European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

WGs & MC Meeting at SOFIA (BG), 16-18 December 2015

New Sensing Technologies for Indoor Air Quality Monitoring: Trends and Challenges

Action Start date: 01/07/2012 - Action End date: 30/04/2016 - Year 4: 1 July 2015 - 30 April 2016

Film Bulk Acoustic Resonator (FBAR) with Potential to selectively Detect CO_2 and Other Gases

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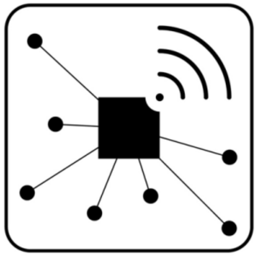
Scientific context and objectives

- **Background / Problem statement:**
  In the context of the EU-funded ESEE project ("Environmental sensors for energy efficiency", promoted by ENIAC JU Nr. 324284) we want to develop a low-cost gas sensor for energy efficient air quality management. The challenge here is to achieve sufficient sensor stability, resolution and selectivity, especially for CO_2.

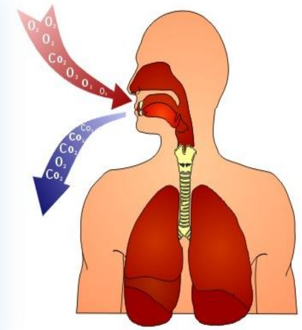


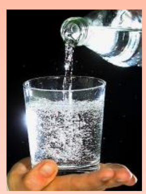
- **Objectives:** New sensing technologies for AQC, Environmental sustainability

Motivation

CO_2, CO, H_2O, NO_x, VOC,…

400 ppm – normal
1.000 ppm – tired
5.000 ppm – headache, drowsiness
30.000 ppm – increased heart rate
100.000 ppm – unconsciousness, death

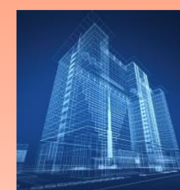




Air quality

Safety

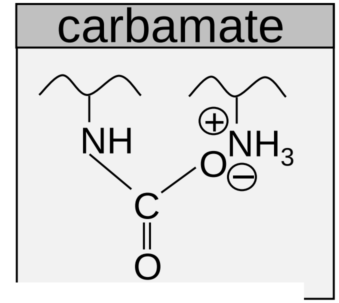
Energy efficiency



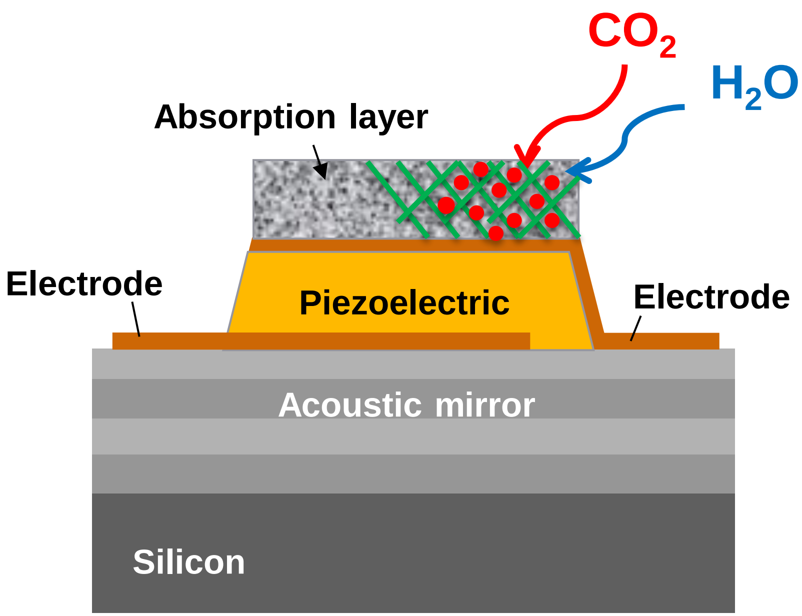
Intelligent buildings

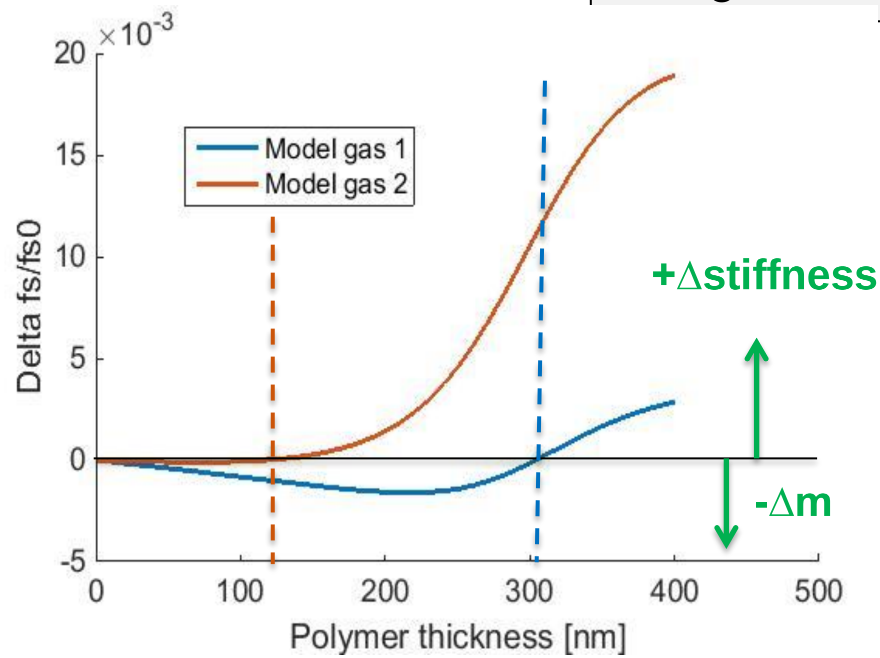
40% energy saving

The sensing principle

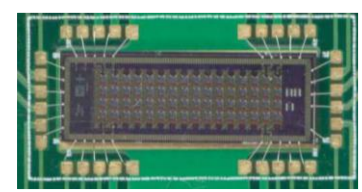


- FBAR (Film Bulk Acoustic Resonator)

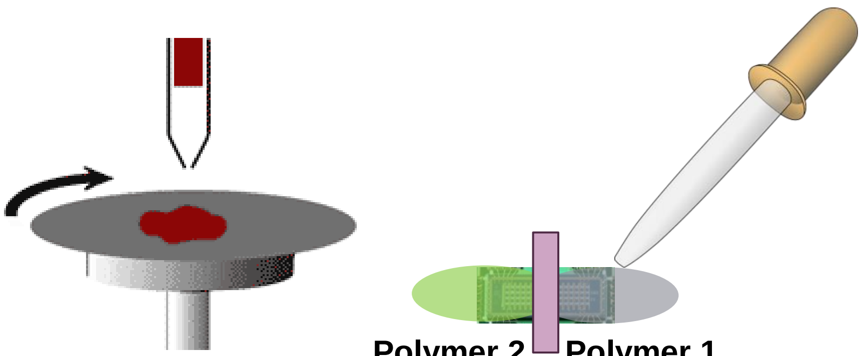




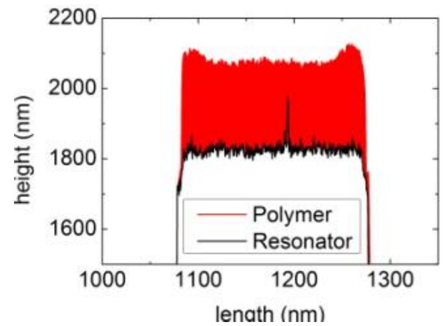
- Mass sensor→ Gas-sensitive absorption layers (CO_2: Aminopolysiloxanes)
- Elasticity sensor→ enables discrimination of different gases (e.g. due to CO_2 cross-linking)
- FBAR sensor array → potential for multi gas detection

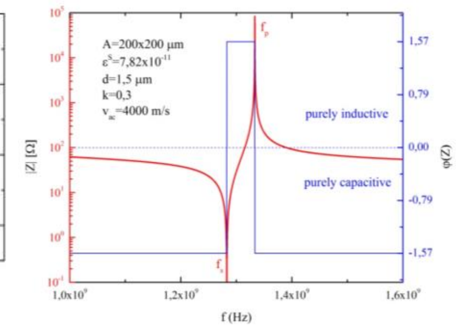


Experimental procedure



1.Spin-coating or dispensing

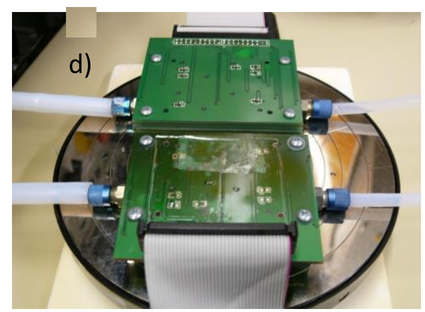


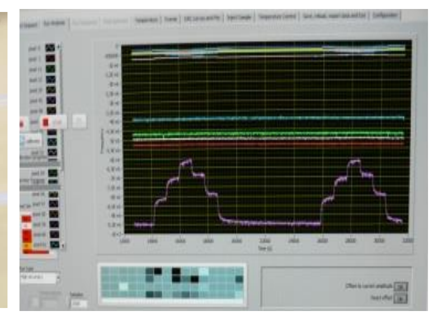


2. Characterisation

Sample preparation:

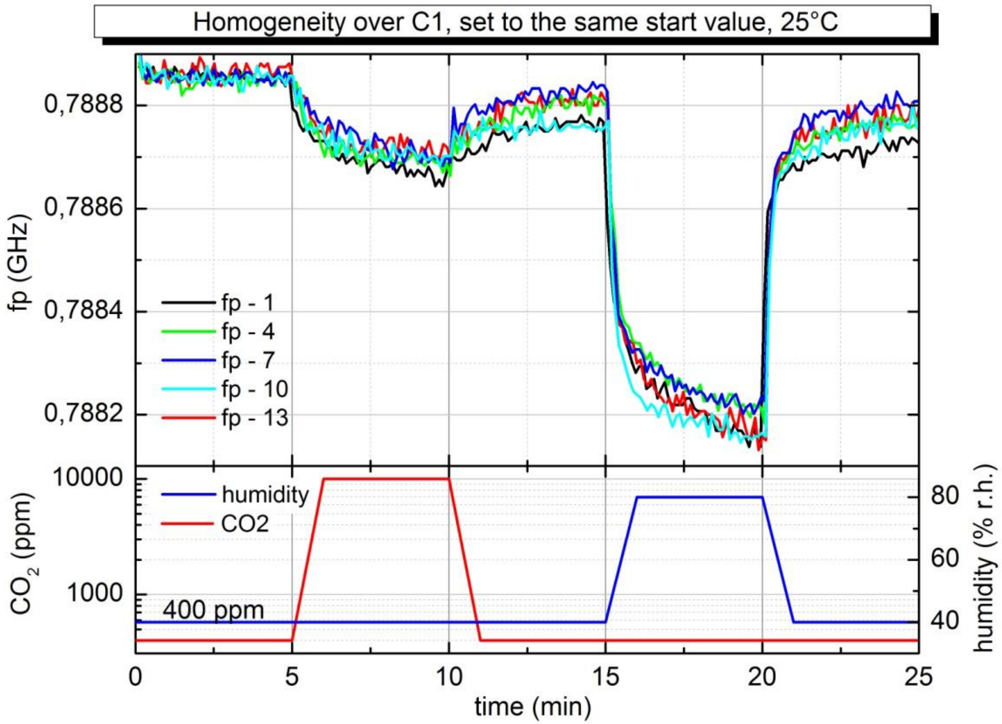
- -5 min O_2 plasma
- -Cleaning with Isopropanol
- -Spin-Coating 60s@5000rpm dynamic (50µl)
- -Anneal at 80˚C, 18h, 80% r.h.



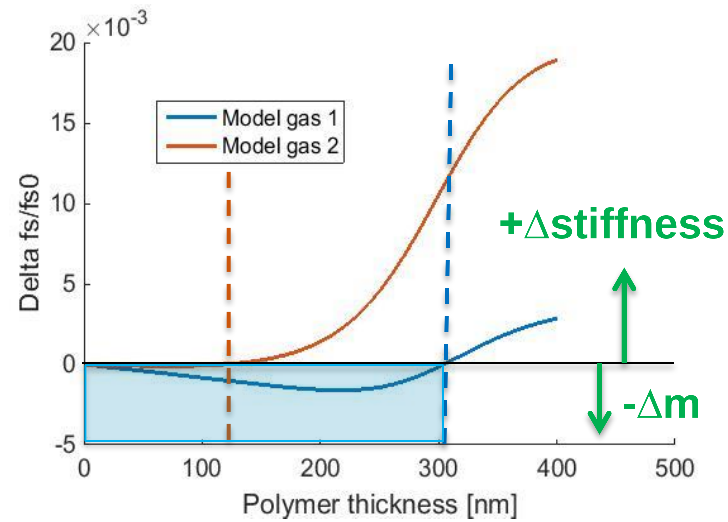


3. Gas measurements

Results

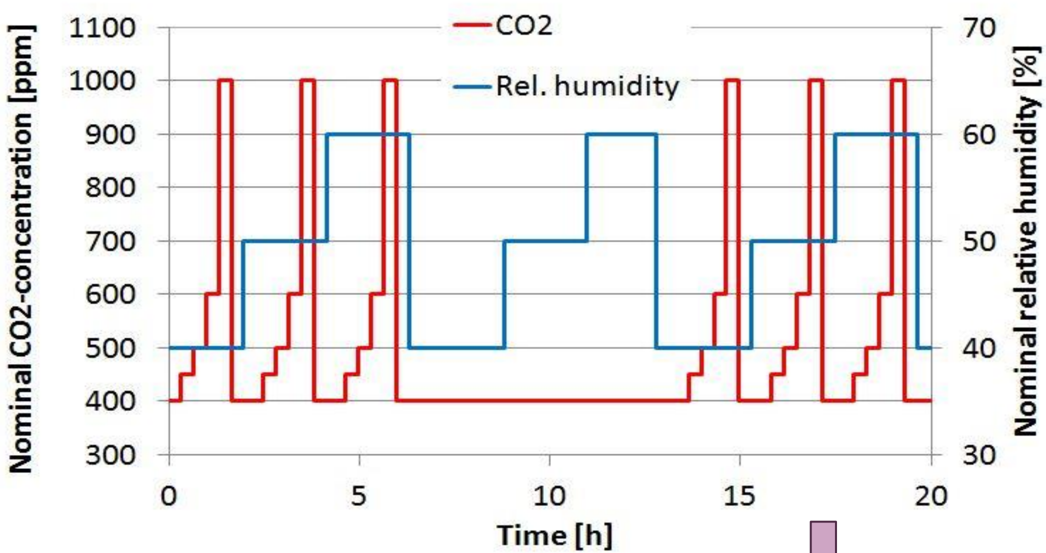


- Polymer is sensitive to CO_2 and H_2O
- Good homogeneity over chip with spin-coating
- Thickness ~200nm

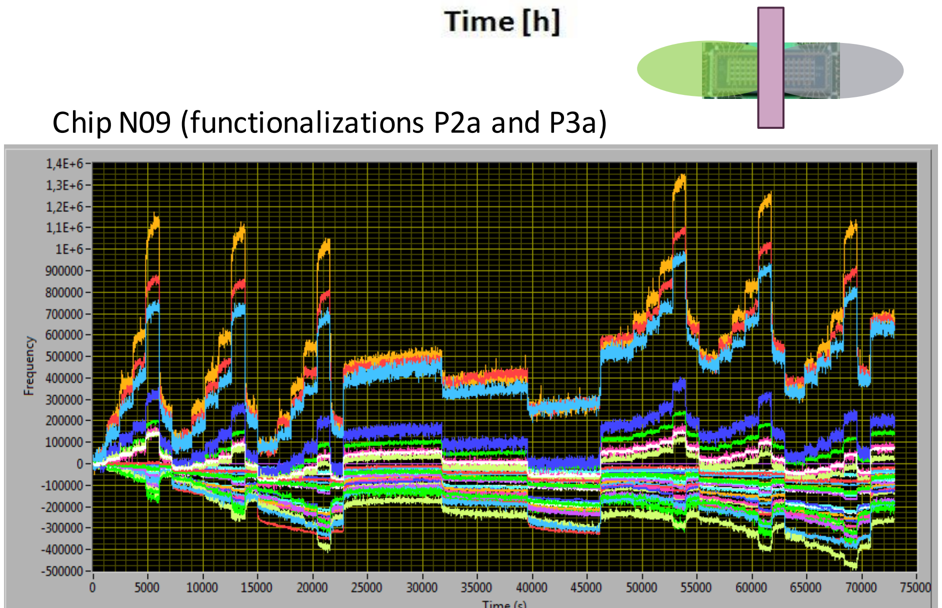


- 200 nm still in mass-sensitive detection mode for CO_2

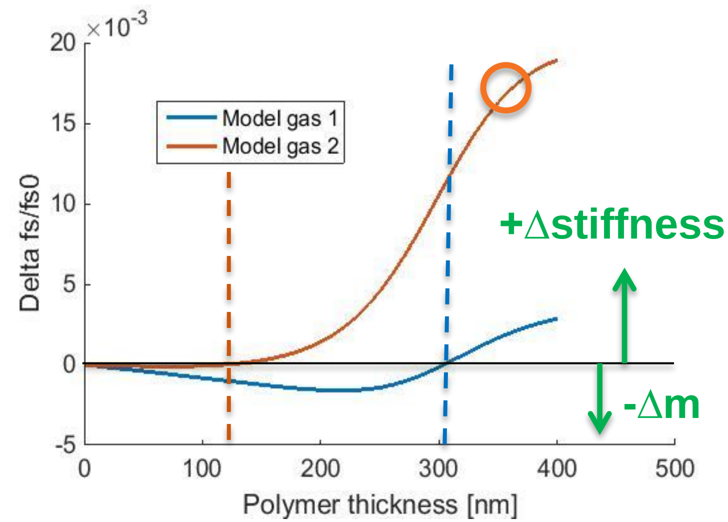
Results



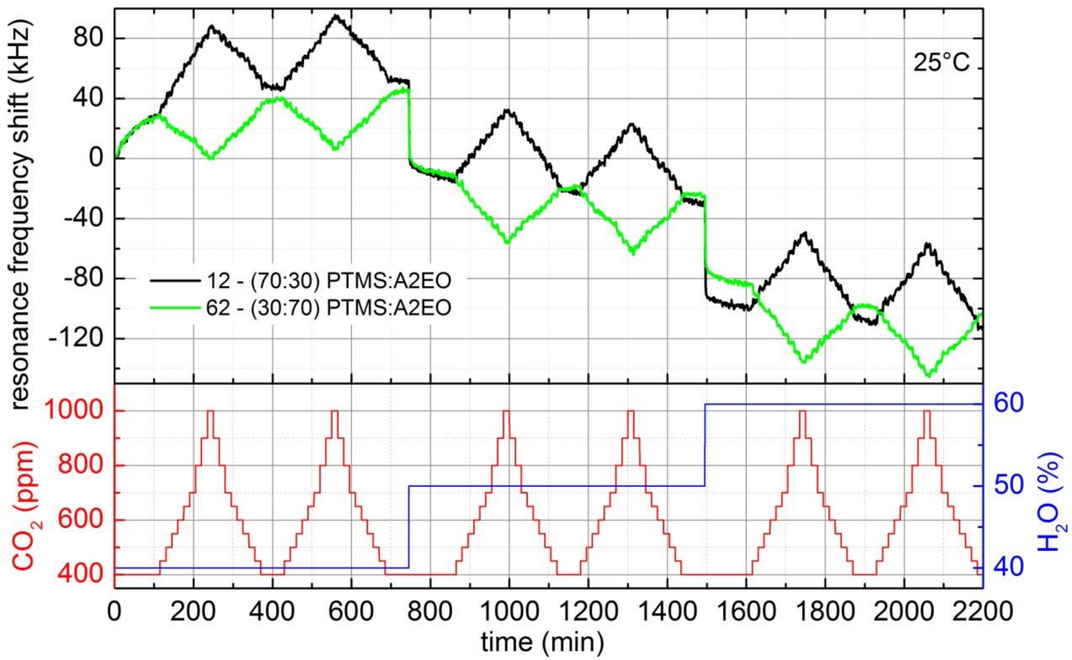
Chip N09 (functionalizations P2a and P3a)

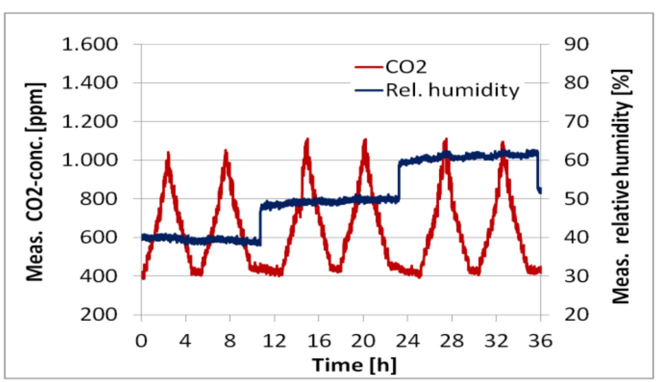


- Dispensing leads to less homogeneity
- Polymer composition influences signals
- Stiffness mode → high sensitivities (20 ppm CO_2)

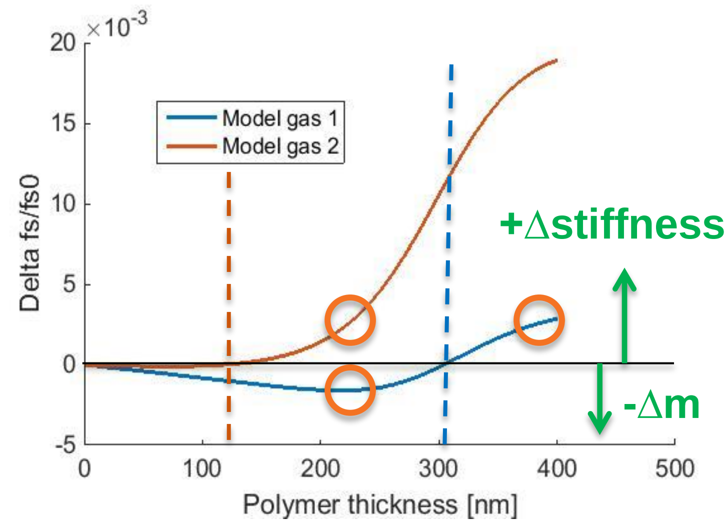


Results





- Certain compositions and thicknesses can be used to distinguish between two different gases
- Simple mathematical model has been applied
- Drifts are critical



Outlook/Future research

- Exact determination of sensitivity curves dependent on:
  - gas
  - polymer composition
- Analytical characterisation of polymer (chemical bonds, E-modulus measured with other methods…)

- Drift compensation (annealing, experimental setup, mathematical model...)
- Cross-senstitivities to other gases
- Evaluate long-term stability
- Other functional materials

Thank you for your attention!!

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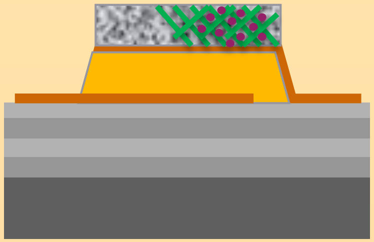
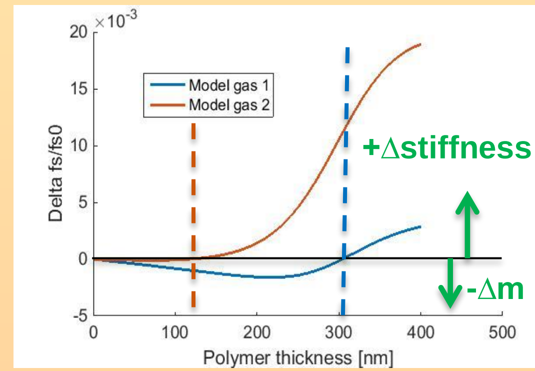
Summary:

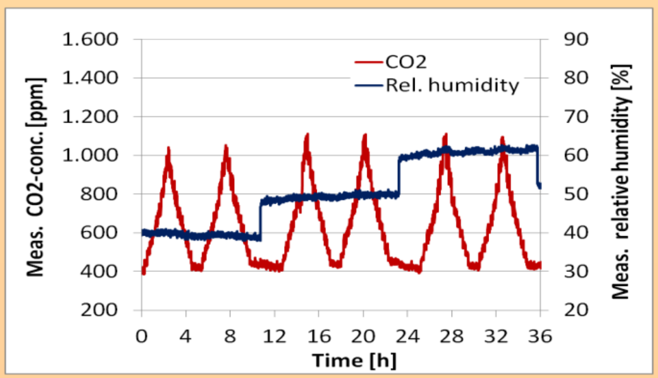
- FBAR has potential to be a low-cost, multi-gas sensor for AQM



- Due to its ability to detect Δmass and Δstiffness



- different polymer compositions, thicknesses and operating temperatures can be used to eliminate cross-sensitivity



- Stability still has to be evaluated

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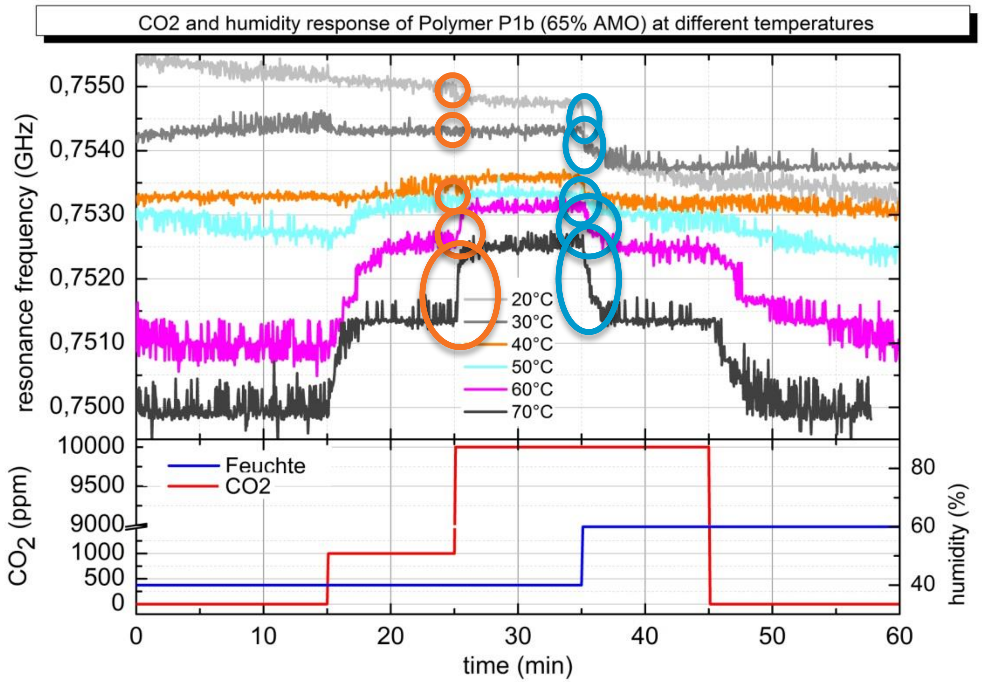
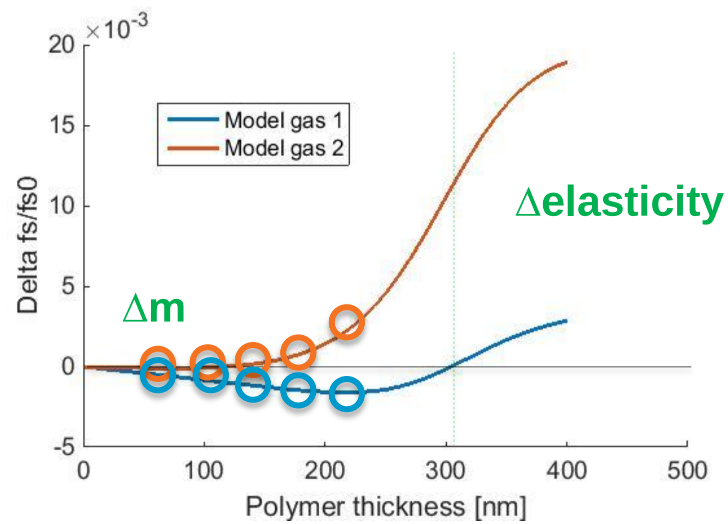
Results



- Temperature can also be used to change the acoustic thickness of a polymer

- Inversion at higher temperature could not be observed for thin films (80nm)



cost
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