qSOFC

Automated mass-manufacturing and quality assurance of Solid Oxide Fuel Cell stacks

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PROJECT OVERVIEW

- **Call year:** 2016
- **Call topic:** FCH-02-6-2016 Development of cost effective manufacturing technologies for key components or fuel cell systems for industrial applications
- **Project dates:** 1.2.2017-31.1.2020
- **% stage of implementation 01/11/2018:** 55%
- **Total project budget:** 2.1 M€
- **FCH JU max. contribution:** 2.1 M€
- **Partners:** VTT, ElringKlinger AG, Elcogen AS, ENEA, Elcogen Oy, Sandvik, HaikuTech, MüKo

PROJECT SUMMARY

qSOFC - Automated mass-manufacturing and quality assurance of Solid Oxide Fuel Cell stacks

- Reduction of stack manufacturing cost by implementing quality assurance and mass-manufacturing methodology
- Reduction of stack cost down to 1000 €/kW at 10 MW/year production volume
- Reduction of cell manufacturing cost down to 400 €/kW at 10 MW/year production volume
- Optimization of interconnect manufacturing process

Fast manufacturing of SOFC cells – increased tape-casting and screen-printing speeds

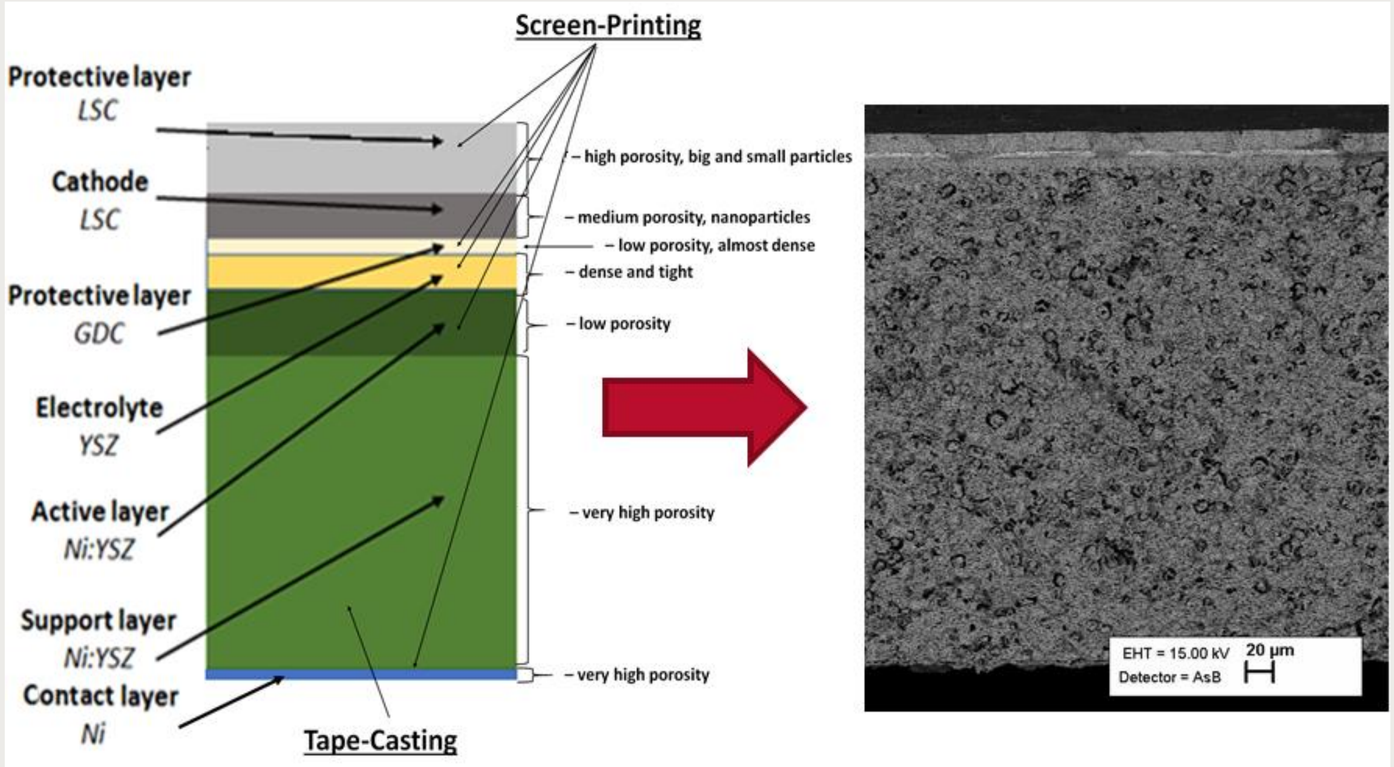
Achievement to-date

Tape casting speed 1x
Screen printing speed 1x

10x
4x

25% 50% 75%

- Manufacturing speed affects directly cell cost structure (CAPEX)
- High-speed manufacturing is required for cost-efficient scale-up of production
- Challenge: achieving defect-free layers



Fast manufacturing of SOFC cells – increased tape-casting and screen-printing speeds

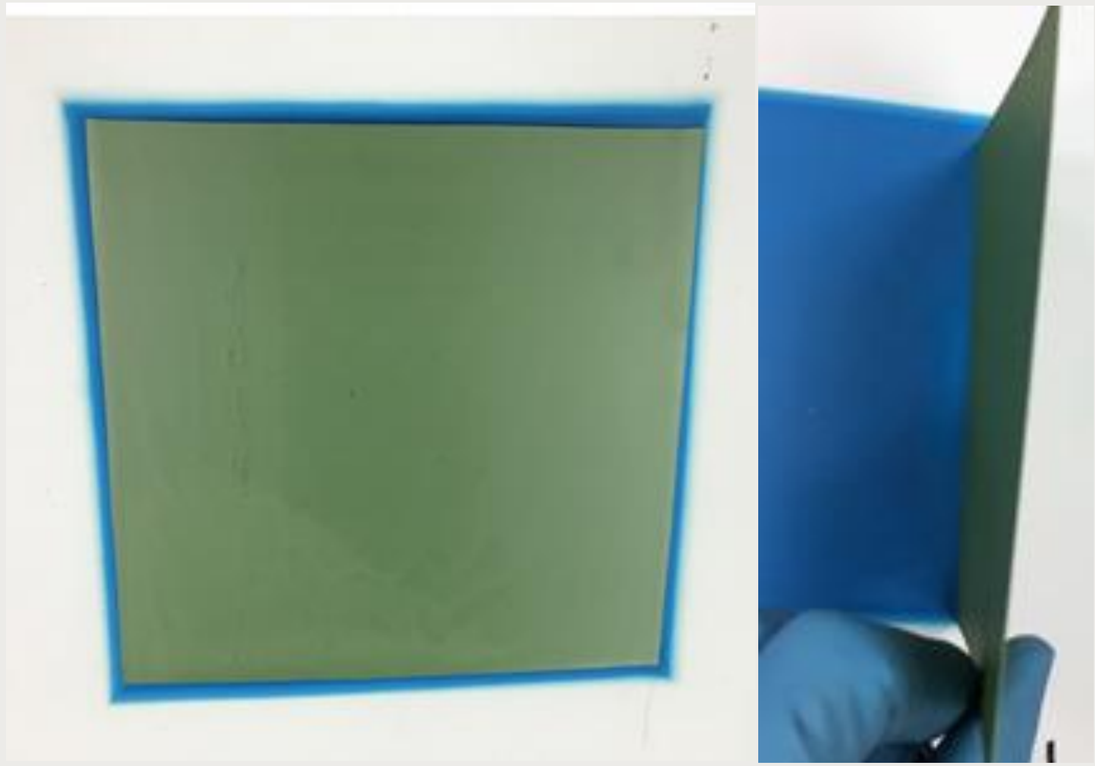
Achievement to-date

Tape casting speed 1x
Screen printing speed 1x

10x
4x

25% 50% 75%

- First half-cells manufactured with all new layers
  - No cracking or major defects
  - Very little curvature after sintering
- Next steps
  - Testing with a bigger batch size to evaluate yield & quality



SOFC cell QA – Visual inspection of cells for defects

Achievement to-date

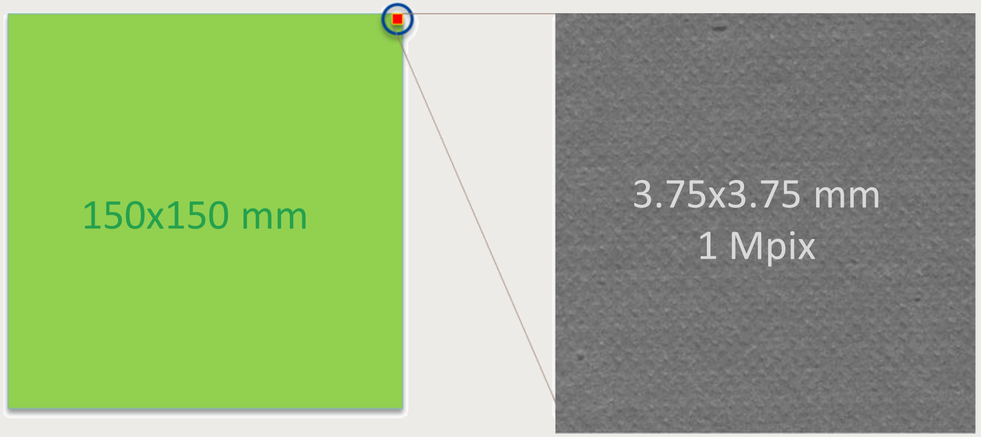
7 h per cell (human)

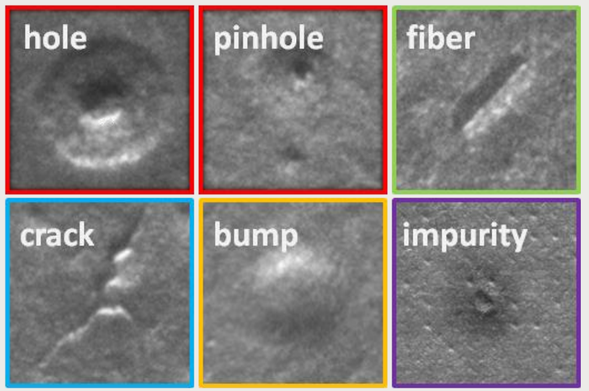
25% 50% 75%

10 s per cell

- Cell manufacturing quality needs to be very high to convince early markets
- Quality control in mass-manufacturing needs to be (mostly) automatic

- Solution: automatic machine vision inspection system
  - Real-time data analysis
  - Pre-trained optimized neural network
  - 3.5 µm/pixel
  - 1800 Mpix image size
  - 10 s per cell (inspection and analysis)





SOFC cell QA – Visual inspection of cells for defects

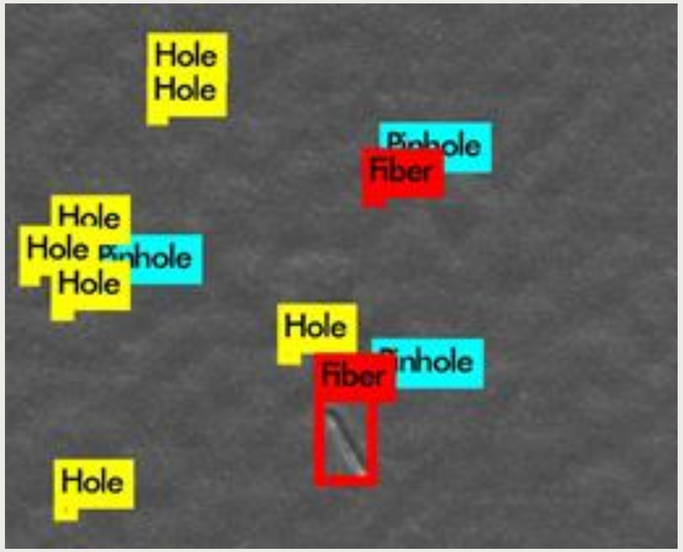
Achievement to-date

7 h per cell (human)

25% 50% 75%

10 s per cell

- First prototype designed, built and validated at Elcogen AS cell production
- 100% visual inspection of >10 µm defects takes 7 h from a person => automated machine vision inspection system developed in the qSOFC project does the same in 16 s
- Next steps
  - Software optimization
  - Further training to improve detection rates
  - Optimization of imaging system to reach 10 s cycle time



SOFC stack manufacturing QA – optimizing stack conditioning process

Achievement to-date

Stack cost reduction 0%

25% 50% 75%

20% reduction in stack cost

- Stack conditioning is the process carried out after stack assembly before shipping to a customer
  - Heat treatment(s)
  - Reduction of anode
  - Electrochemical testing
  - QA-tests
- Streamlining stack conditioning can result in up to 20% lower stack cost
- Research questions
  - Could the conditioning process be shortened?
  - What is the effect on stack performance if conditioning process is modified?

Test step	Duration / h	Comments
Heat-up	6	
Open circuit voltage (OCV)	1	
IV-curve	0.8	
Nominal operating conditions (NOC)	1	
Fuel utilization test (FU)	0.5	Stack at NOC, fuel flow reduced in steps
NOC	1	
Air utilization test (AU)	0.25	Stack at NOC, air flow reduced in steps
NOC	430	Electrochemical impedance spectroscopy analysis at NOC is carried out five times during this step.
OCV	1	
IV	0.8	
NOC	1	
FU	0.5	
NOC	1	
AU	0.25	
NOC	1	
OCV	1	
Cool-down	12	Cooling takes extra time because of the relatively large heat capacity of the test rig.

SOFC stack manufacturing QA – optimizing stack conditioning process

Achievement to-date

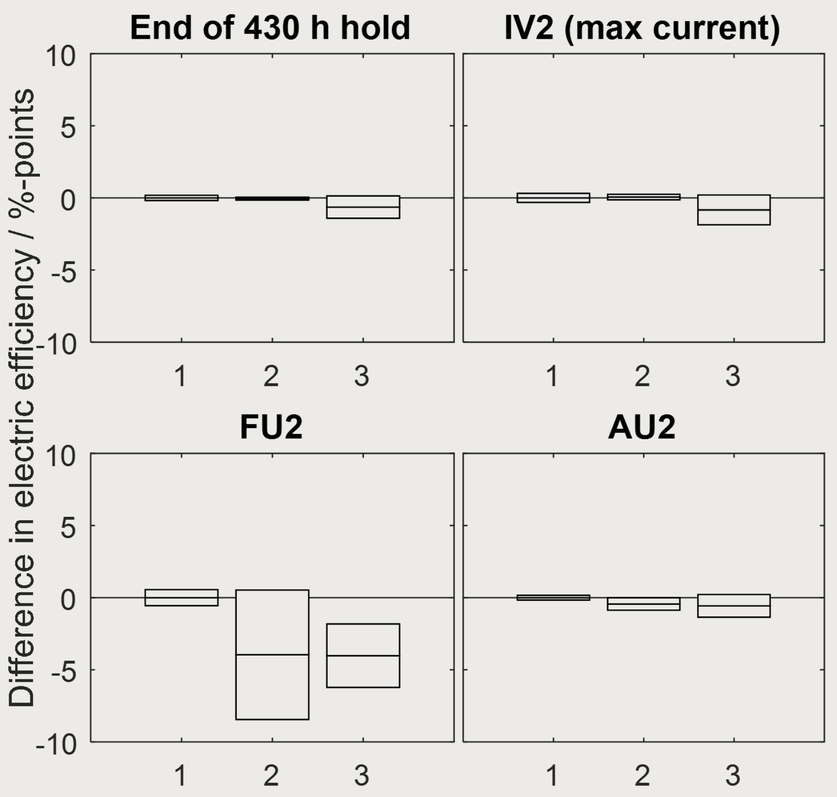
Stack cost reduction 0%

25% 50% 75%

20% reduction in stack cost

- Three different conditioning processes are being evaluated
  - P1: “baseline procedure” but with higher heating/cooling ramp-rates
  - P2: higher heating/cooling ramp-rates and no anode reduction
  - P3: no conditioning at factory

- Preliminary results indicate that all of the processes yield usable stacks
  - Possibly slightly lower performance with P2 & P3 stacks => needs more stacks to be tested



Dissemination and Communication Activities

- 5 presentations in 3 conferences
- 2 press releases (Elcogen and Convion)
- One workshop organized
- Promotional and educational video, together with qSOFC and DEMOSOFC projects: https://www.youtube.com/watch?v=KK-sjnnEcuo

SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES

Interactions with projects funded under EU programmes

- FCH JU INNOSOFC: system-level requirements for stacks, operational experience
- FCH JU DEMOSOFC: system-level requirements for stacks, operational experience

- FCH JU NELLHI: single cell and stack development
- Marie-Curie HELTSTACK: single cell and stack development

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

Thank you!

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