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New Trends and Challenges for Air Quality Control

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Integration and performance of an ultra-low power palladium-based MEMS hydrogen sensor for high selective monitoring and fast detection

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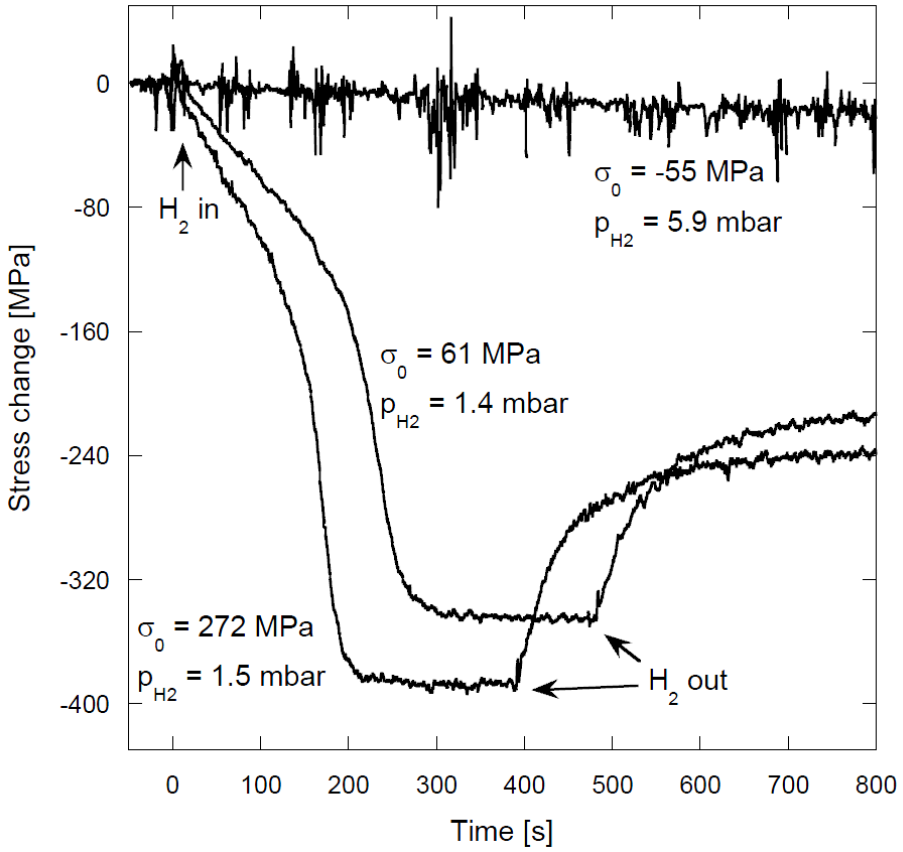
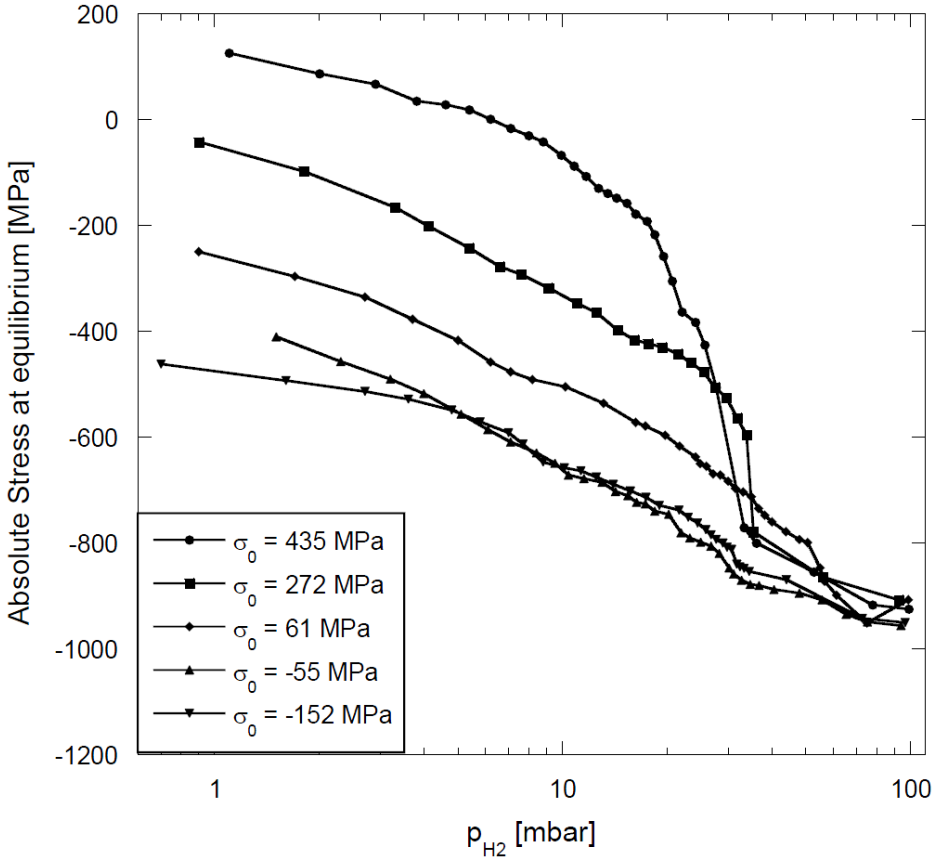
From Pd hydriding to H_2 detection



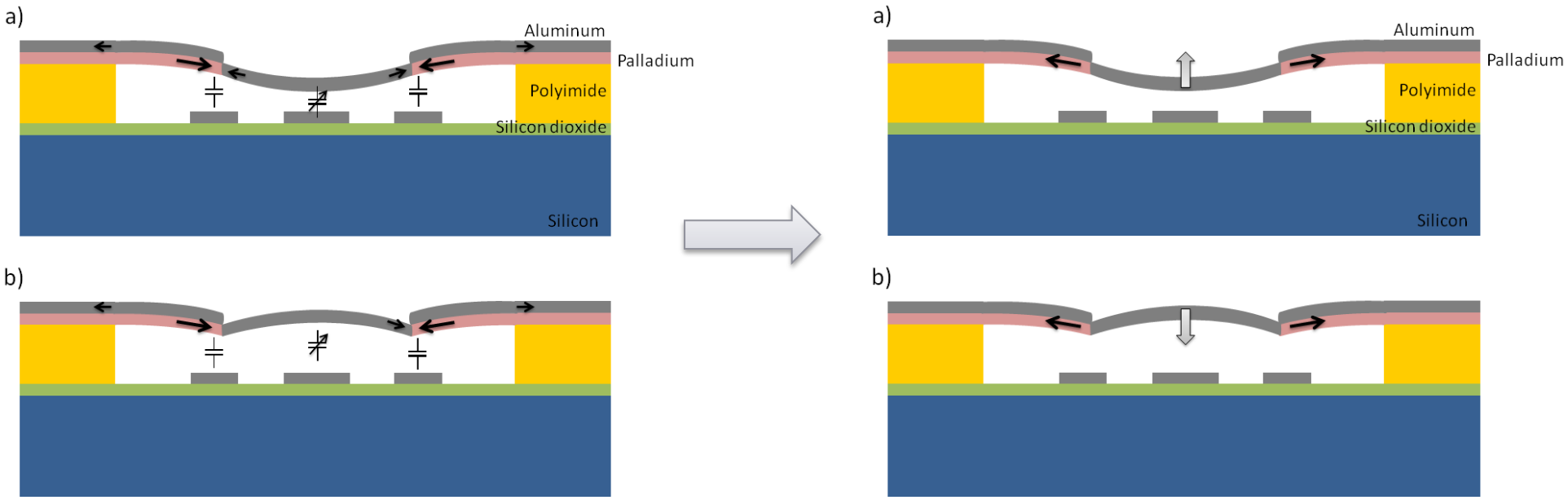


- Pd-hydriding kinetic induces compressive stress modification

$\Delta\sigma \approx -700$ MPa for $\sigma_0 = 435$ MPa at $p_{H2} = 10$ mbar or 1 % vol. H_2

R. Delmelle *et al.*, Acta Materialia, 61 (2013) 2320-2329.

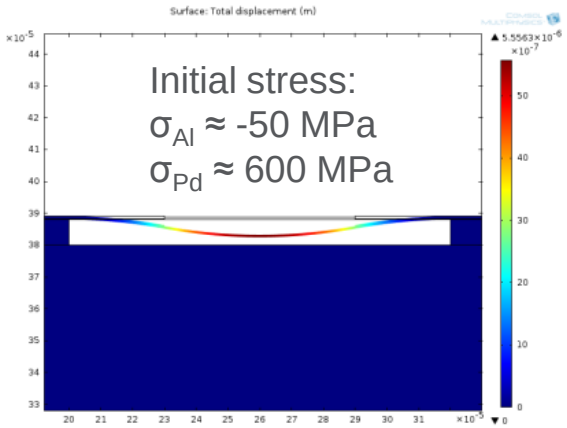
… and MEMS integration



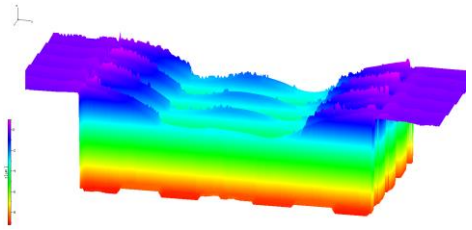
- Initially: Pd tensile stress induce Al buckled state (compressive stress)
- With H_2: Pd compressive stress induce tension in Al. Feedback is enabled through actuation electrode
- Moving direction depends on the initial buckling

MEMS capacitive transduction

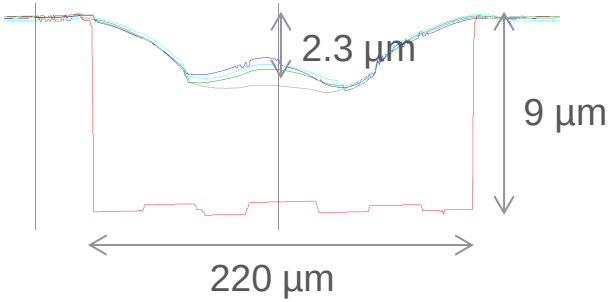
- From modelling … to characterization



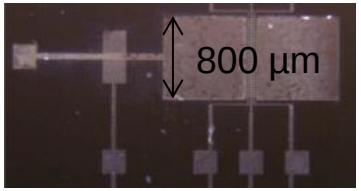
COMSOL Multiphysics®

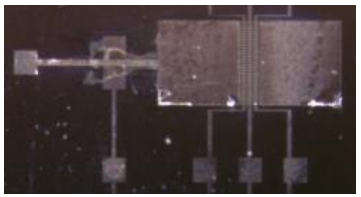


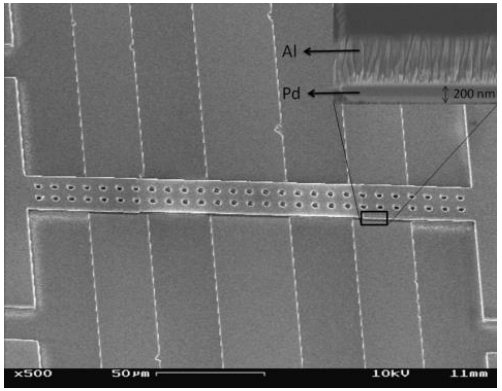
Polytec MSA-500



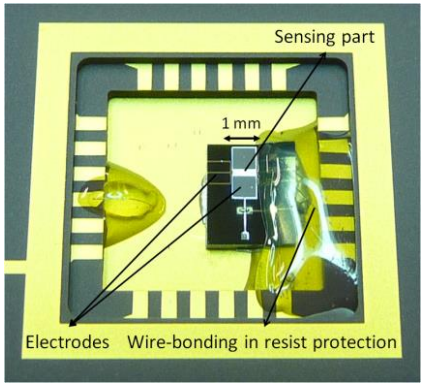
- Fabrication





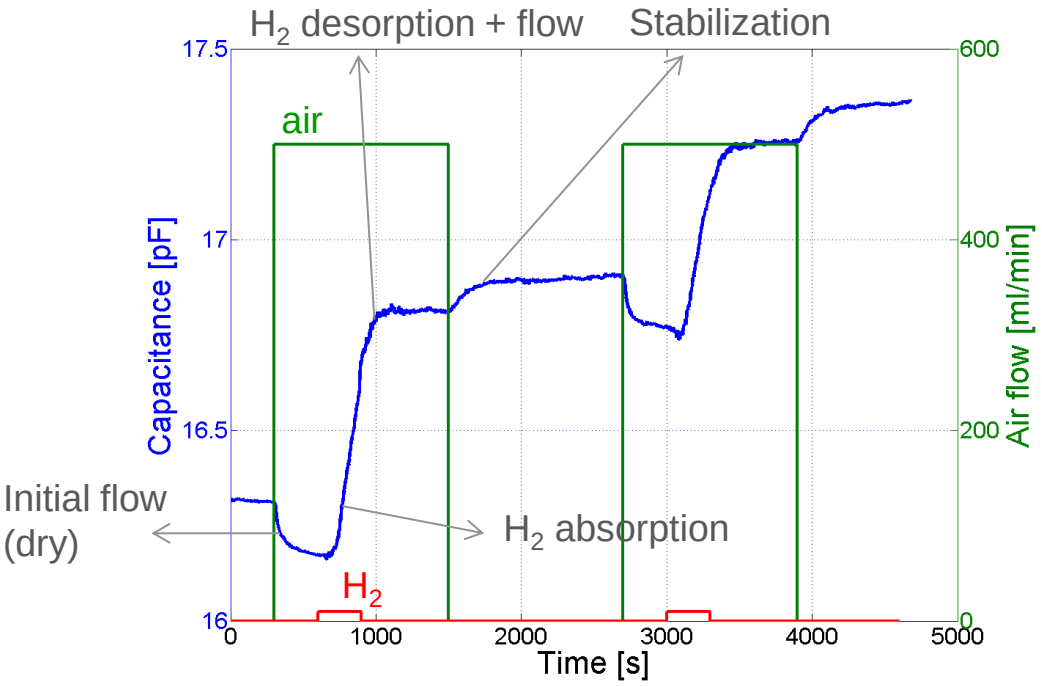


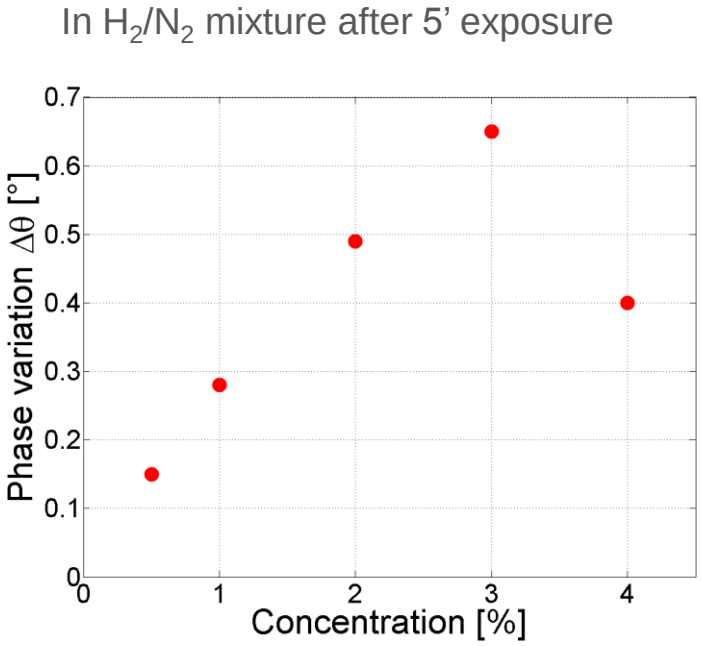
SEM



DIL-24 package

Measurements in H_2

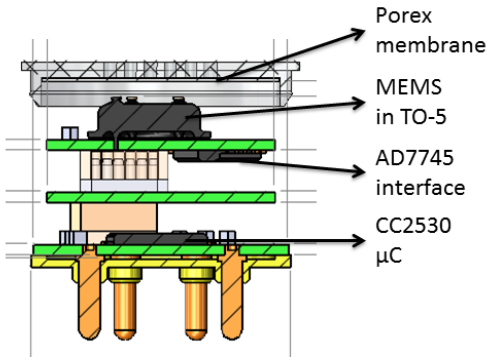


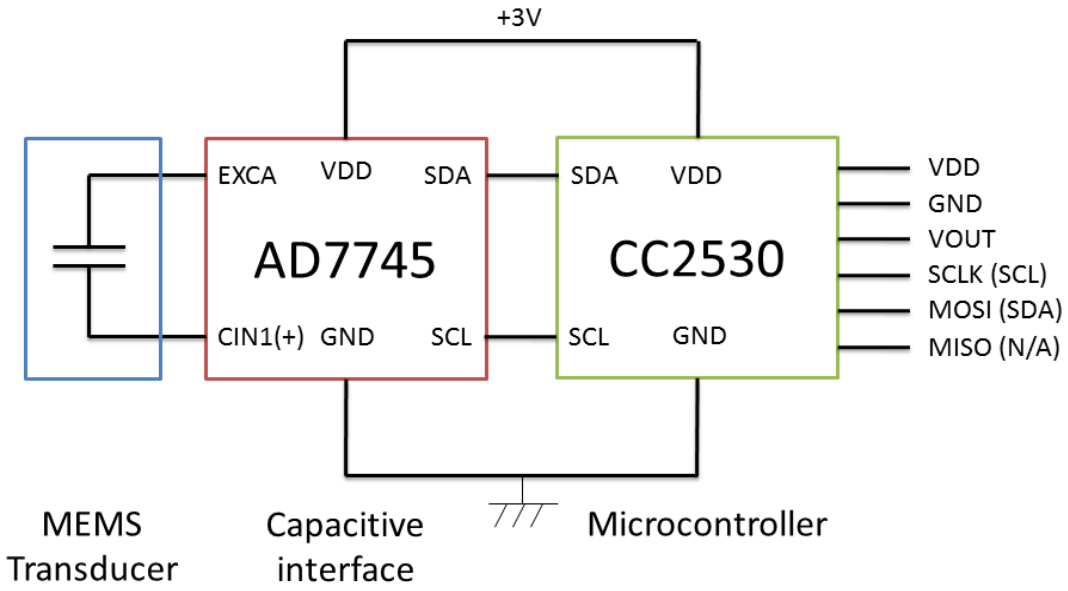


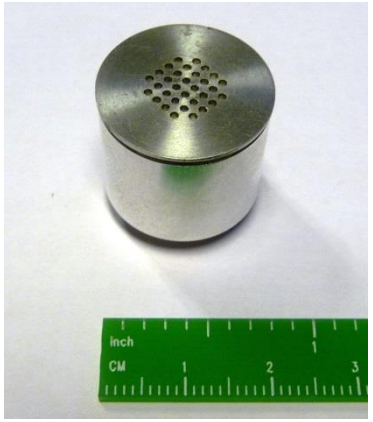
- Capacitance increases with H_2: beams move downwards
- Initial slope proportional to the H_2 concentration

System integration

- Use of a microporous membrane filter (Porex®) as humidity and small particles filter within a dedicated housing (4-Series compatible)
- Electronic interface with COTS (AD774x and CC25x0)
- ATEX compatibility







System integration

- Effect of each sub-component on the system dynamics

Component	Response time [s]	Total time [s]
Housing diffusion holes grid	2.8	2.8
Porex® membrane	2	4.8
Sintered-metal filter	0.8	5.6
MEMS transducer	3	**8.6**

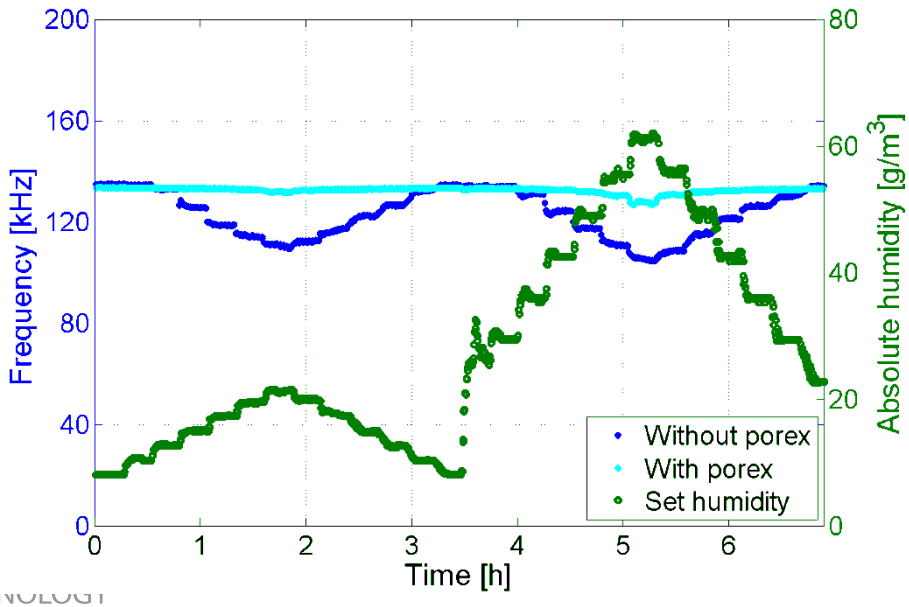
at 0.2 % H_2 in dry air

- Effect of the Porex® filter on the humidity inside the housing

measured by a CCMOSS Ltd. silicon-on-insulator platform functionalized by atomic layer deposition for humidity sensing

The filter totally protects the sensor to moisture up to 90 %RH at 45 °C, or 60 g/m^3 absolute

Humidity monitored in an ESPEC SH-261 humidity chamber



Conclusions and perspectives

- Low power consumption: 10 mW in continuous mode (2 Hz sampling)
- Capacitive sensor: ultra-low power sensing applications, IoT
- Pd-functionalization: selectivity to H_2, “reversibility”, but stress
- High dynamics: response time < 5 s (SNR = 5)
- Sensibility to humidity and temperature to be considered
- Filter (Porex®) and housing induce higher response time, > 8 s

Acknowledgements

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