NH_3 – High temperature experimentation

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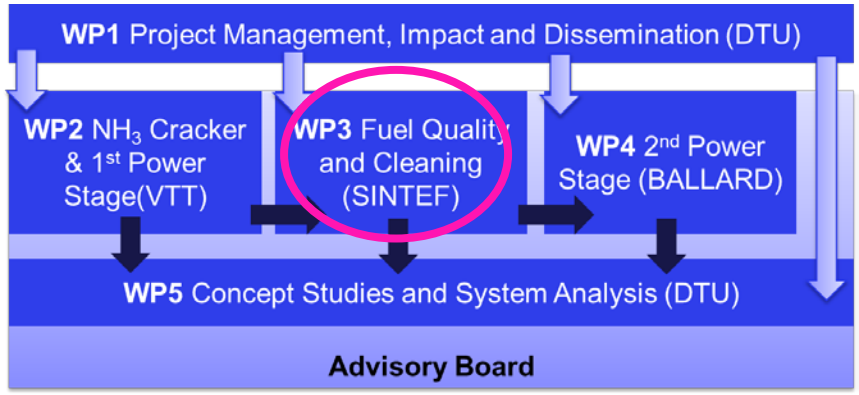
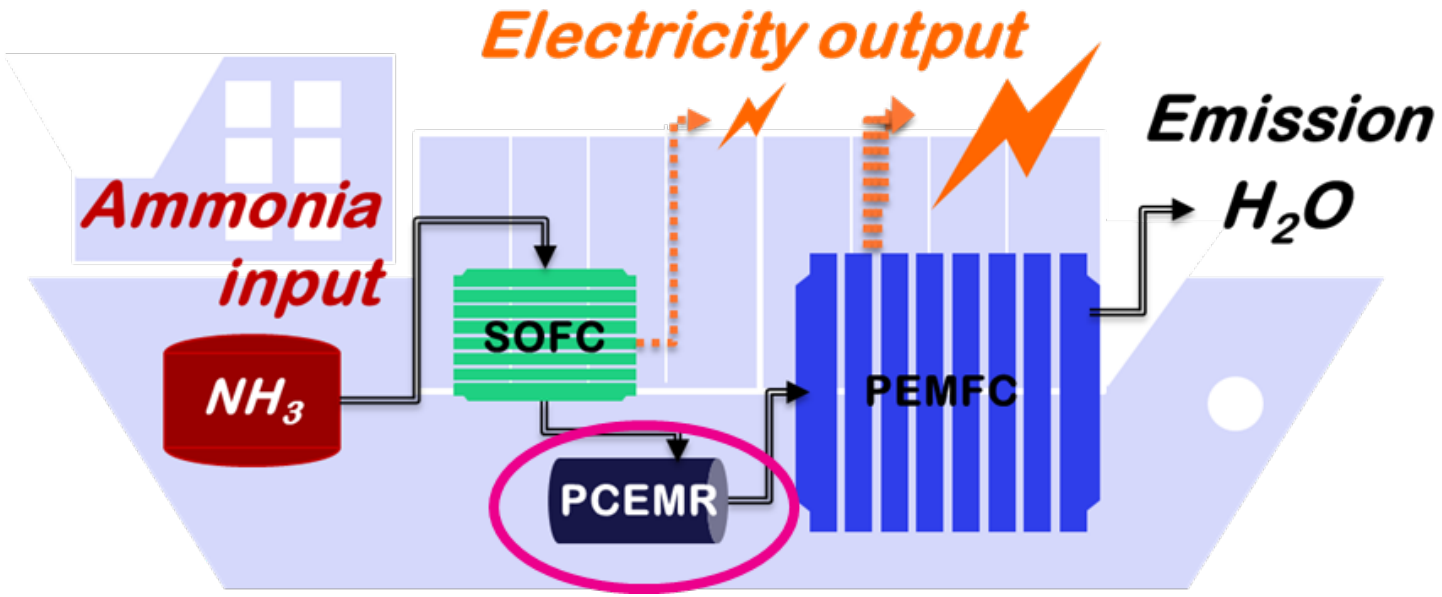
NH_3 webinar, AEGIR, 14.02.2023

Outline

- Short introduction
- Working with NH_3 at high temperatures
  - Prior to experiment
  - During experiment
  - After experiment
- Purpose-built NH_3-lab

AEGIR project





PCEMR – Proton Ceramic Electrochemical Membrane Reactor
Extraction of high purity H_2 from $NH_3/H_2/N_2$ mix

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Prior to experimental start-up start

- All valves, gaskets and MFCs in existing infrastructure was replaced to qualify for use of concentrated dry/wet NH_3.
- Safety assessment of the NH_3 activities, following standard procedures for safe job analysis at SINTEF.
- FTIR used for gas analysis.
- Scrubbing system for exhaust.
- Bubbling through saturated $Cu(NO_3)_2$-solution
  - $Cu(NO3)2 + NH_3 = Cu(OH)_{2(s)} + Cu(NH_3)_4^{2+}$
  - $Cu(OH)_{2(s)}$ can cause clogging of gas lines.
- Bubbling through lactic acid
  - Liquid ammonium complex
  - Keep track of pH

NORWEGIAN FUEL CELL
AND HYDROGEN CENTRE

NH_3-cracking – Choice of gas-inlet material

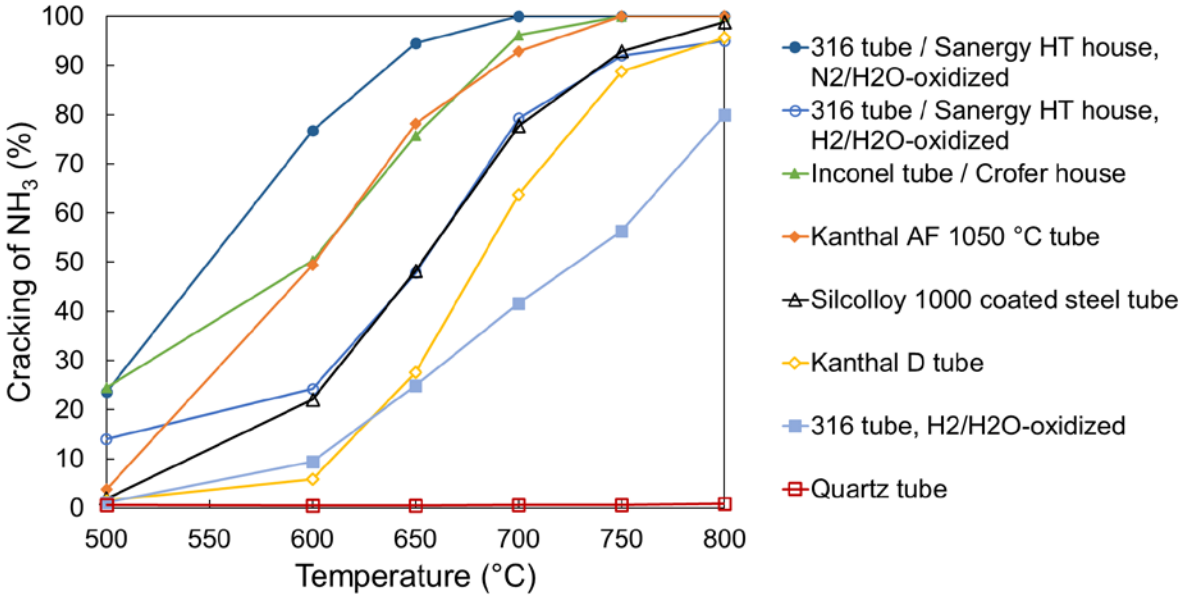


Figure 2: Ammonia cracking as a function of temperature for different materials utilizing a flow rate of 0.12 L/min 10% NH_3/Ar.

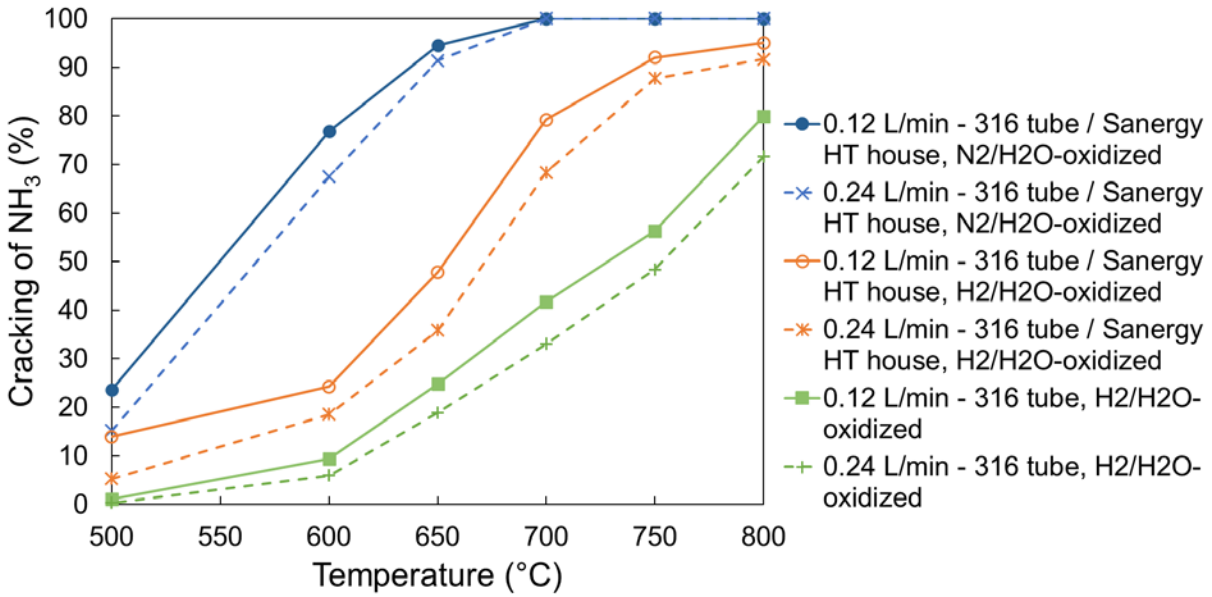
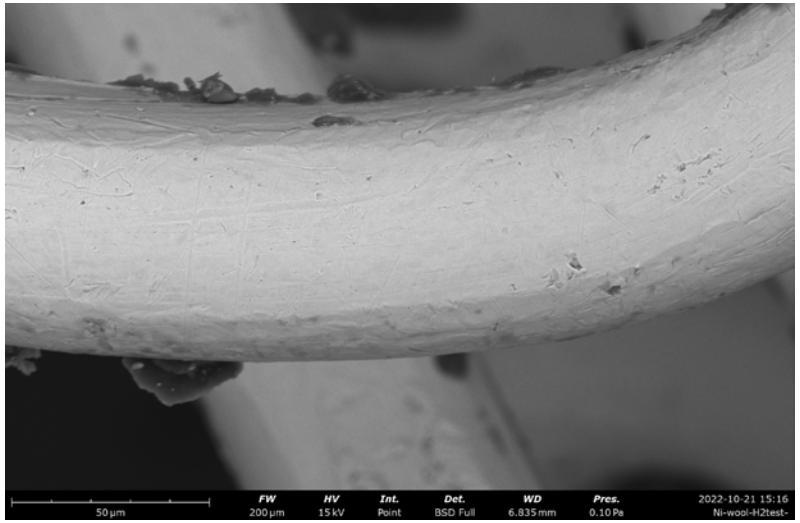
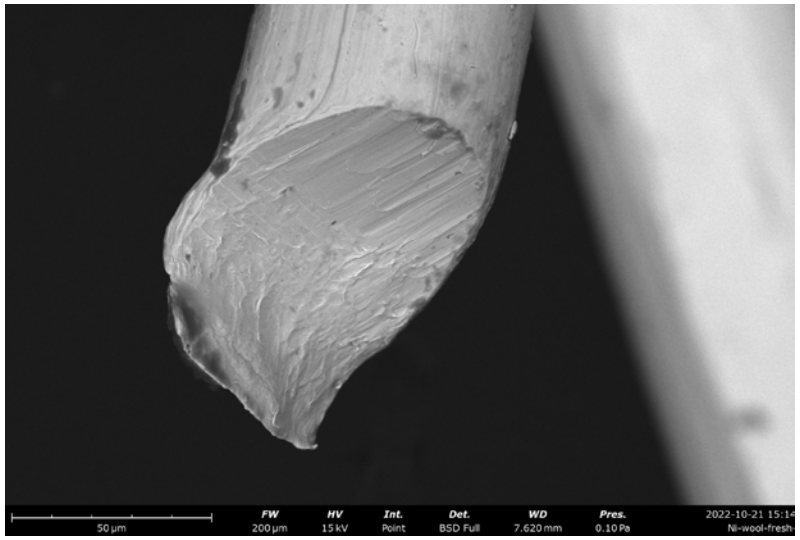
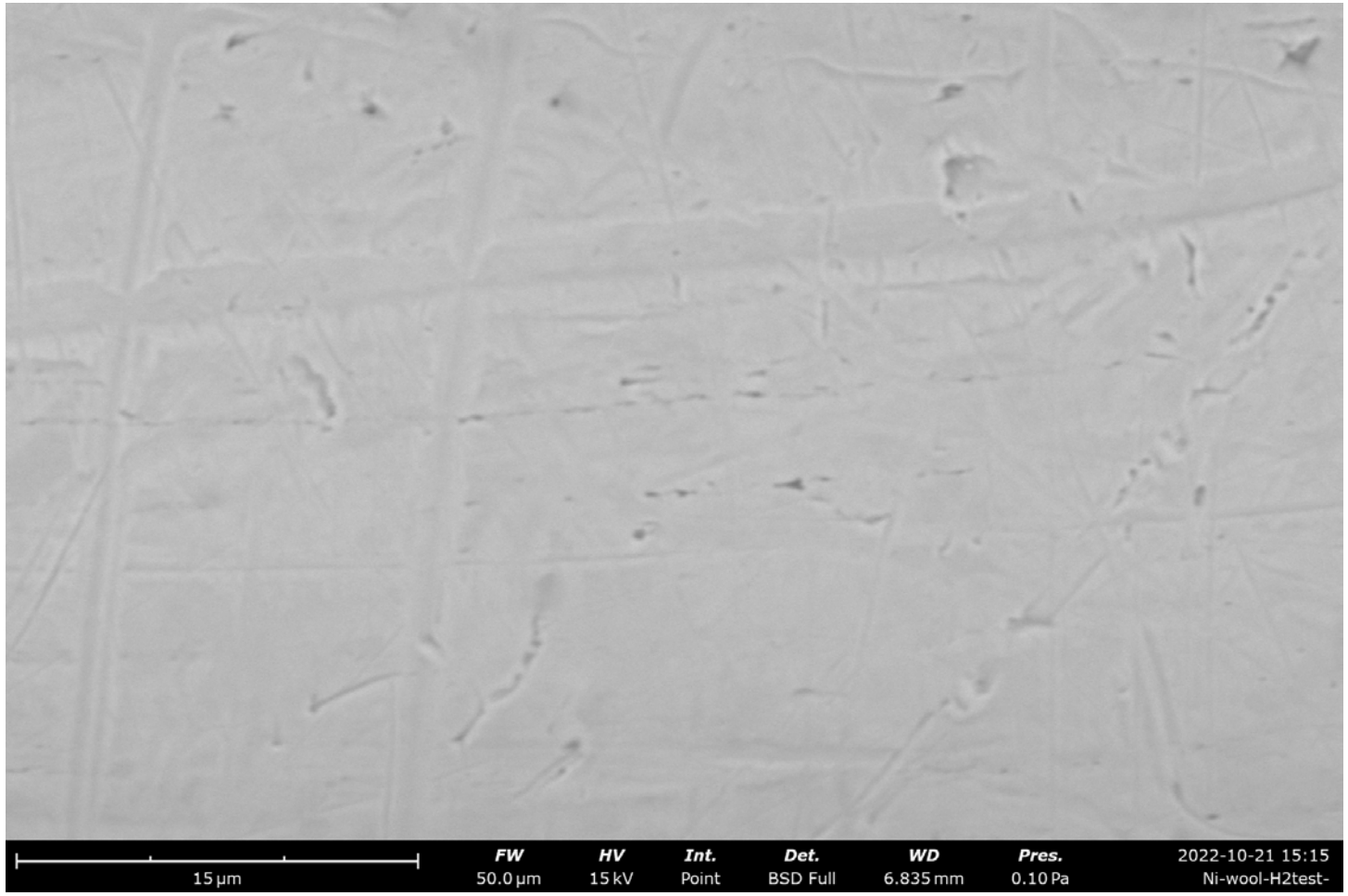


Figure 3: Ammonia cracking as a function of temperature for different materials utilizing a flow rate of 0.12 L/min (solid lines) or 0.24 L/min (dashed lines) of 10% NH_3/Ar.

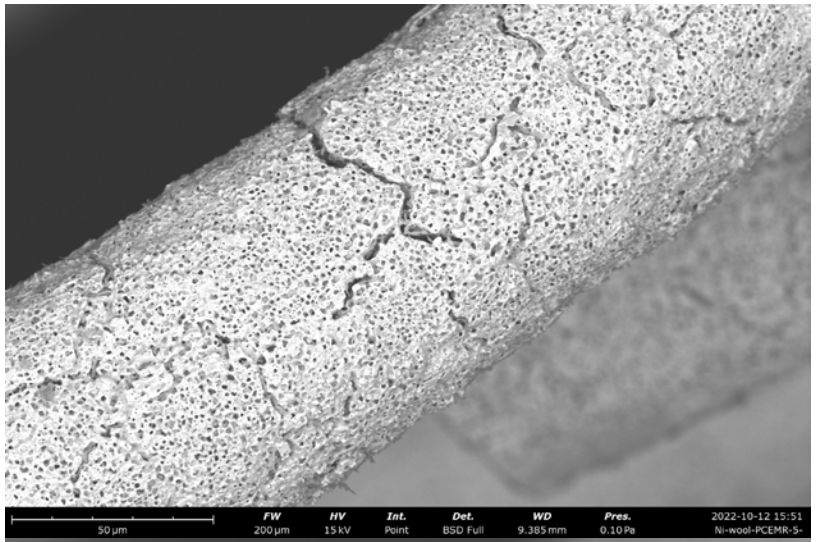
Ni-wool from H_2 test

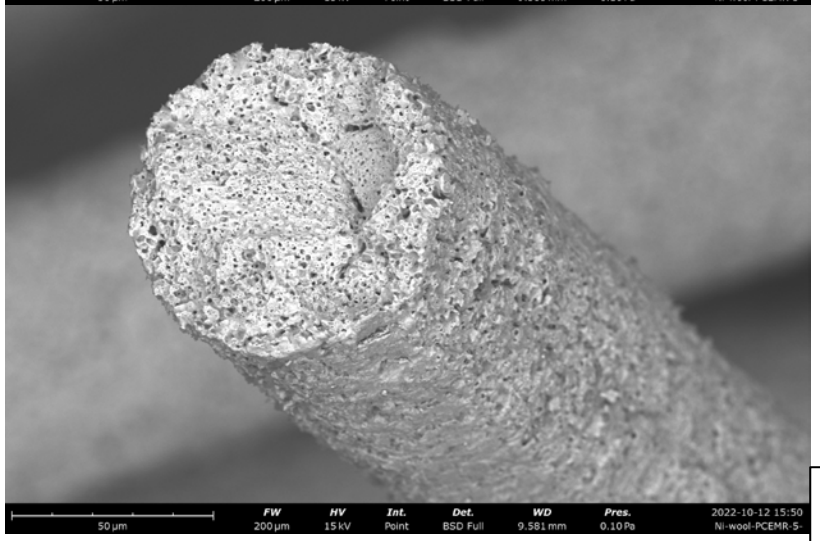


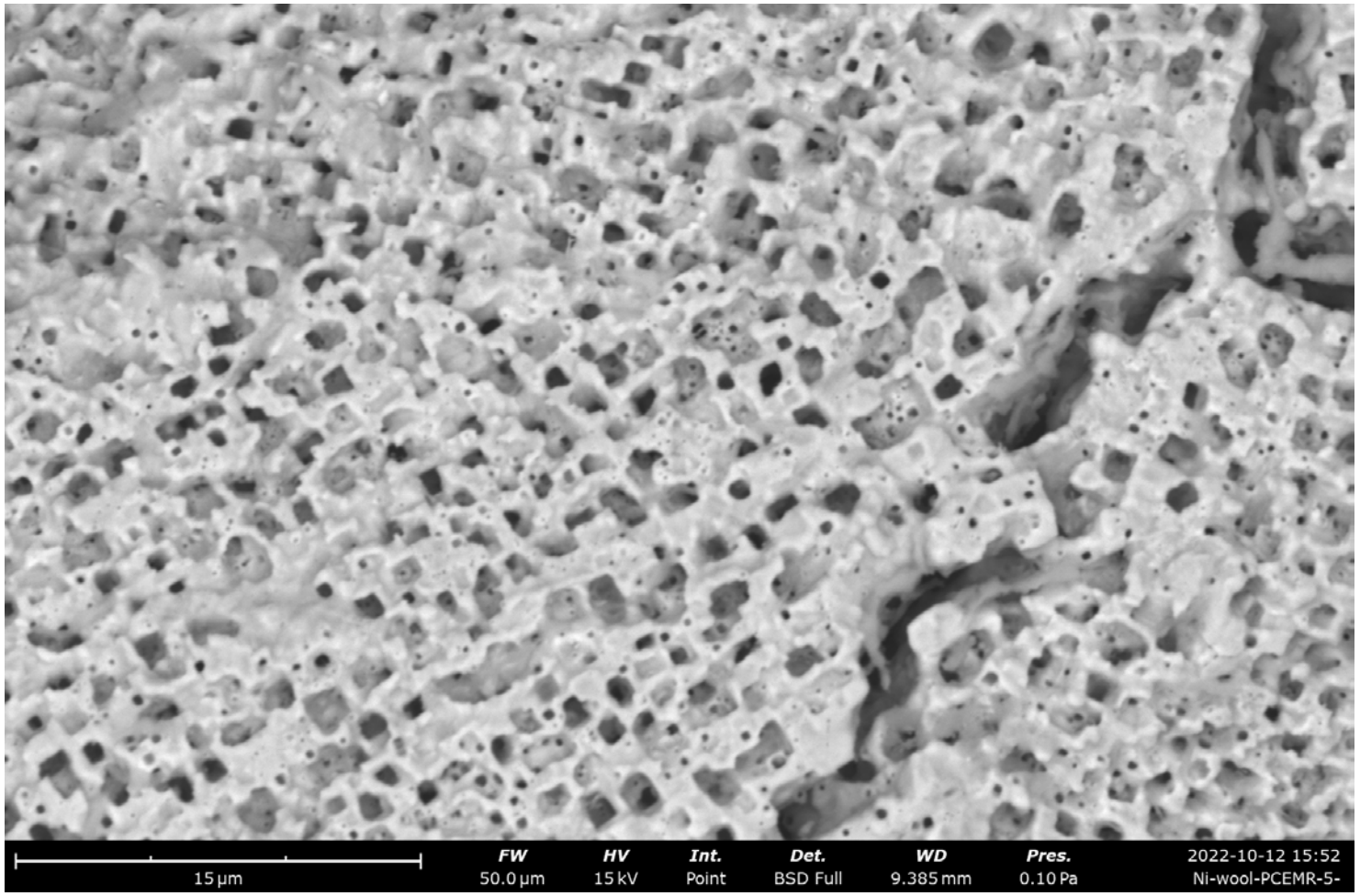




Ni-wool from test with NH_3



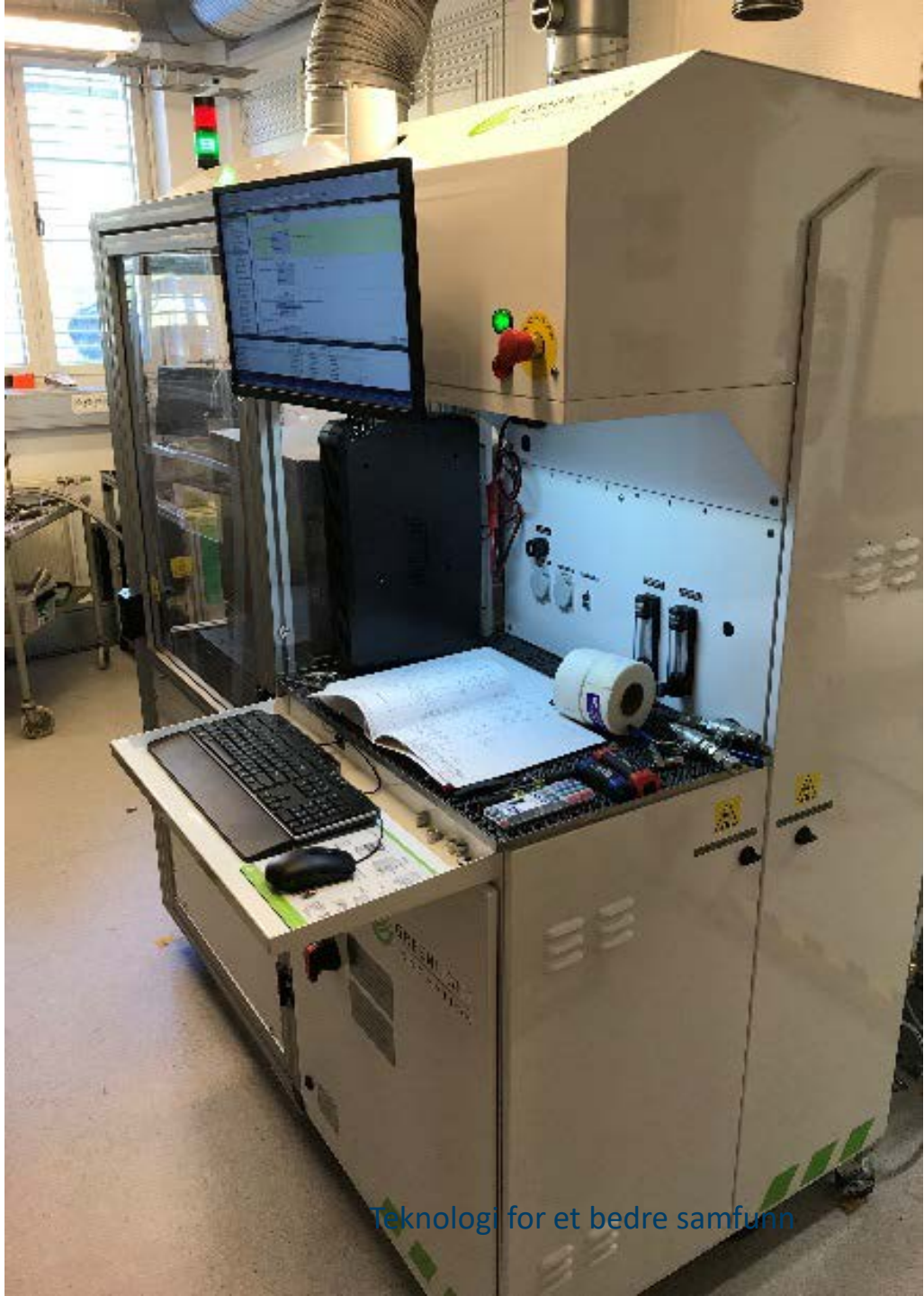




→ 5-15 % increase in wire diameter

After experiment

- Flush gas lines containing dry/wet NH_3
- Replace water in humidifier
- Replace scrubber solution.



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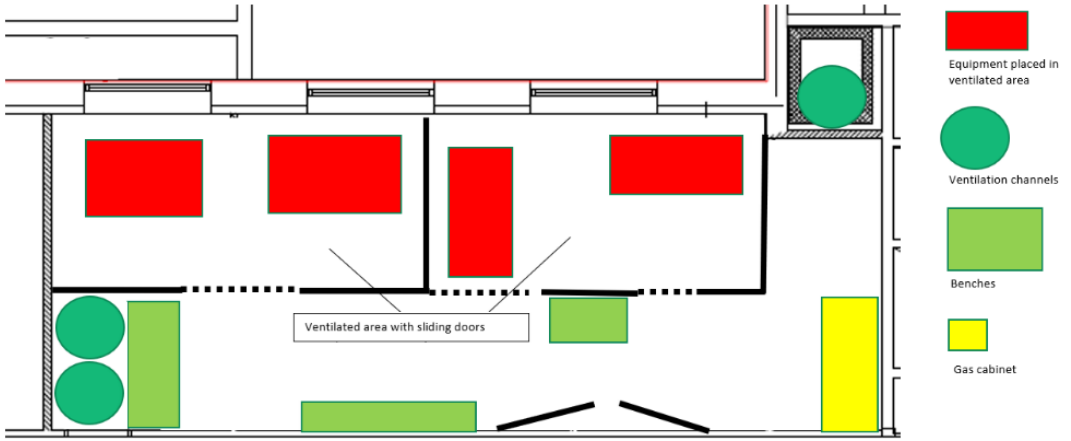
Testing infrastructure – NH_3-lab

- Total area: ~60 m^2
- Two ventilated areas separated from work space by sliding doors
- Ventilation capacity: 5000 m^3/h
- 4 NH_3 sensors + sensors for LEL (H_2) and CO

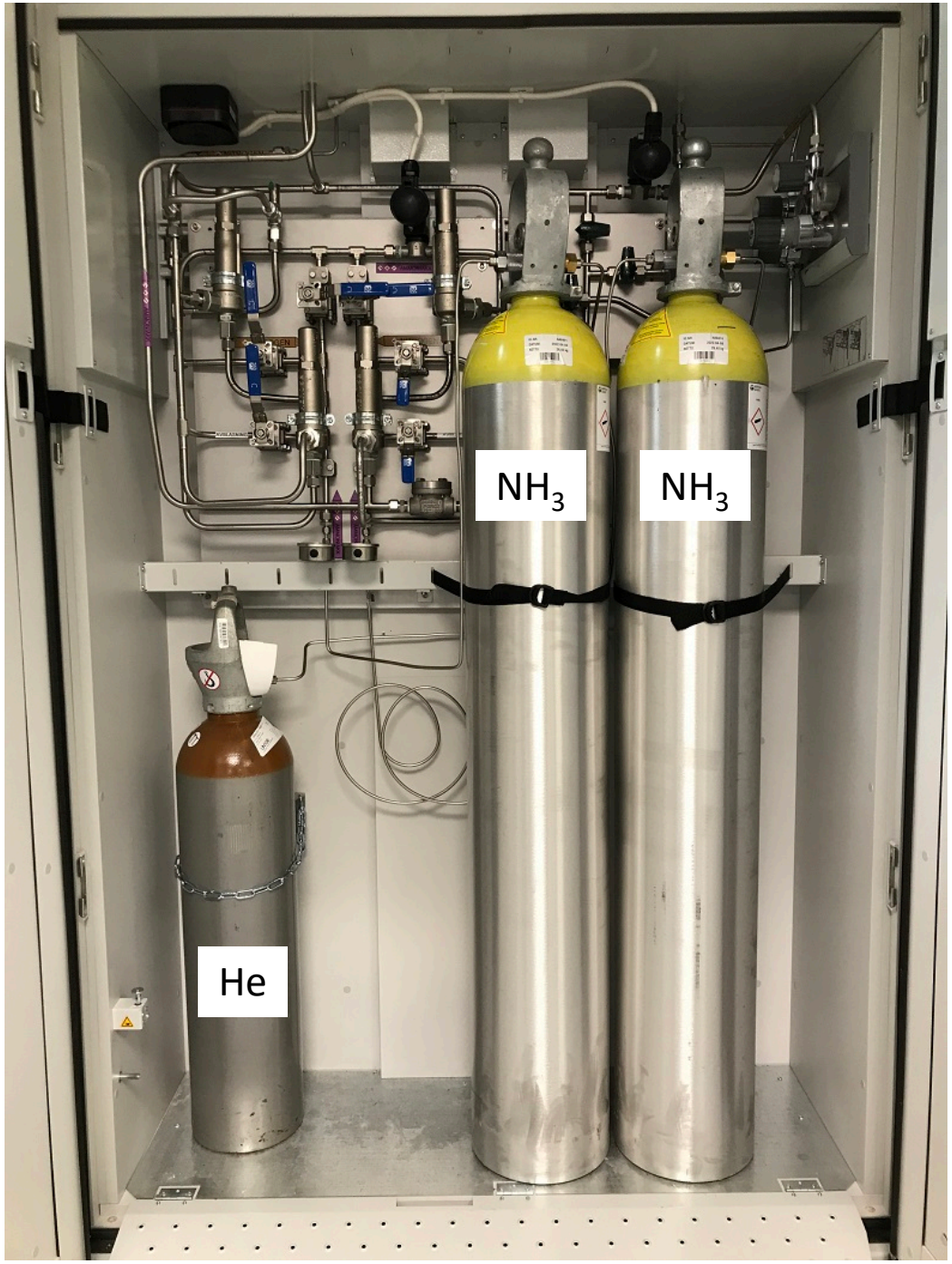
- Commissioned Jan 2023
- Shared with CoorsTek Membrane Sciences



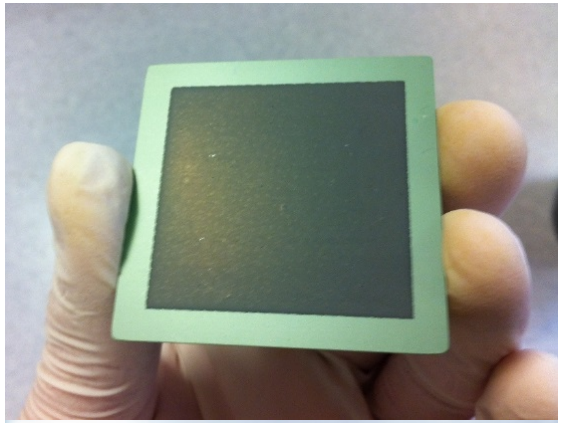

Ventilation room

NH_3-lab

- Safety storage cabinet with 2 × 26 kg NH_3 (50 L)
- He for pressurizing the NH_3
- N_2 for flushing of gas lines during bottle changes
- NH_3 sensor inside cabinet
- Magnetic solenoid valves connected to NH_3 line for automatic shut off in case warning level is exceeded



Testing infrastructure – NH_3-lab



- From small components and "button cells" to full-size planar (10x10 cm^2) and tubular fuel cells and short stacks (5 kW)
- Infrastructure for H_2, O_2, air, CO, CO_2, CH_4, He, Ar, H_2S and NH_3
- Micro-GC, MS and FTIR for gas analysis
- New lab dedicated to NH_3 activities
  - Current: Greenlight X40 station for single cell testing
  - Planned: corrosion furnace, Pd testing setup, ProboStat testing setup

Concluding remarks

High temperature experiments with NH_3

Prior to experimental start-up

- Follow all HSE procedures! Concentrated NH_3 is deadly.
- Replace all valves, gaskets, MFCs
- Careful evaluation of gas-inlet materials.

During experiment

- Wet NH_3 is highly corrosive
- Expect Ni_3N formation

After experiment

- Flush lines, clean scrubbers

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