



# FURTHER-FC



Further **U**nderstanding **R**elated to **T**ransport limitations at **H**igh current density towards future **E**lect**R**odes for **F**uel **C**ells

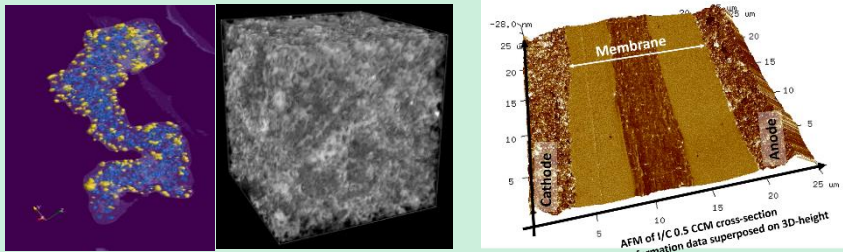
Impact of cell degradation on transport and structural properties of the cathodic catalyst layer in a PEMFC

J. Mittel, P. Gazdzicki: German Aerospace Center (DLR)

T. Morawietz, H. Kaess: Esslingen University of Applied Sciences

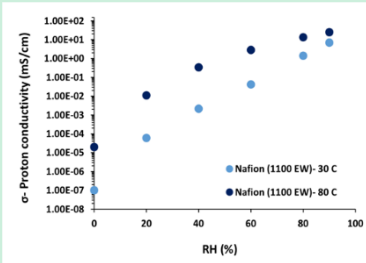


## Multiscale characterization

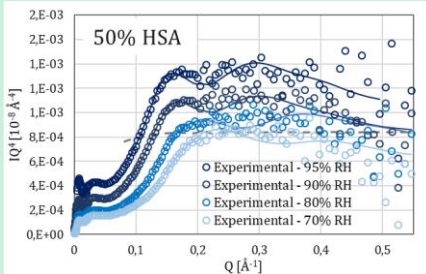


3D TEM and FIB/SEM

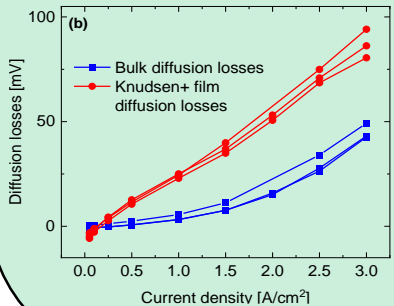
AFM



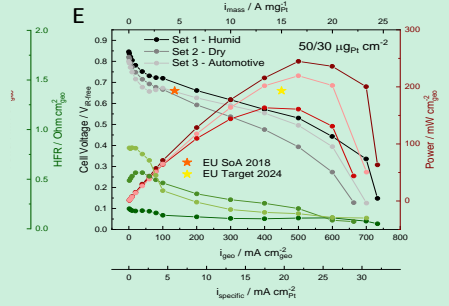
Ionomer transport properties



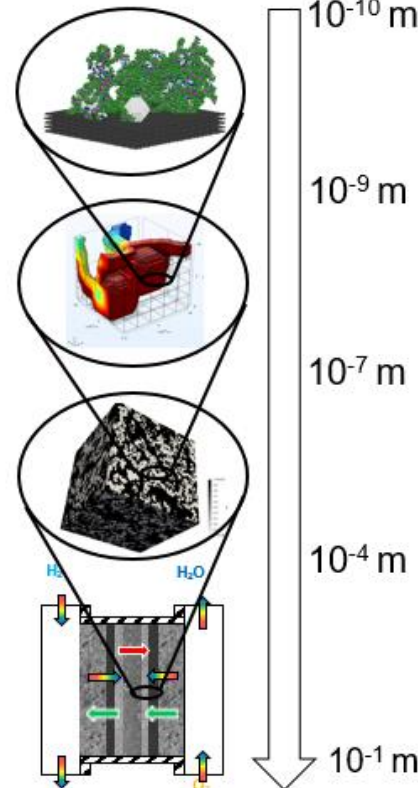
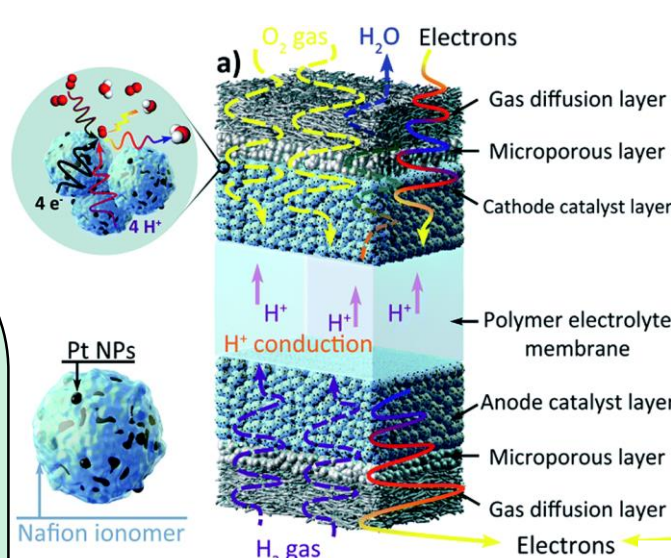
Small Angle Scattering



Mass transport losses

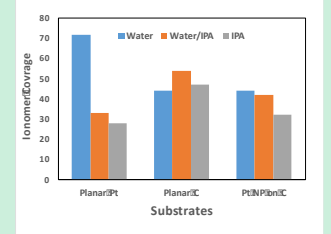
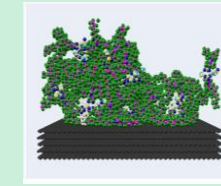
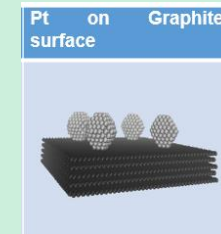


Ultra-thin electrode

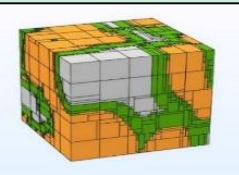


## Multiscale modeling

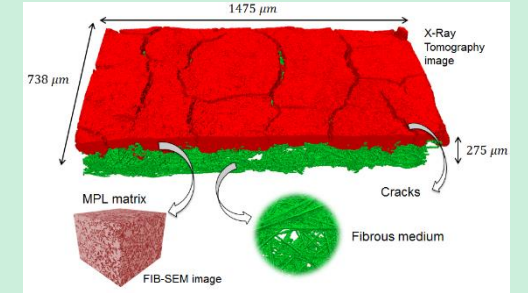
### Ionomer film scale



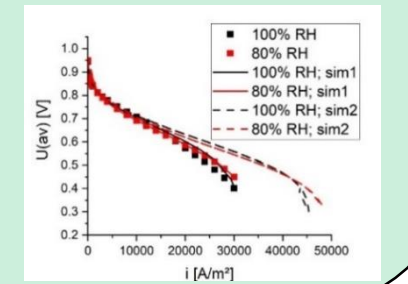
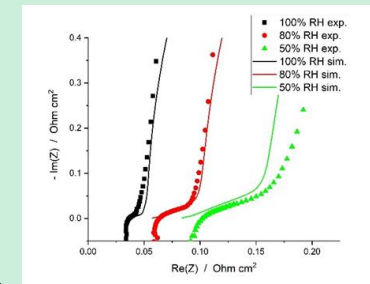
### Sub $\mu\text{m}$ scale



### CCL scale



### Cell scale





# Outline



- Durability test: setup, procedure and conditions
- Performance decay analysis
- Impact on:
  - membrane properties
  - catalyst properties
  - electrode properties
- Conclusions

# Conclusion

- Significant performance loss in 500 h AST test:  $\sim 100$  mV lower voltage at  $2 \text{ A cm}^{-2}$
- Minor impact of membrane properties:
  - Hydrogen crossover current slightly decreased
    - Formation of Pt particles (50-100 nm) in membrane at cathode/membrane interface close to hydrogen inlet
    - Enables chemical recombination of permeating  $\text{H}_2$  and  $\text{O}_2$
  - No impact on high frequency resistance
- Performance loss mainly caused by loss of catalyst activity:
  - Polarization curves show lower performance in catalyst-dominated regime (low  $j$ )
  - EIS show significant increased charge transfer resistance
  - ECSA loss of about -40%: Pt redeposition in membrane and ionomer agglomerates at CL/membrane interface
- Additional impact of structural changes in cathode CL mainly at air outlet:
  - Significantly reduced porosity and degreased cathode thickness ( $\sim 10\%$ )
  - Ionomer agglomeration on surface of cathode CL
  - Results in 33% increase of proton conductivity and only slight increase of oxygen mass-transport resistance





# Thank you very much for your attention!



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