DOLPHIN

Disruptive pemfc stack with n**O**vel materia**L**s, **P**rocesses, arc**H**itecture and optimized **IN**terfaces

Innovative manufacturing process: 3D Printing

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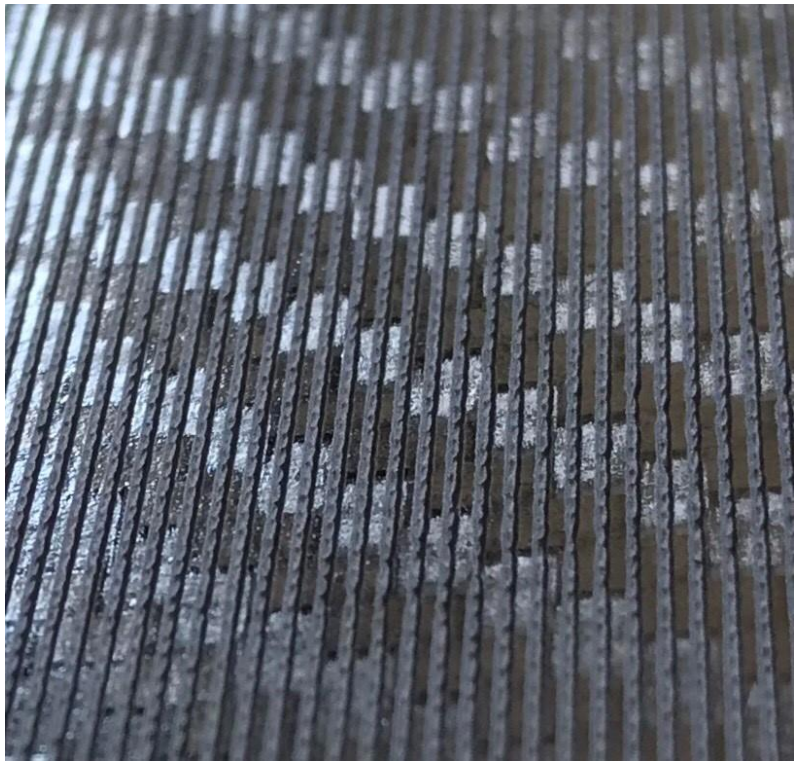
Presentation outline

- Interest of the printed technology for PEM fuel cells
- Development of the technology
  - Materials
  - Process
- Single fuel cell test results
- Conclusion



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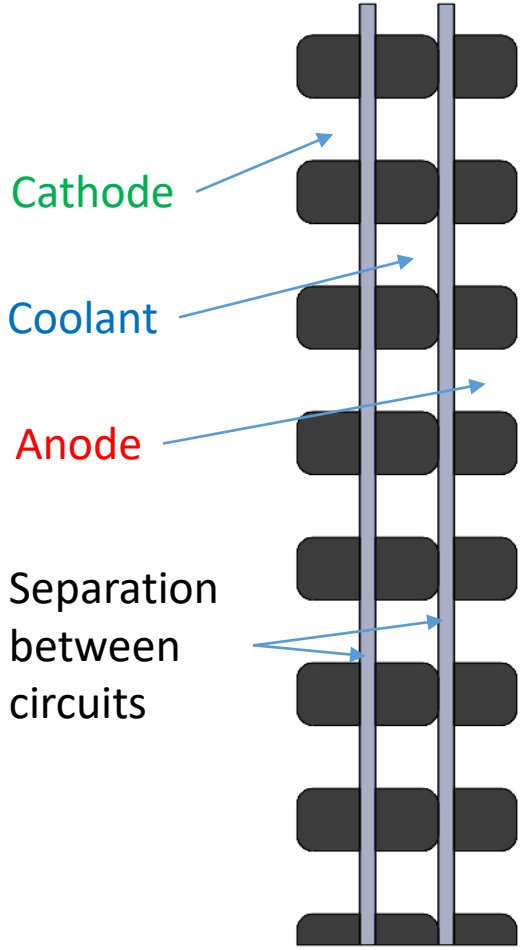
Interest of printed bipolar plates

- Association of two materials
  - Gas separator are thin and flat laminated foils with a high electrical conductivity
    - Good mechanical resistance
    - No welding, no stamping
  - Gas and coolant flow fields are formed by inks deposits
    - Fluid circuits are designed independently
    - Narrow ribs and channels can be targeted
- Potentially compatible with continuous roll-to-roll process
  - High speed manufacturing
  - Low cost



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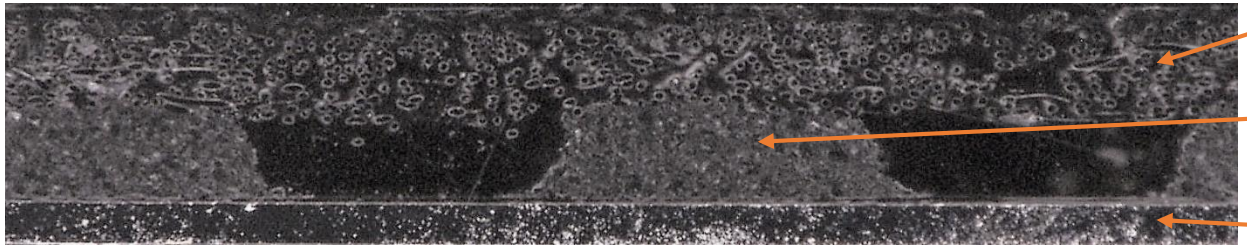
Development of the technology

- Materials
  - Different substrates tested for ribs printing
    - Carbon coated stainless steel sheets (thickness less than 50 µm)
    - Sheets of carbon prepregs (thickness about 100 µm)
    - Gold coated stainless steel machined pads : reference plates used for single fuel cell tests
  - Formulation of the ink
    - Numerous mixtures and compounds have been tested
      - Selection of specific carbon particles and binder
      - Adhesion to the substrate
      - Characterization of electrical resistance, mechanical behaviour



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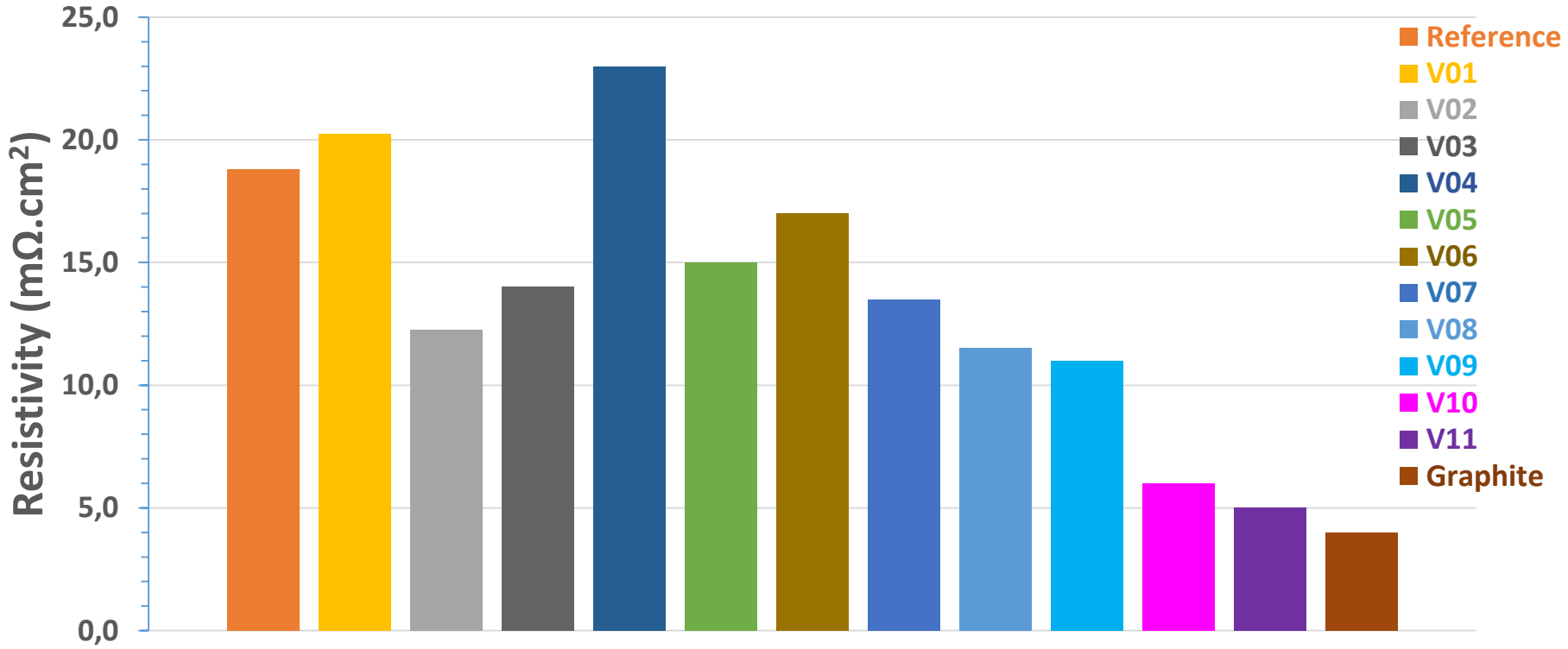
Resistivity measurements

- Flat layer deposited on a gold plated stainless steel pad
- Comparison with the resistivity of graphite in a similar device



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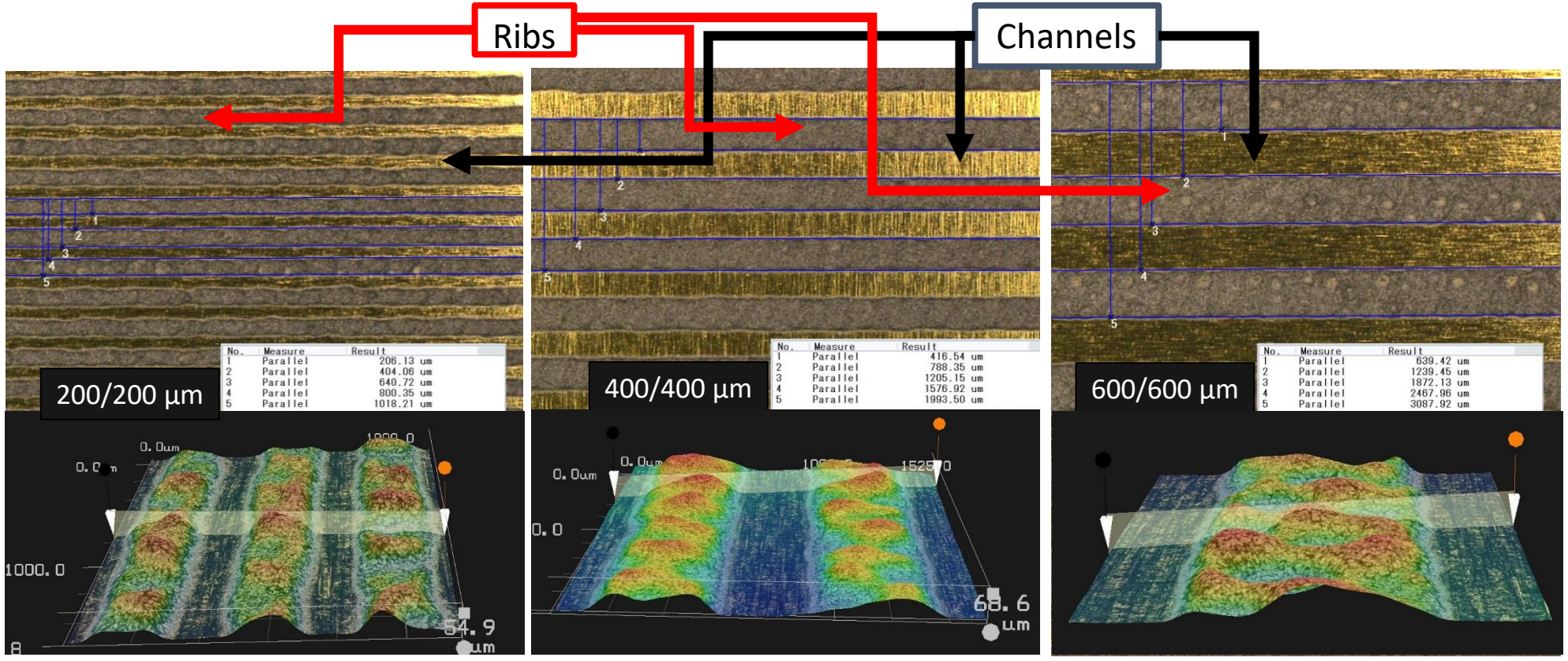
Process development

- Optimization of the screen printing parameters
  - Repeatability of the printing process for low rib-channel pitches



Early versions of repeatable printed ribs, still exhibiting a significant “mesh effect”

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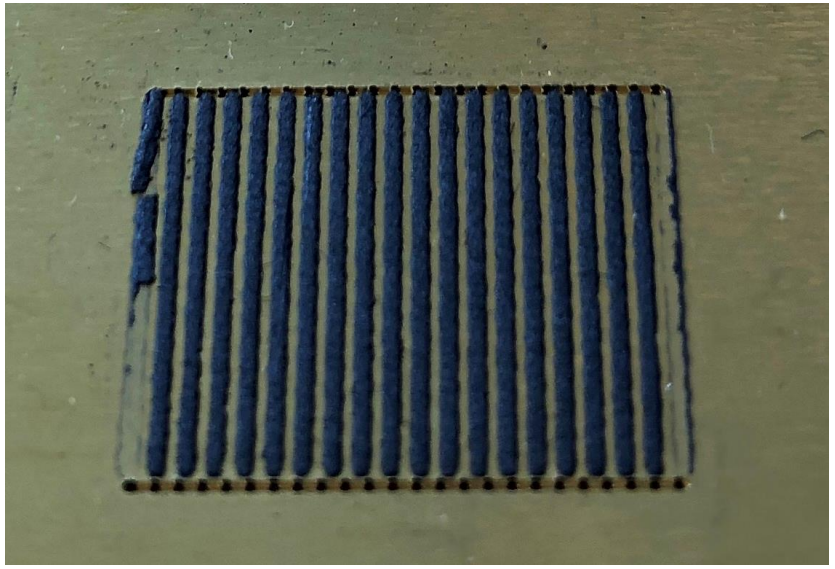
Increase of the height of the channel ribs

- Improvement of the multi-layered screen printing process
  - The height of the rib depends on the channel and rib width
    - 350 µm for a width of 400 µm
    - 150 µm for a width of 200 µm
    - 75 µm for a width of 100 µm

- Search for the optimum compression vs. composition of the rib to avoid rib creeping (example on 1.8 cm² pad)



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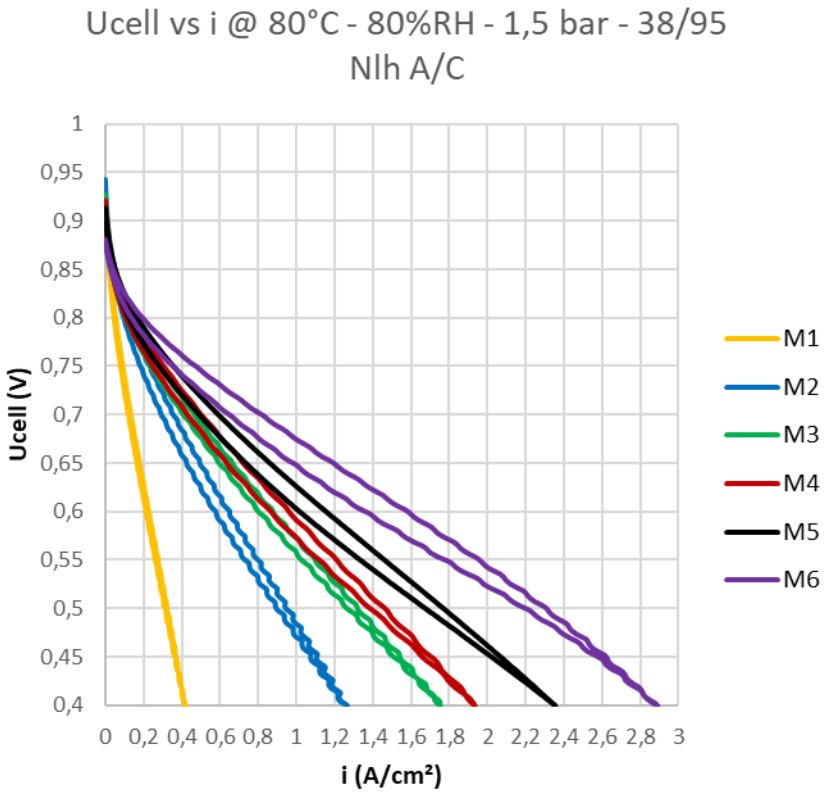
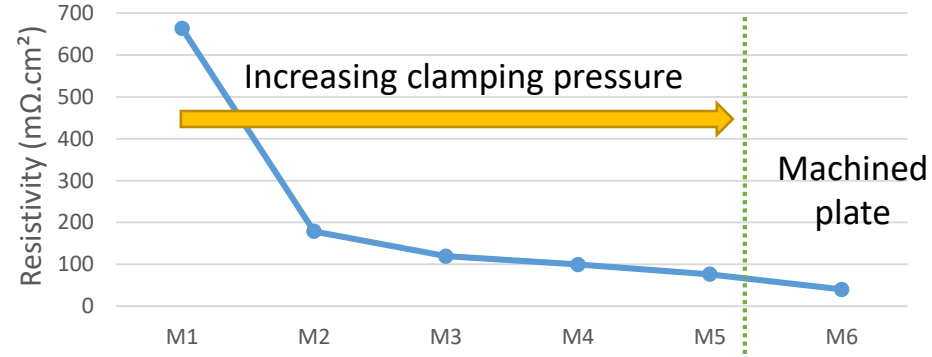
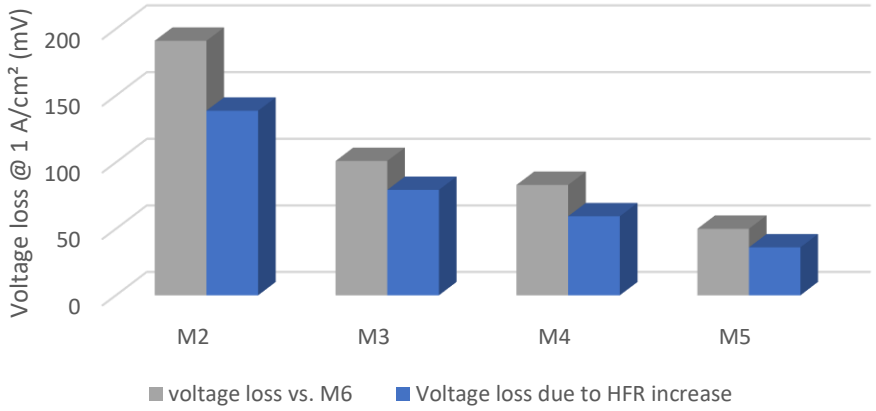
Resistance of printed ribs

- During the first tests, the printed cell performance loss (M1 ~ M5) compared to machined metal plate (M6) is mainly due to the ohmic resistance of the ribs
- The resistance of the rib depends on the mechanical compression of the cell







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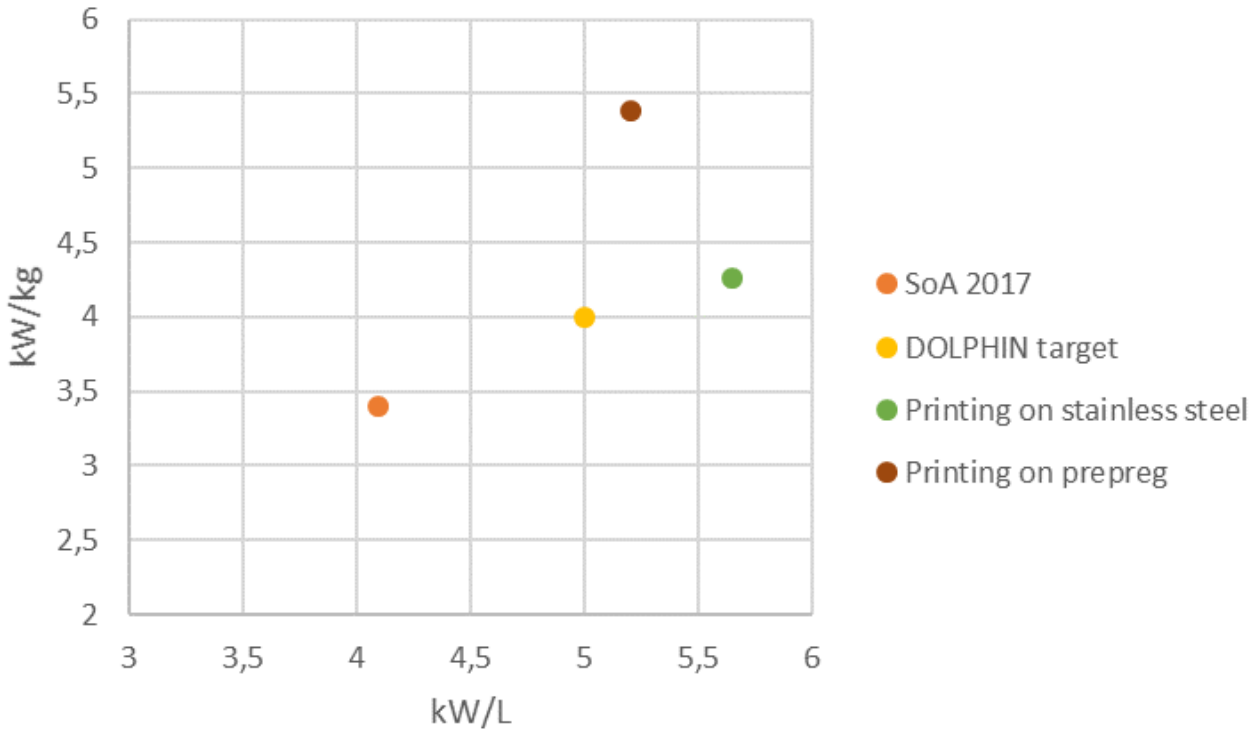
Assessment of stack performance

- Stack performance is estimated with the assumption of a cell power density of **2 W/cm²**
  - Actual power density obtained with printed pads remains lower, still needs some improvement
- If the cell power density target is reached, stack power densities can be higher than the project target for both substrates



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Conclusion

- Enhanced conductivity of the ink deposited on the substrate has been obtained
  - Optimization of process parameters is still required in order to obtain a good mechanical behaviour
- Printing on large active area has been demonstrated (100 cm^2 flat stainless steel pad)
  - Single cell tests will be conducted soon
- Advantageous stack weight and volume can be assessed

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Thank you for your attention!

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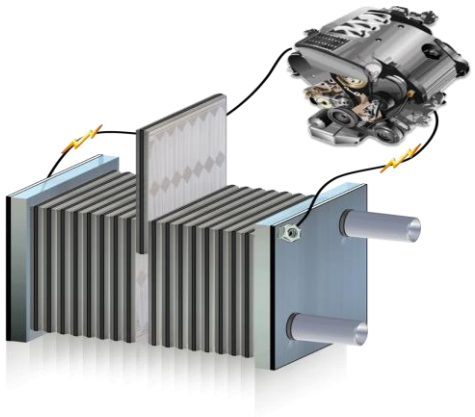

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DOLPHIN Project: 1st public workshop
(cell and manufacturing technologies) - virtual – 18/06/2021