

Operando Characterization of the Interactions between Hydrogen and Palladium Electrocatalysts

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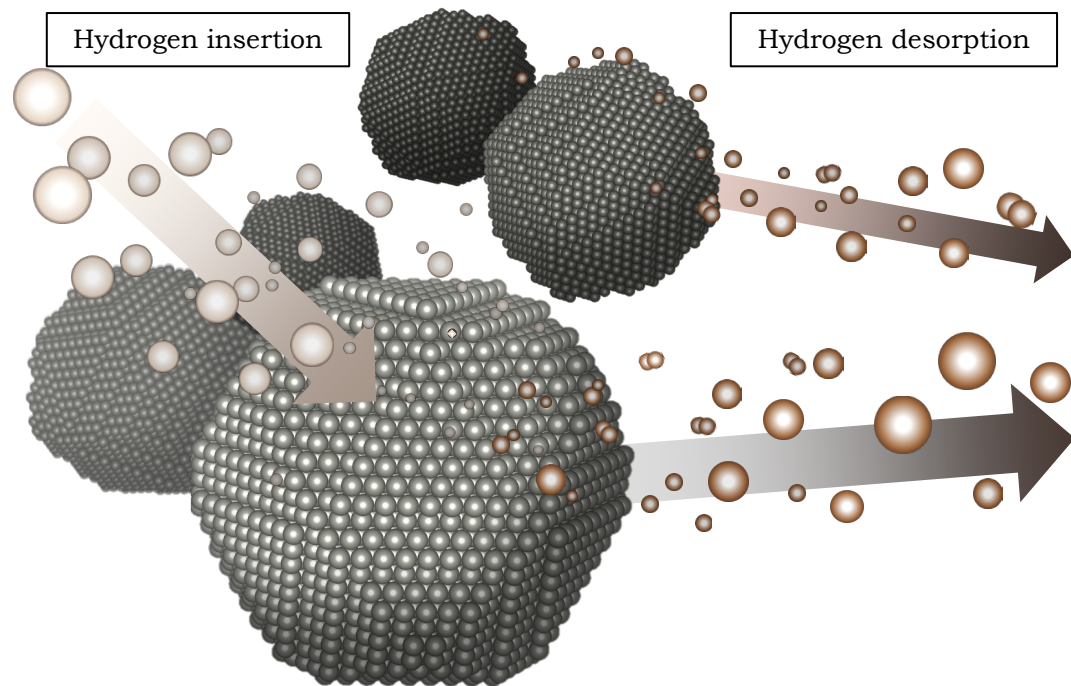
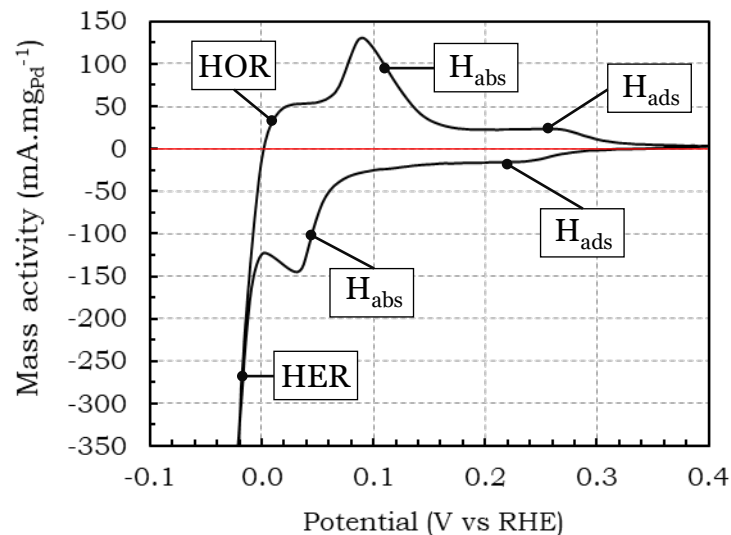


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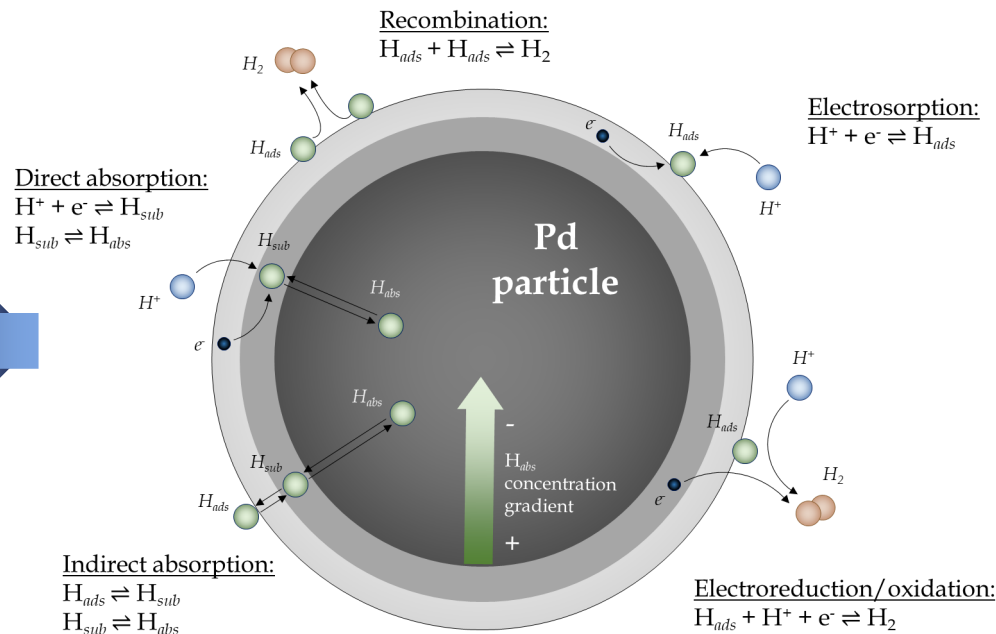
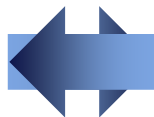
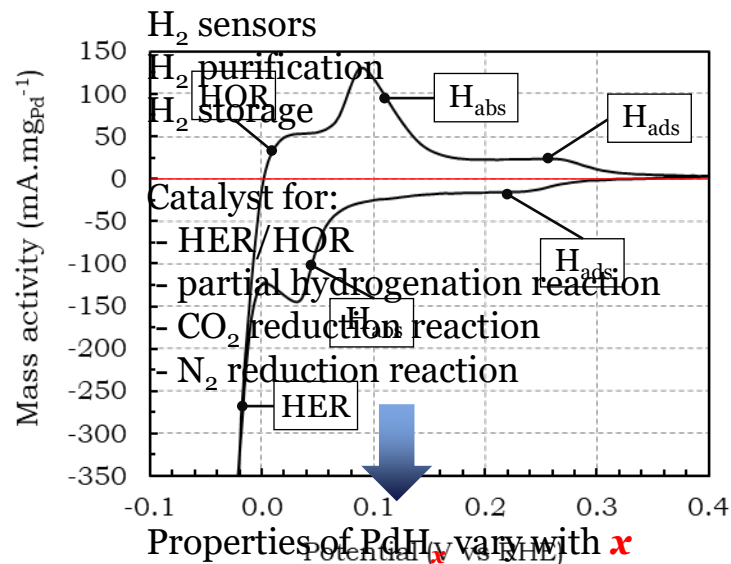


Introduction – Palladium hydride

Why study palladium hydride systems?

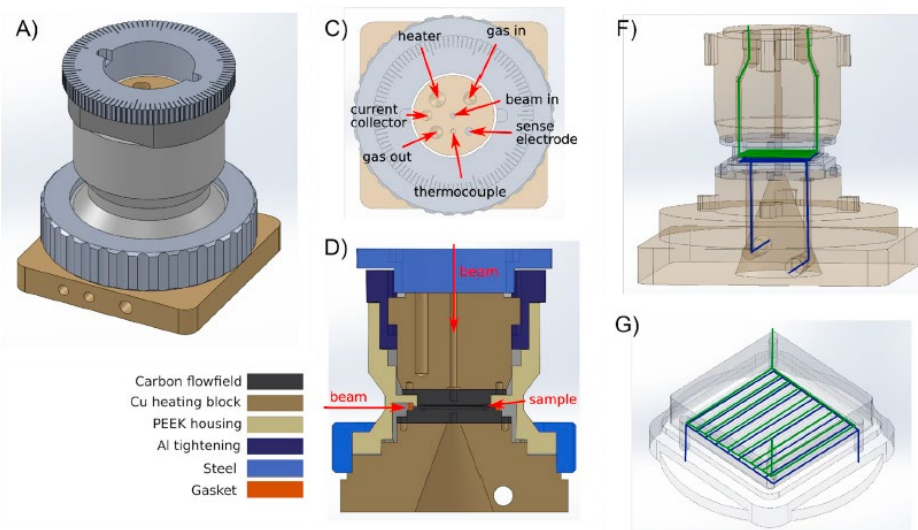
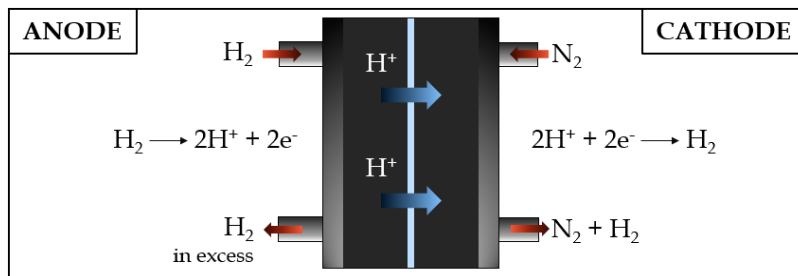


Introduction – Palladium hydride



Experimental considerations

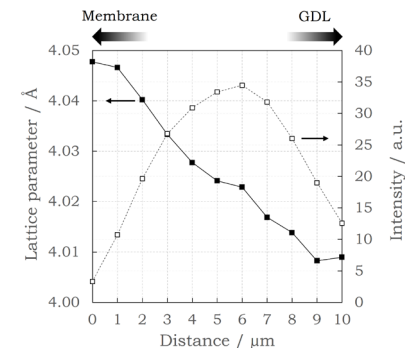
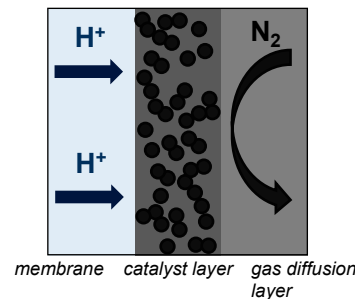
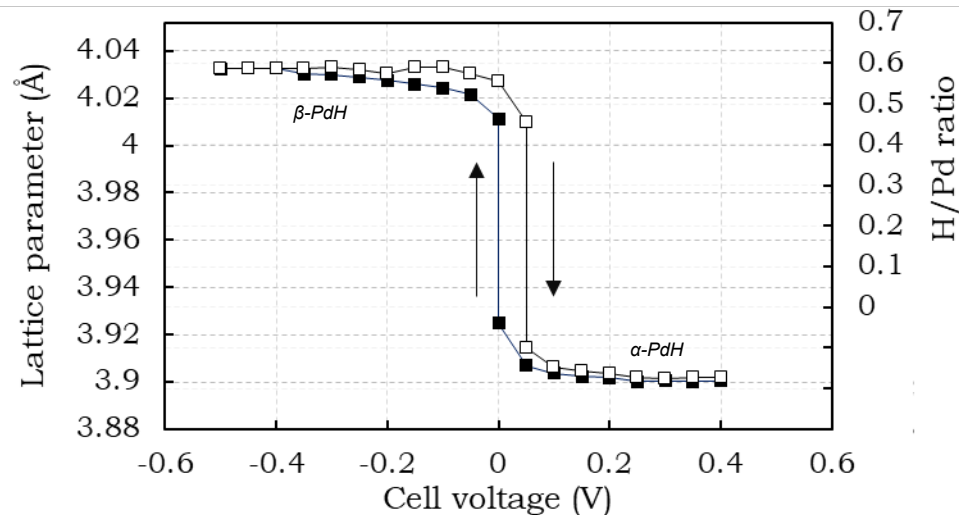
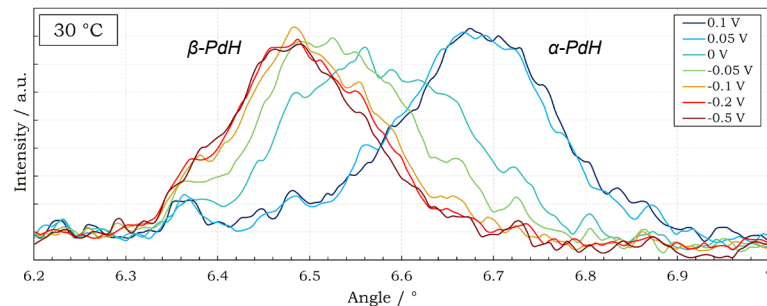
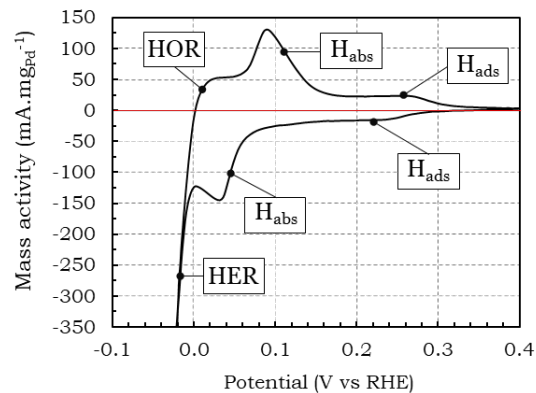
- ❑ MEAs of 5.29 cm², coated with Pt@C 20 wt.% (anode) and Pd@C 20 wt.% (cathode) based inks
- ❑ Loading approx. 0.5 mg_{Me}.cm⁻², Nafion 115 membranes (127 μm thick)
- ❑ H₂/N₂ (anode/cathode), 100 mL.min⁻¹, humidification 100%
- ❑ 30 – 60 °C



Martens I. et al., *Journal of Power Sources*, 10.1016/j.jpowsour.2019.226906

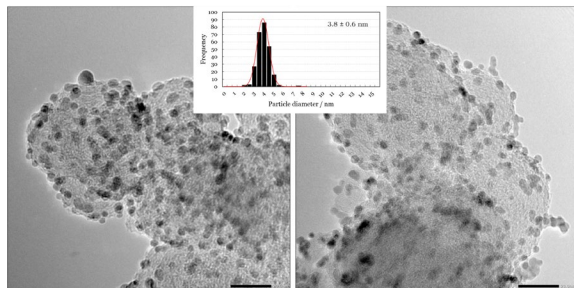
- ❑ European Synchrotron Radiation Facility (ESRF), Grenoble, France
- ❑ ID31 beamline
- ❑ Wide-angle X-ray scattering (WAXS)
- ❑ Time resolution < 100 ms

H/Pd Interactions under electrochemical conditions

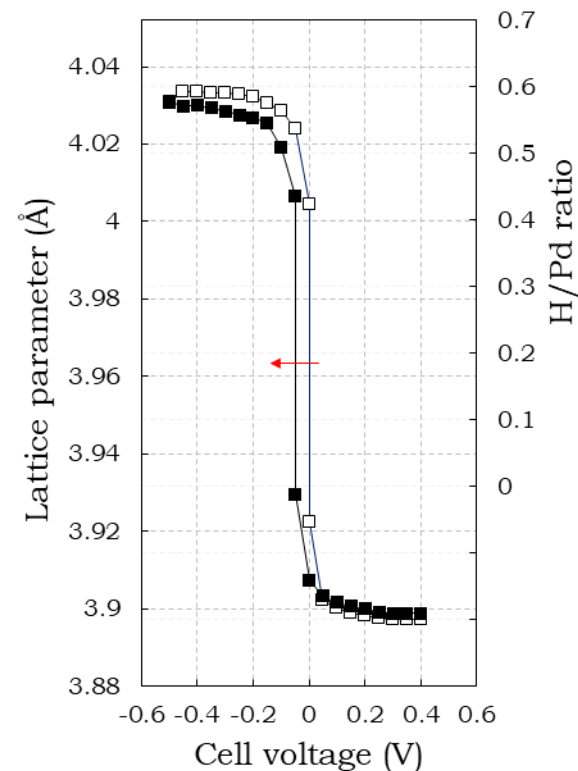
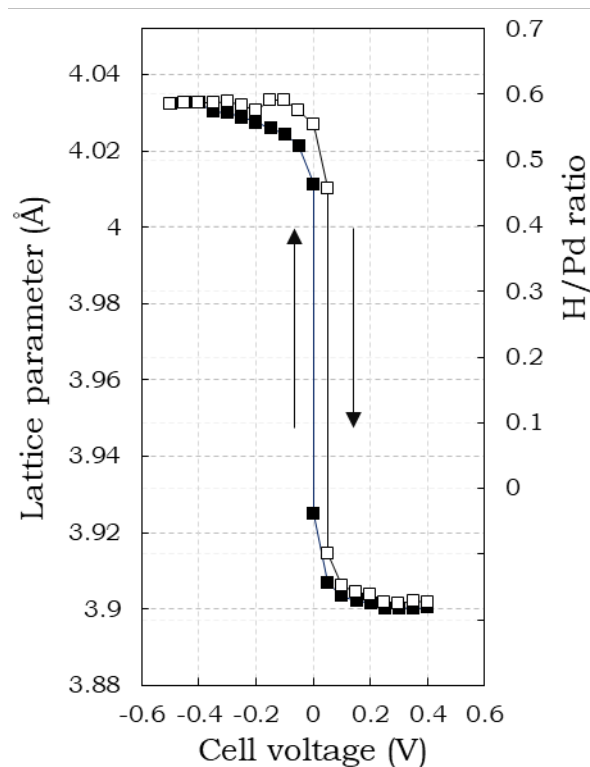
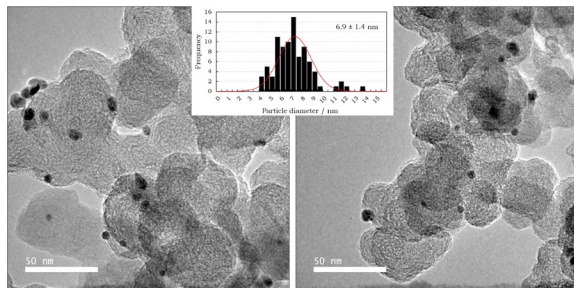


H/Pd Interactions: influence of the particle size

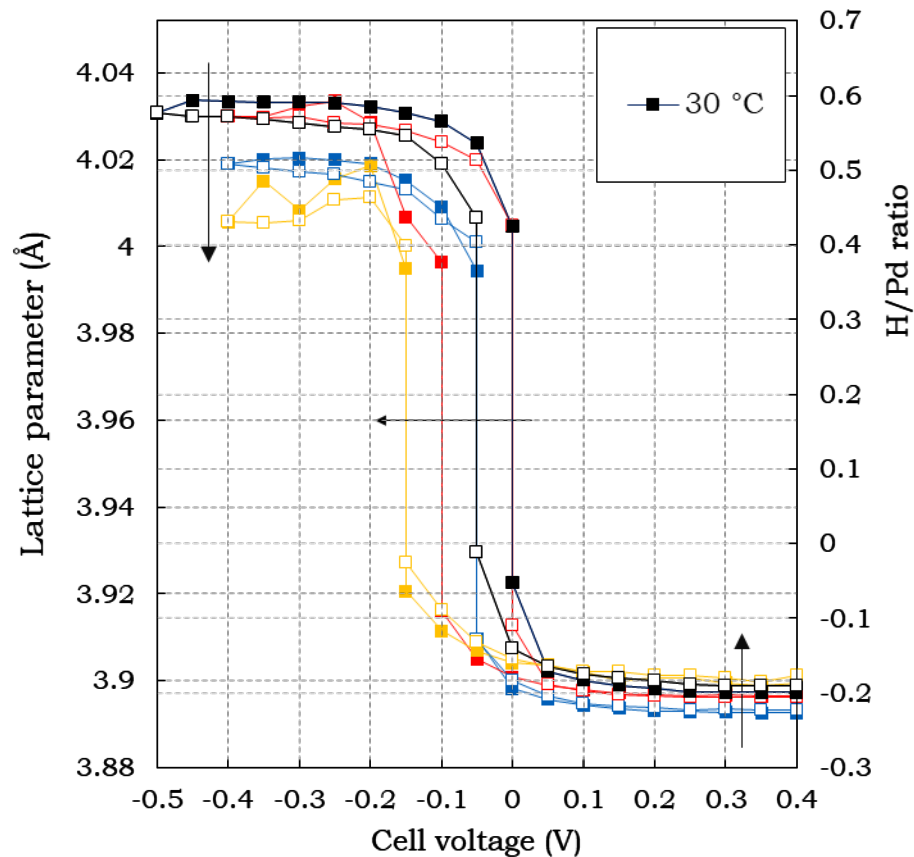
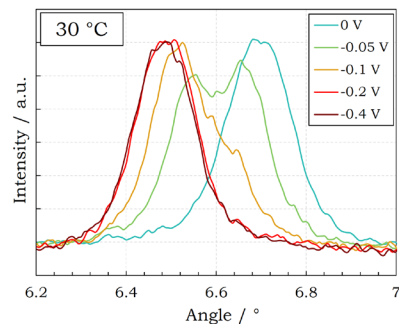
Commercial catalyst (3.8 nm)



Lab-made catalyst (6.9 nm)



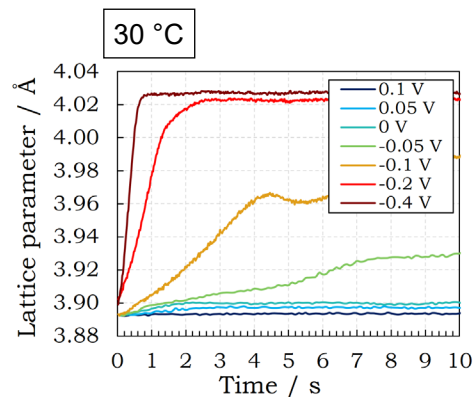
H/Pd Interactions: influence of the temperature



Controlling the H:Pd – Kinetics of H insertion

Extremely brilliant source of X-rays
= very high *time resolution* (20 – 100 ms)

- ❑ Possibility of following H absorption *operando*
- ❑ Absorption kinetic decreases with T°C
 - Is H diffusion not getting faster?
- ❑ Counteracting mechanisms:
 - Exothermic H adsorption
 - Increase in HER reaction rate



Conclusion

- ❑ No better way to understand what occurs in a cell than by looking directly inside of it!
 - Challenge of designing custom cells to allow the observation
 - Identification of pertinent parameter(s) to follow (*e.g.* lattice parameter, resistivity, Raman spectra, *etc.*)
- ❑ Within this study we showed:
 - The coexistence of the two Pd hydride phases (α & β)
 - The influence of the cell voltage on the H absorption capacity
 - The influence of the cell temperature on the H absorption rate
- ❑ Synchrotron measurements bring unbeatable time resolution, enabling the observation of rapid processes (tens of milliseconds)

Thank you for your attention!

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