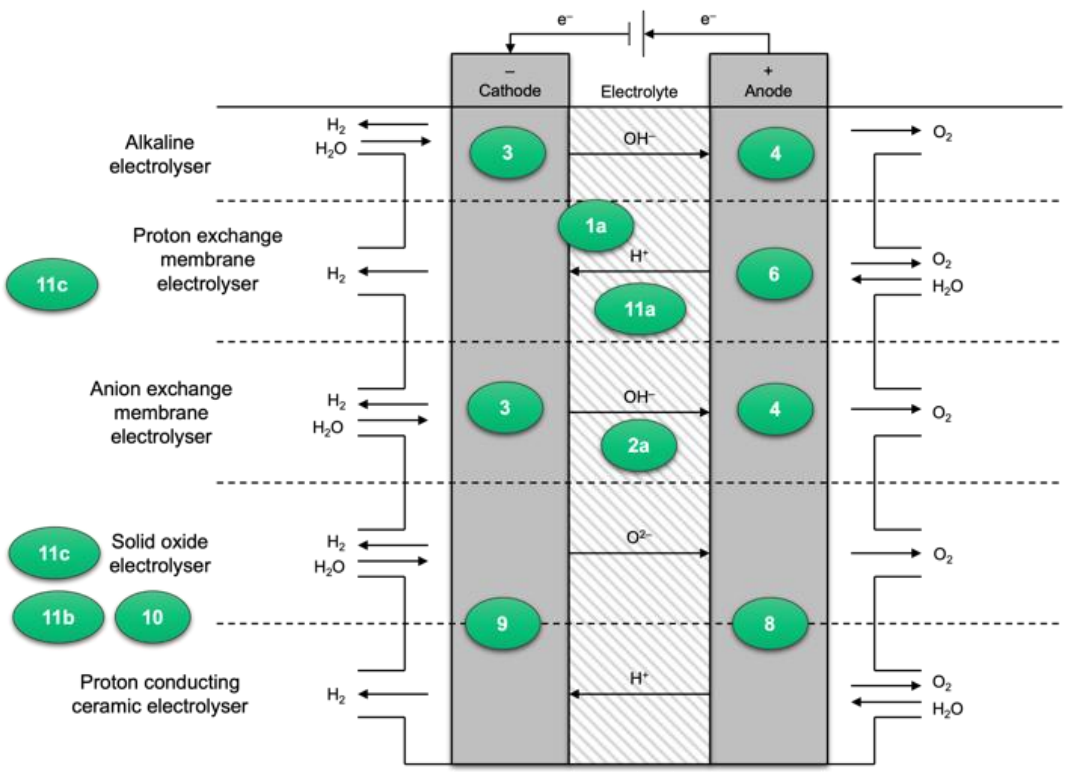
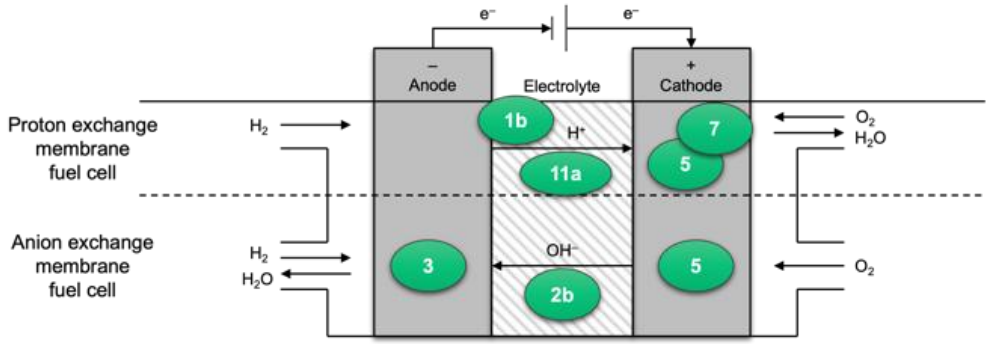
CRM free or lean solutions prospected





Ground-breaking innovations of SUSTAINCELL underpinned with sustainable processing:

1a,b: F-free or F-lean polymers for PEMEL, PEMFC
2a,b: F-free polymers for AEMEL, AEMFC
3: CRM-free HOR/HER electrocatalysts for AEL, AEMEL, AEMFC
4: CRM-free OER electrocatalysts for AEL, AEMEL
5: CRM-free ORR electrocatalysts for PEMFC, AEMFC
6: CRM-lean OER electrocatalysts for PEMEL
7: CRM-lean ORR electrocatalysts for PEMFC
8: CRM-free or CRM-lean electrodes for SOEL, PCCEL
9: Ni-lean or Ni-free CRM lean electrodes for SOEL, PCCEL
10: CRM-lean, Ni lean cell architectures for SOEL, PCCEL
11: EoL strategies: a) MEA recycling; b) Oxides recycling; c) PGMs, Ni, Co, REEs recycling

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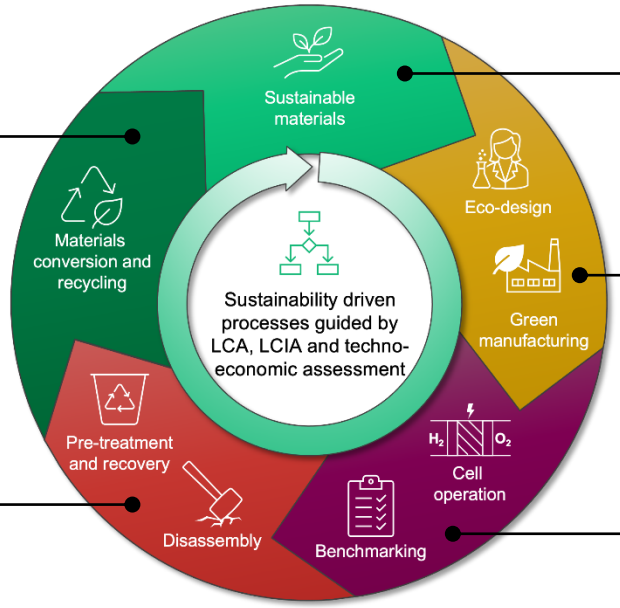
Circular approach

- Definition and optimization of transformation processes for conversion of recovered materials to sustainable feedstock
- Evaluation of required resources

- Disassembly steps and management of non-recoverable waste
- Novel processes for pre-treatment, separation and recovery of CRM and ionomers from scraps and wastes



- New materials
- Recycled materials

- New cell architectures
- New manufacturing routes (included high throughput / AI assisted process)

- Validation of performance and durability at cell level
- Round Robin testing

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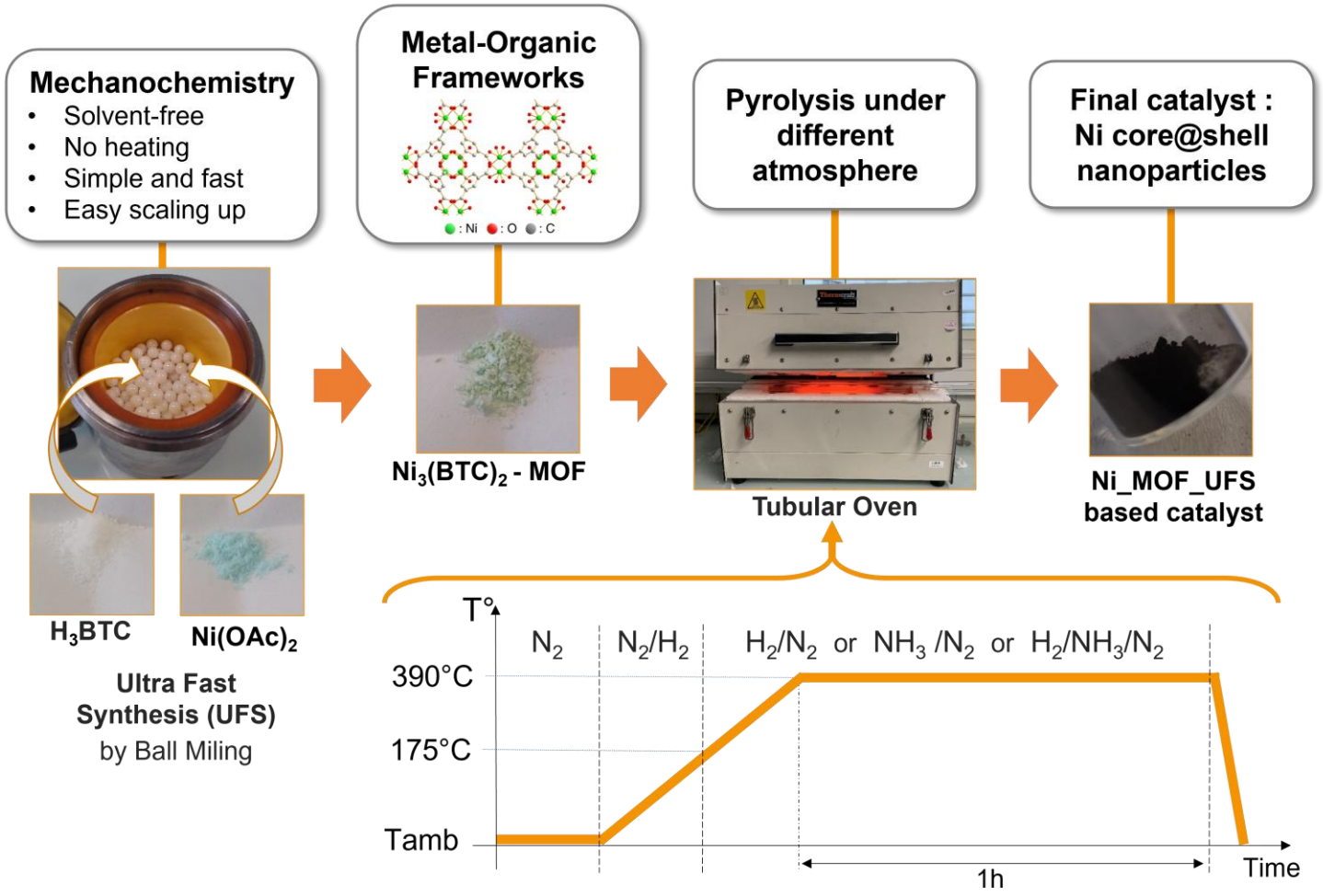
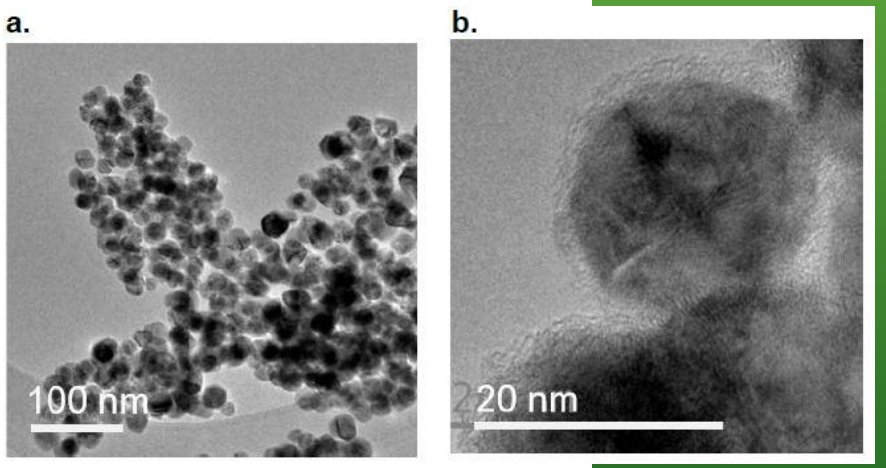
Example 1: Low temperature Ni-based anode catalyst for AEMFC (Gen 1)

Derived by annealing a Ni-MOF -> Ni@N-C core@shell materials





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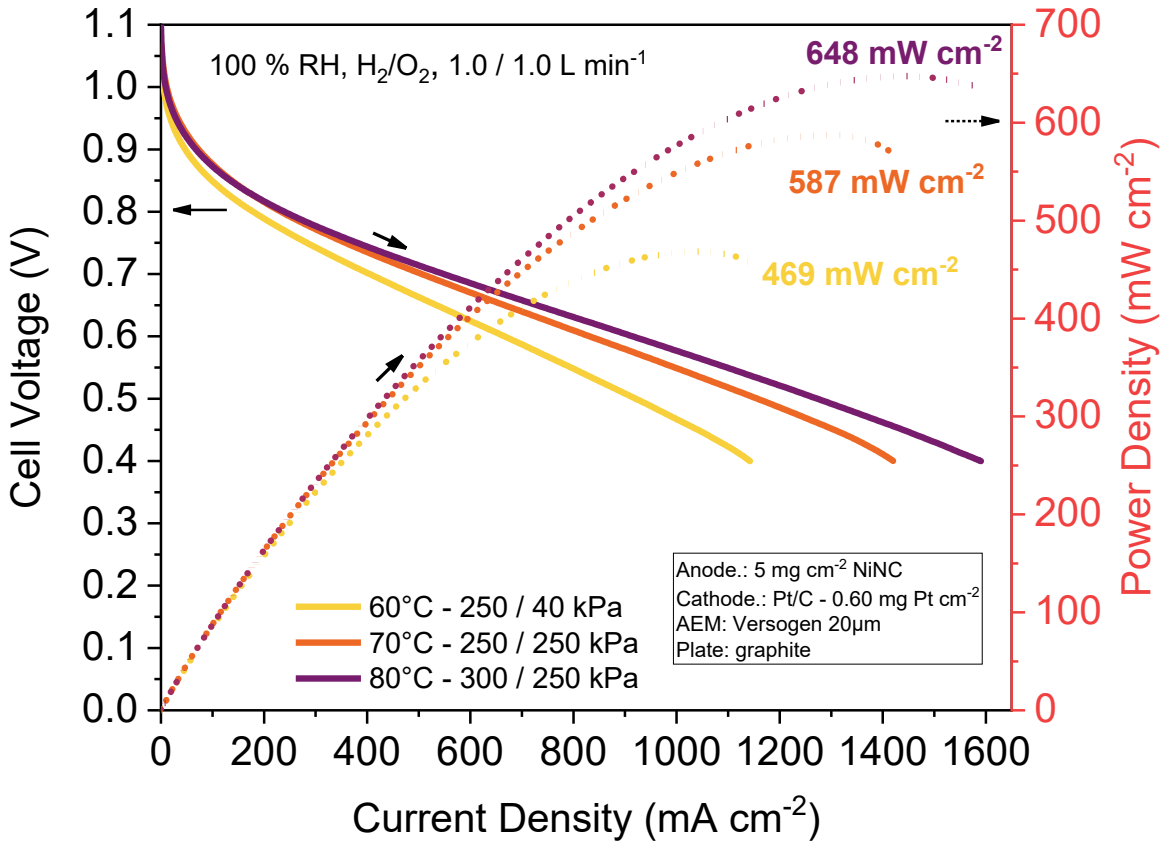
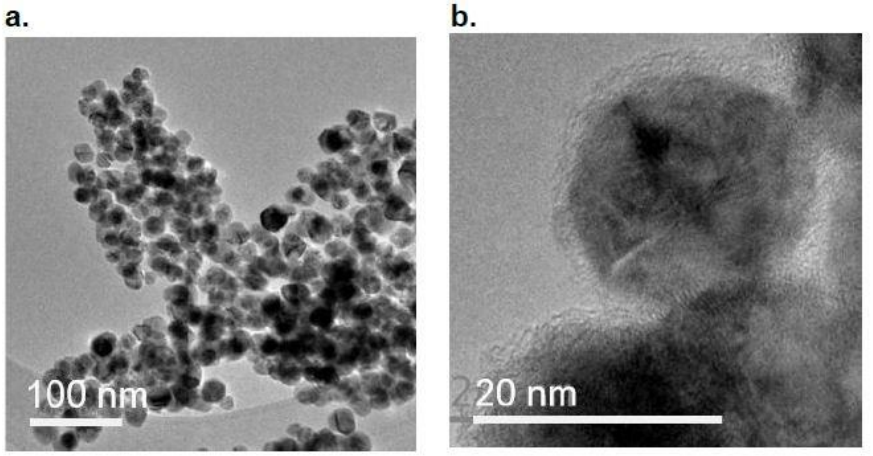
1st Gen Ni-based anode catalyst for AEMFC



Pt/C cathode, Ni@C anode



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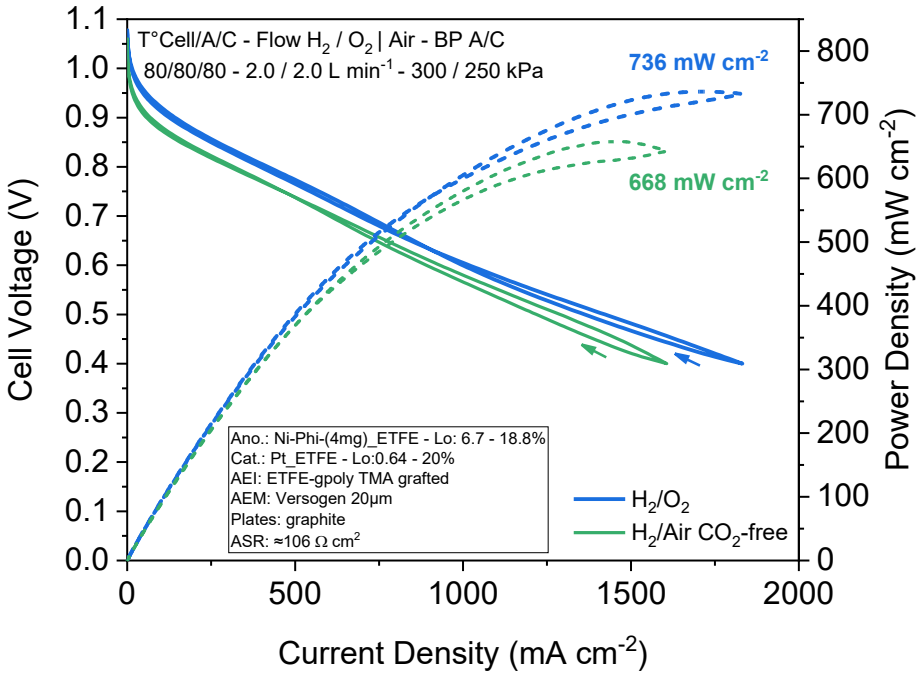
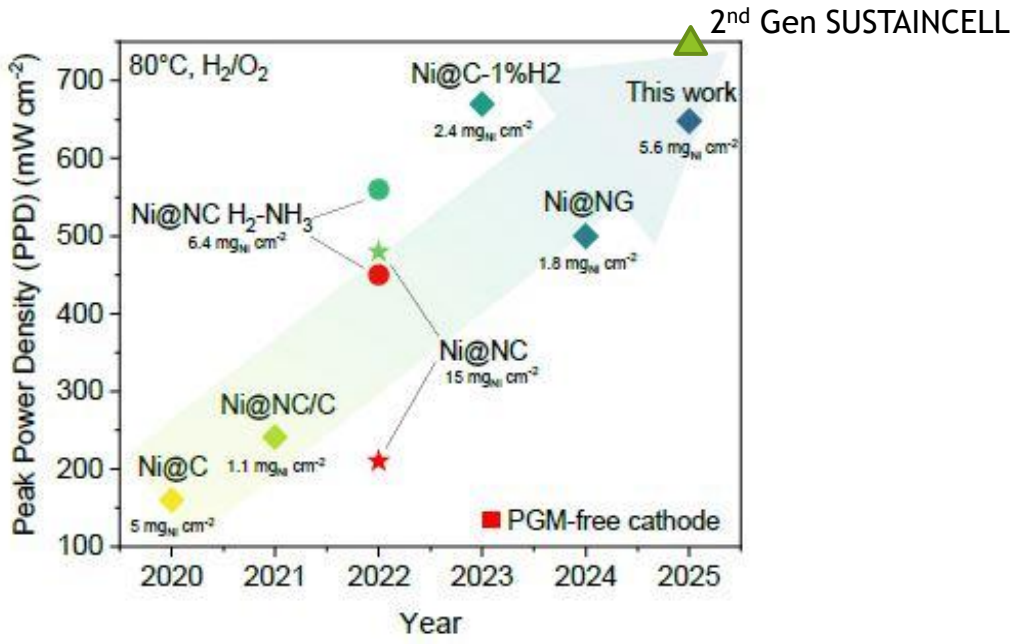
2nd Gen Ni-based anode catalyst for AEMFC (unoptimised)

Ni@NC structure two-step synthesis :

a) Ni NPs formed on carbon support, b) deposition of a N-C shell



Pt/C cathode, Ni@C anode



- Initial AEMFC performance 80°C, H2/O2 with Ni-based anodes
- In red, values obtained with same Ni-based anode but with a PGM-free cathode

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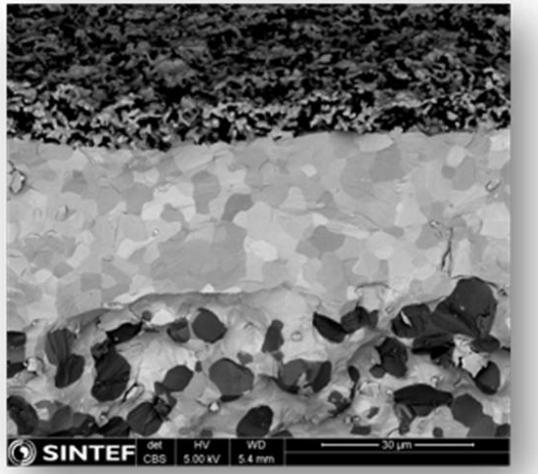
Example 2: High temperature: PCCEL

- "Non-optimized" cell architectures → Nanostructured architectures using nano-fibers



Steam electrodes:
- Composite Electrolyte + $(Ba,Gd,La)Co_2O_{3-\delta}$
- $(Pr,Ba,Sr)(Co,Fe)O_{3-\delta}$
- ....

Electrolyte:
$(Ba,Sr)(Zr,Ce,Y,Yb)O_{3-\delta}$

H_2 electrode: Ni + Electrolyte:
$Ni\text{-}(Ba,Sr)(Zr,Ce,Y,Yb)O_{3-\delta}$

→ Reducing Co and REEs /unit cell

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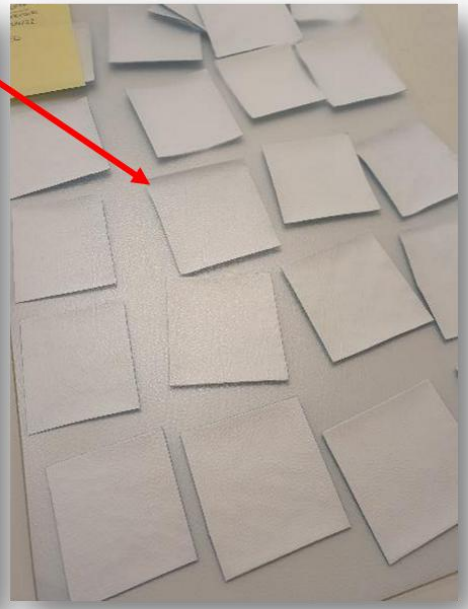
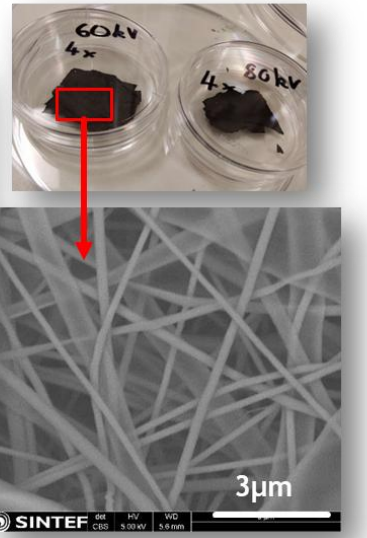
Electrode fiber mats and fibers

PBSCF: $(PrBa_{0.5}Sr_{0.5})(Co_{1.5}Fe_{0.5})O_{5+\delta}$

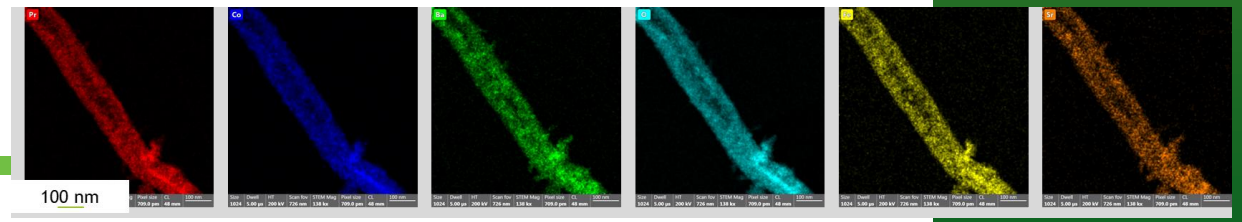
PBSCF Precursors + PVP* in DMF → Electrospun PBSCF precursors/PVP mat → Electrospun mat cut into coupons → Coupons annealed in air → Porous electrode mat used as is / Porous mat is crushed and fibers used in inks

*PVP = polyvinylpyrrolidone = polymer carrier for electrospinning.





750°C, 2h



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Architectures screening

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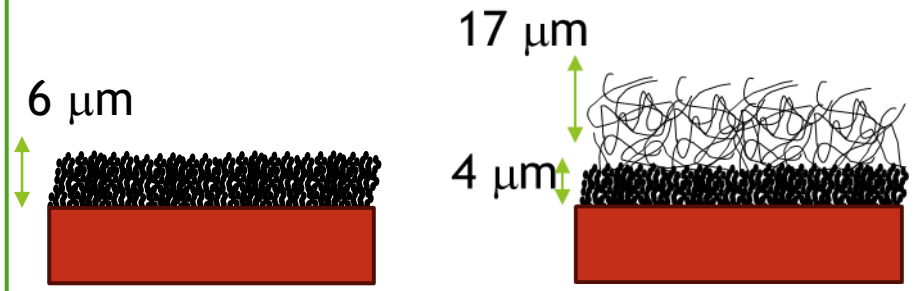
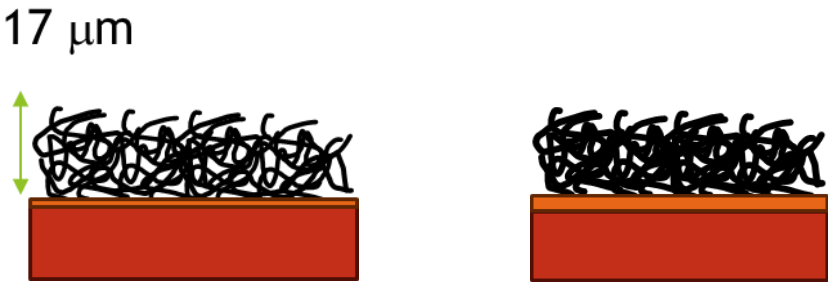
INTERFACE BZCY with Commercial PBSCF round grains



PBSCF CP ink

PBSCF NF CP ink

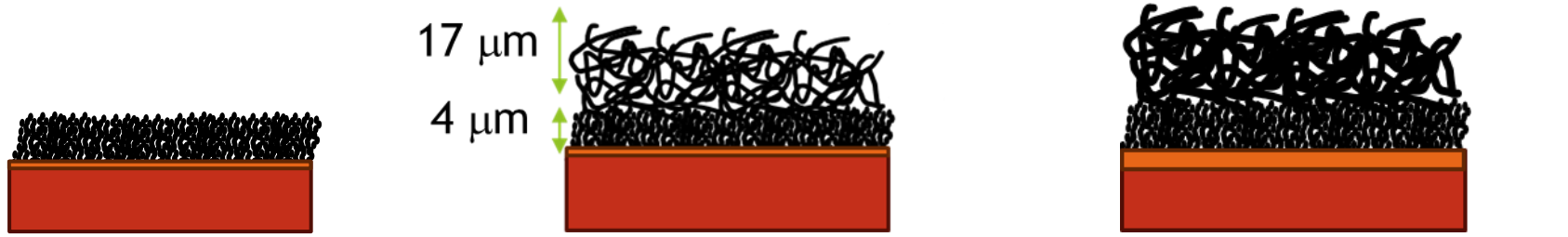
INTERFACE BZCY with CeO_2 / Nano-Fiber PBSCF



PBSCF NF ink / CeO_2 (100nm)

PBSCF NF ink / CeO_2 (200nm)

INTERFACE BZCY with CeO_2 / Commercial PBSFC round grains



PBSCF CP ink / CeO_2 (100nm)

PBSCF NF mat CP ink / CeO_2 (100nm)

PBSCF NF CP ink/CeO_2 (200nm)

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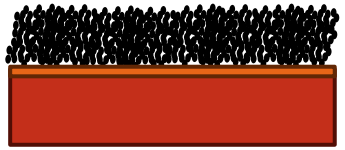
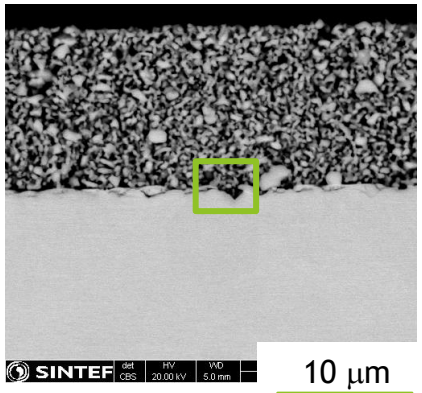
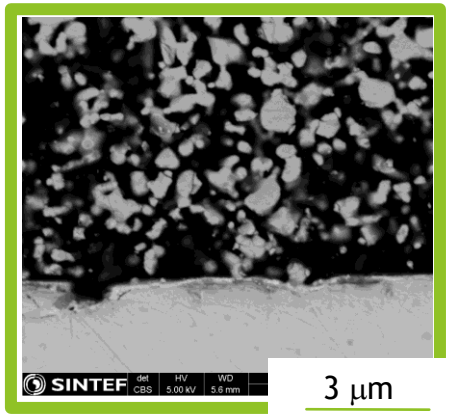
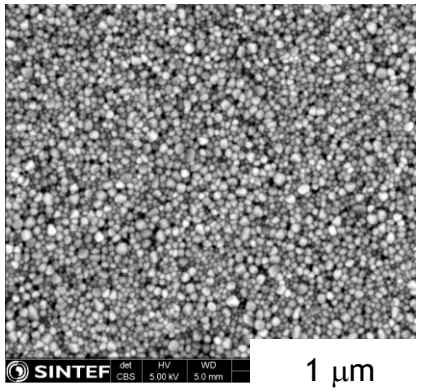
SEM



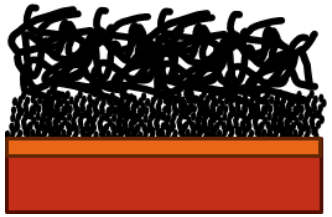
PBSCF CP ink / CeO_2 (100nm)



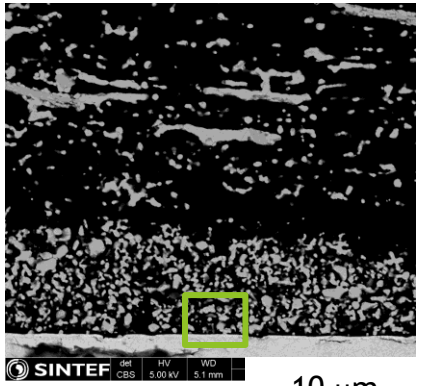


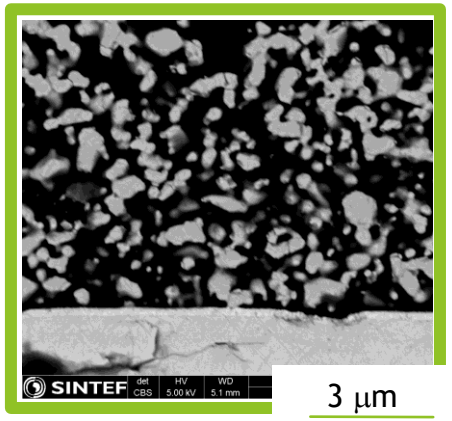


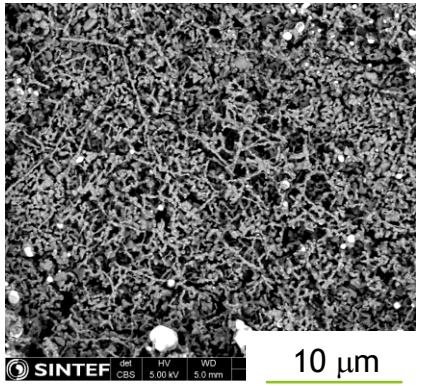
Surface CeO_2 layer (not coated by PBSCF)



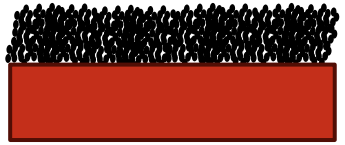
PBSCF NF mat CP ink / CeO_2 (200nm)



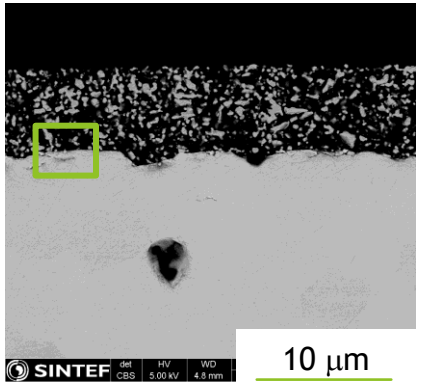


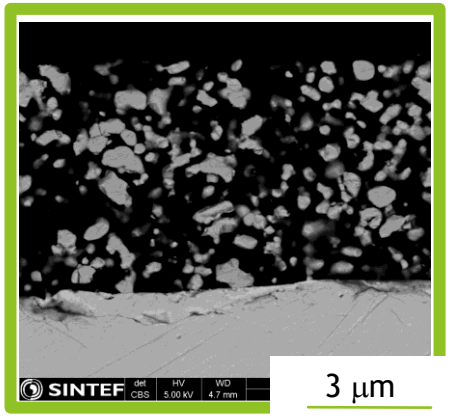


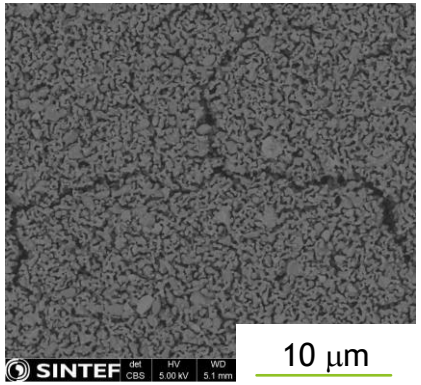
Surface PBSCF fiber mat (*Au from current collection*)



PBSCF CP ink







Surface PBSCF commercial powder

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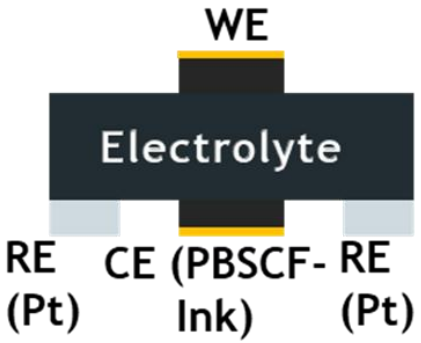
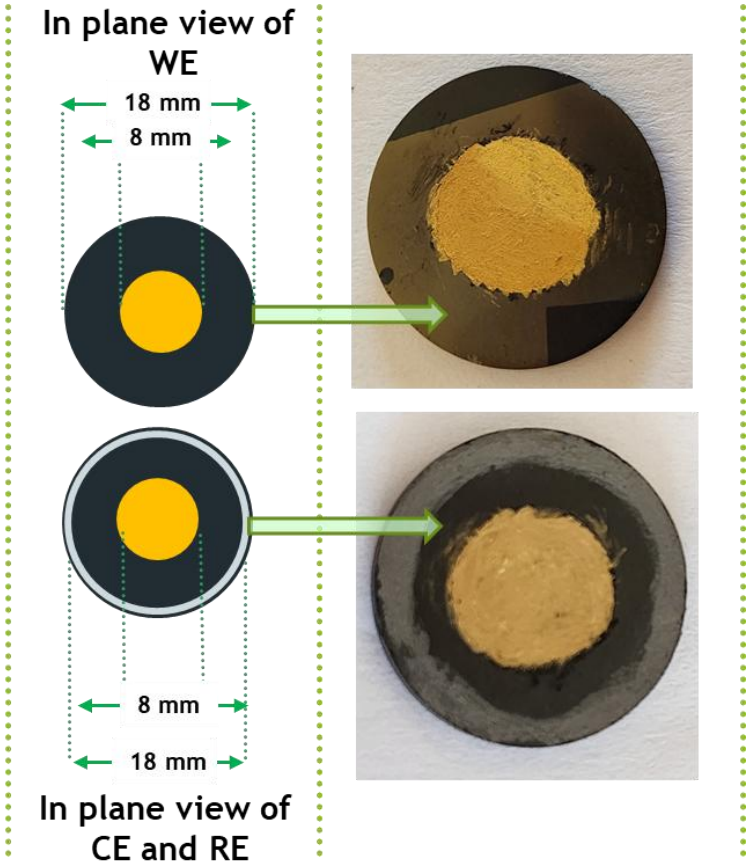
Electrochemical characterisation

- Measurements using Probostat™
- Temperature dependency
- Wet and dry conditions





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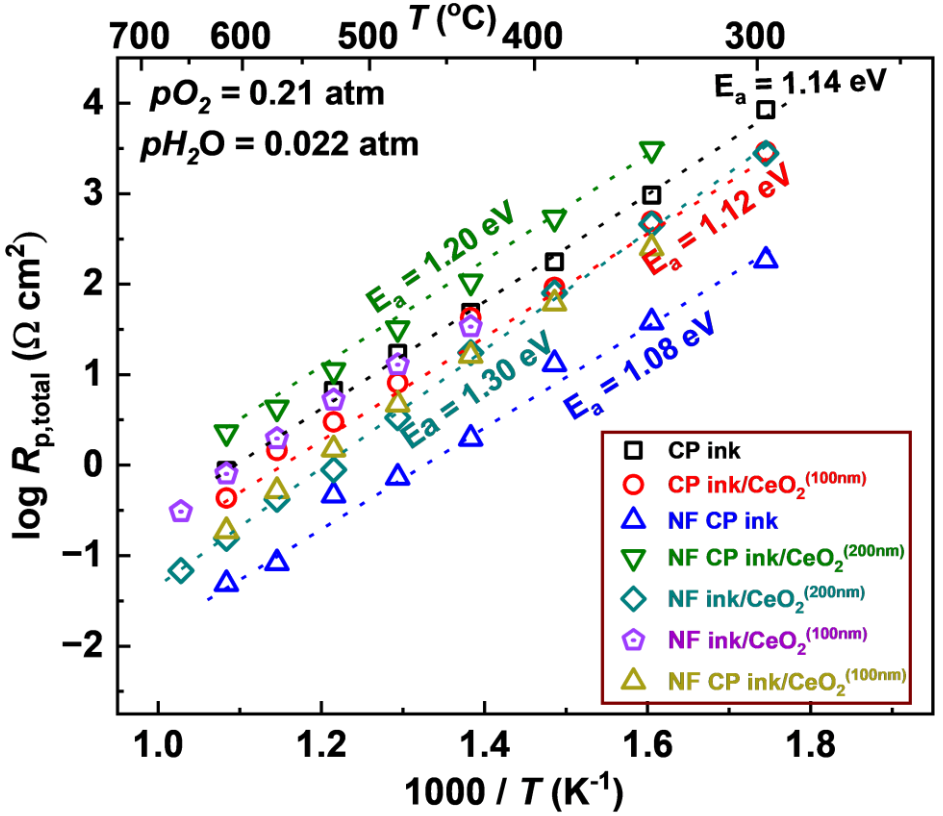
Effect of electrodes : $R_{p,total}$



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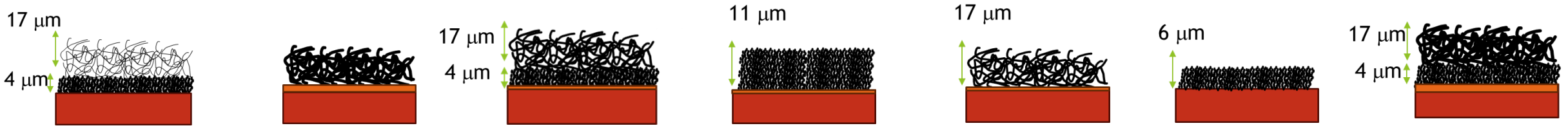
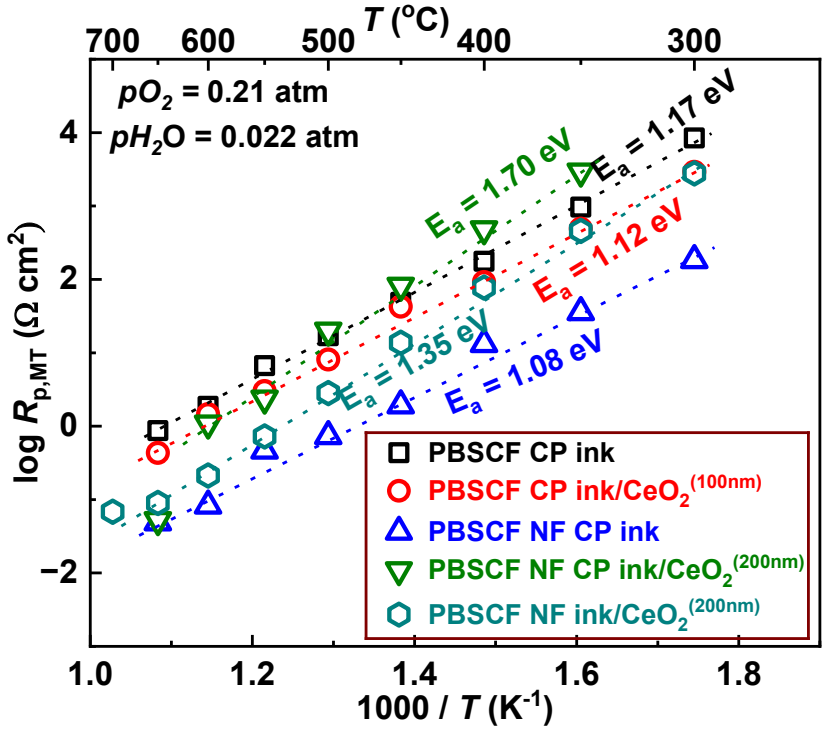
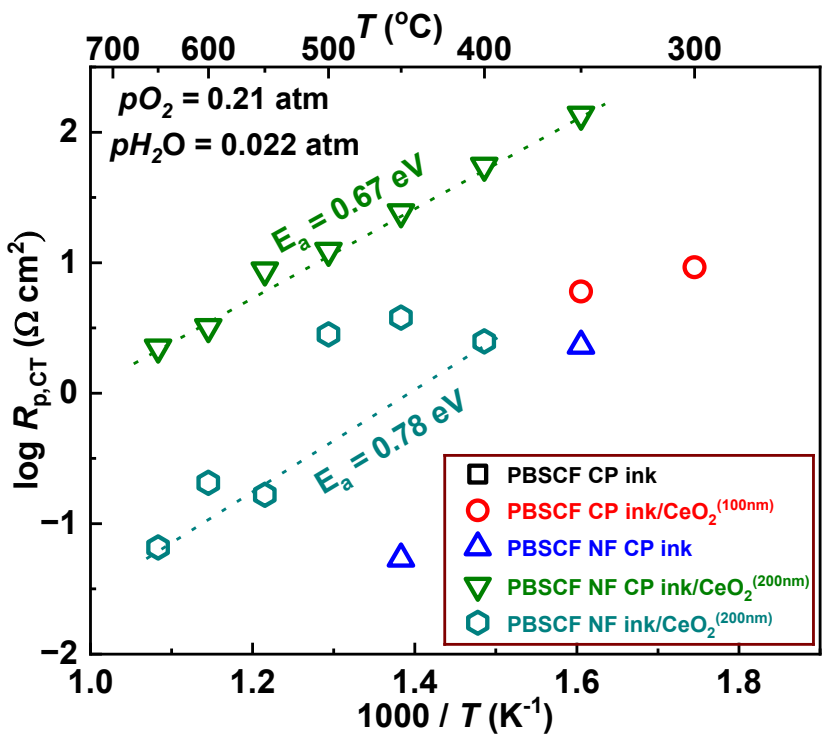


Rp PBSCF NF mat CP ink < PBSCF NF ink / $CeO_2^{(200nm)}$ = PBSCF NF mat CP ink / $CeO_2^{(100nm)}$ < PBSCF CP ink / $CeO_2^{(100nm)}$ = PBSCF NF ink / $CeO_2^{(100nm)}$ = PBSCF CP ink < PBSCF NF CP ink/ $CeO_2^{(200nm)}$

Effect of electrodes : *MT and CT*





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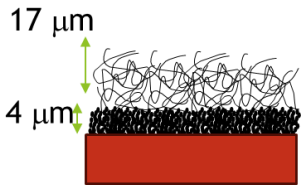
Total Rp



PBSCF NF mat CP ink

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PBSCF NF ink / $CeO_2^{(200nm)}$

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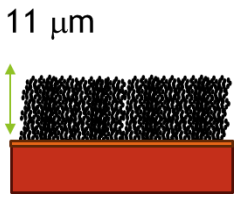

PBSCF CP ink / $CeO_2^{(100nm)}$

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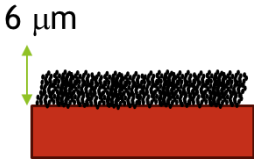

PBSCF CP ink

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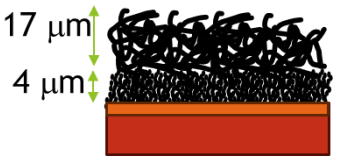
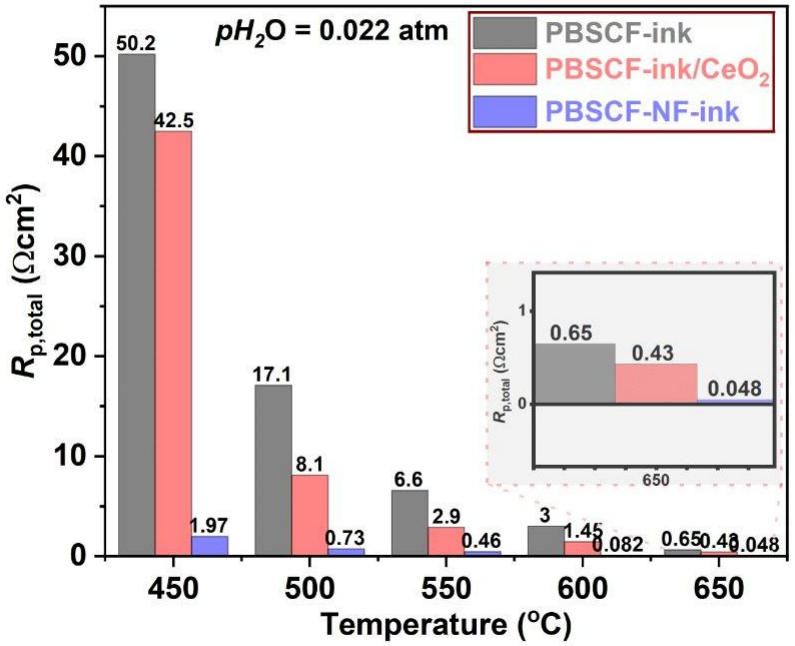


PBSCF NF CP ink/ $CeO_2^{(200nm)}$



Reduction of CRM?

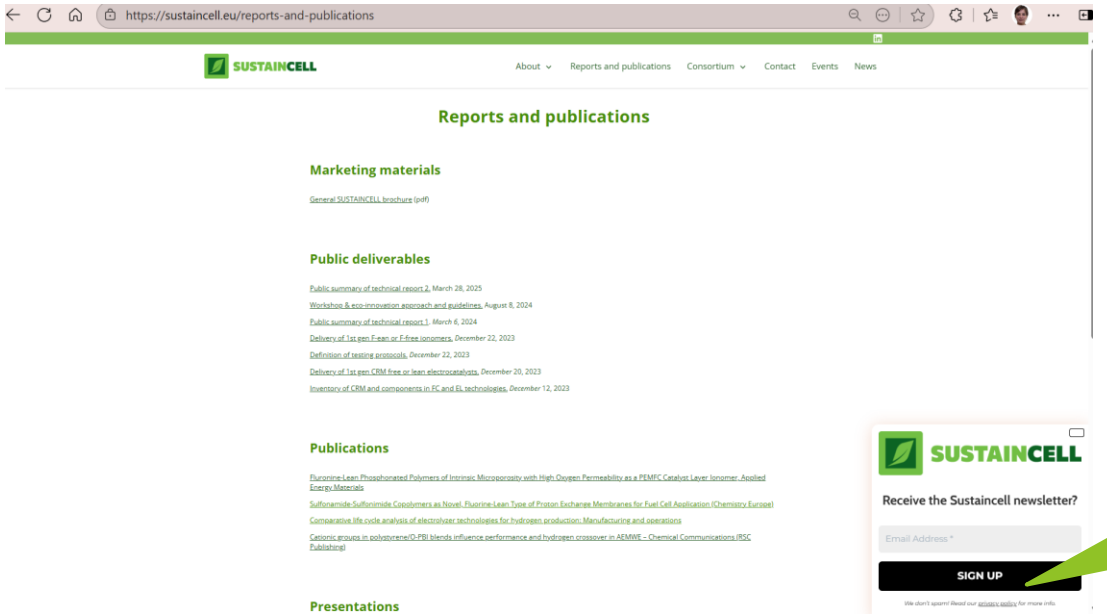
- About 25% less PBSCF material utilized in PBSCF-NF-ink versus PBSCF commercial powder - ink positrode.
- Employing electrospun nanofiber architectures lowered the polarization resistance by ≈ 97 % at 600 °C.

linkedin.com/company/sustaincell/

https://sustaincell.eu

Durable and Sustainable component supply chain for high performance fuel cells and electrolysers

☞ Check our website for more information!!



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The project is supported by the Clean Hydrogen Partnership and its members Hydrogen Europe and Hydrogen Europe Research under Grant Agreement No 101101479.

Contact: Marie-Laure.Fontaine@sintef.no

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