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

COST Action TD1105

WGs and MC Meeting at ISTANBUL, 3-5 December 2014

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Year 3: 1 July 2014 - 30 June 2015 (*Ongoing Action*)

AEROSOL DEPOSITED THICK FILM $BaFe_{0.7}Ta_{0.3}O_{3-\delta}$ CERAMIC FOR NITROGEN MONOXIDE SENSING

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Function in the Action: Early Stage Researcher

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

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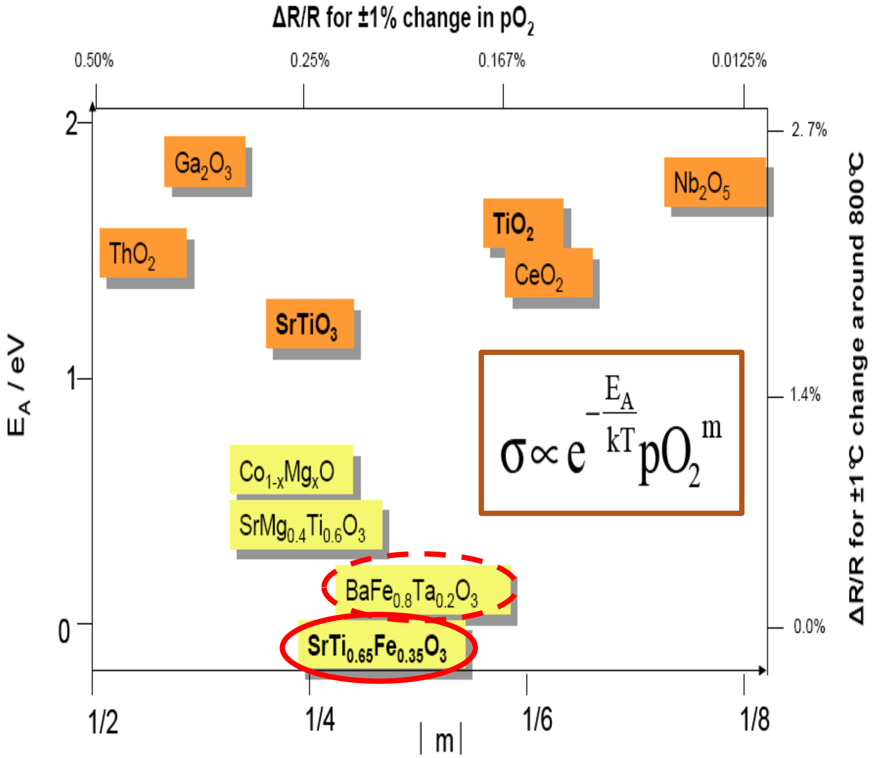
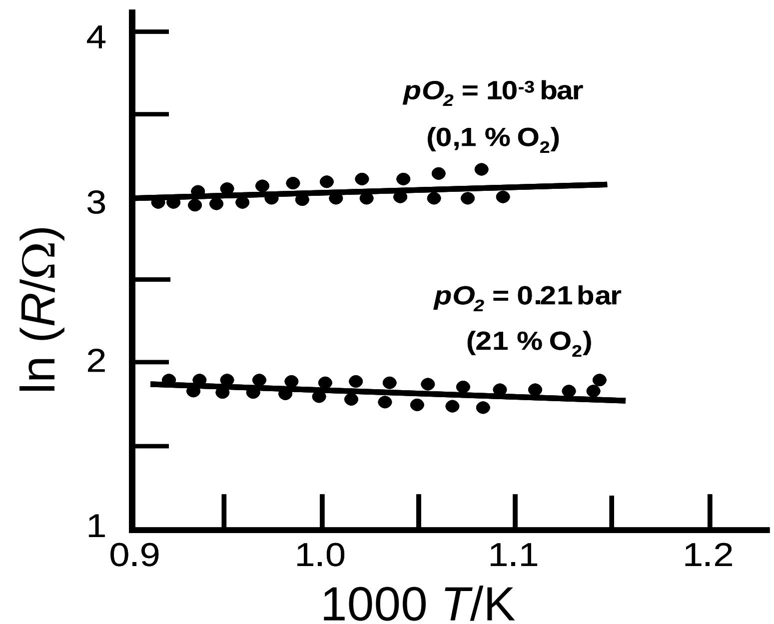
1. Introduction



Sensitivity and activation energy of some oxygen sensors [1].



In real application $SrTi_{0.65}Fe_{0.35}O_{3-\delta}$ has a sulfur oxide poisining problem and it decomposes under rich conditions.

$BaFe_{0.8}Ta_{0.2}O_{3-\delta}$ can be a good alternative

[1] H.L. Tuller, 14th International Meeting on Chemical Sensors IMCS 2012 May 20-23, 2012, Nuremberg, Germany.
[2] P.T. Moseley, D.E. Williams, Gas sensors based on oxides of early transition metals, Polyhedron 8 (1989) 1615–1618.
[3] R. Moos, N. Izu, F. Rettig, S. Reiß, W. Shin, I. Matsubara, Resistive oxygen gas sensors for harsh environments, Sensors 11 (2011) 3439 – 3465.

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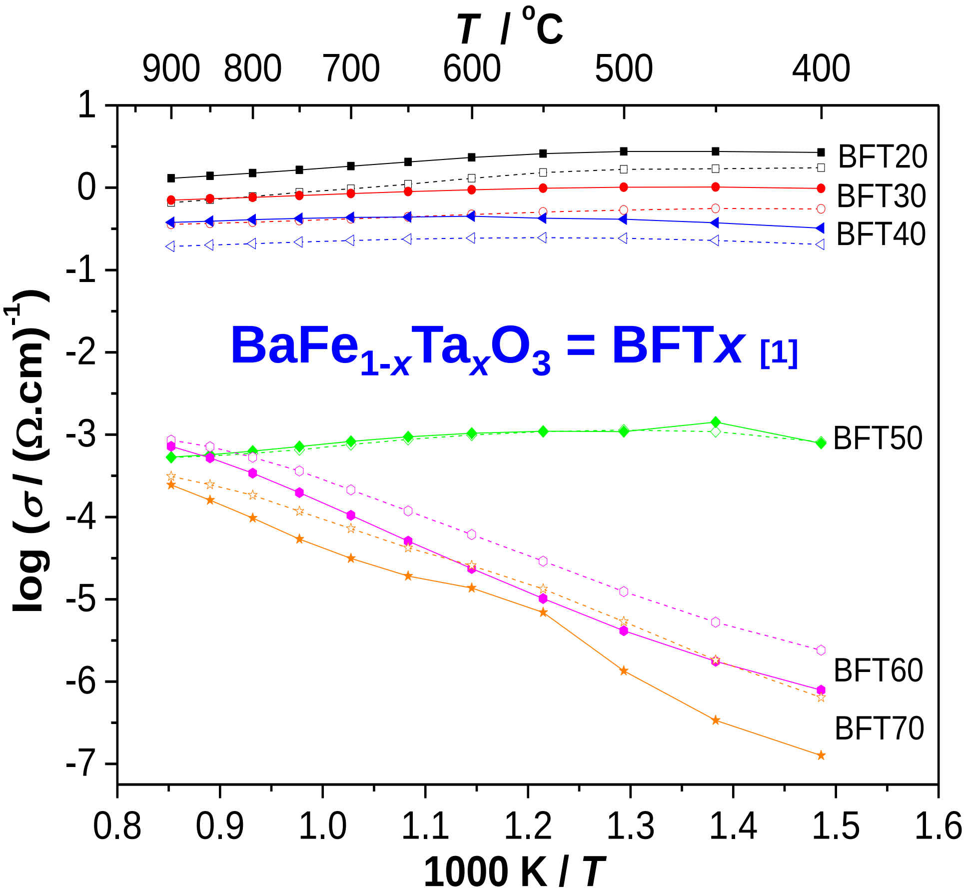
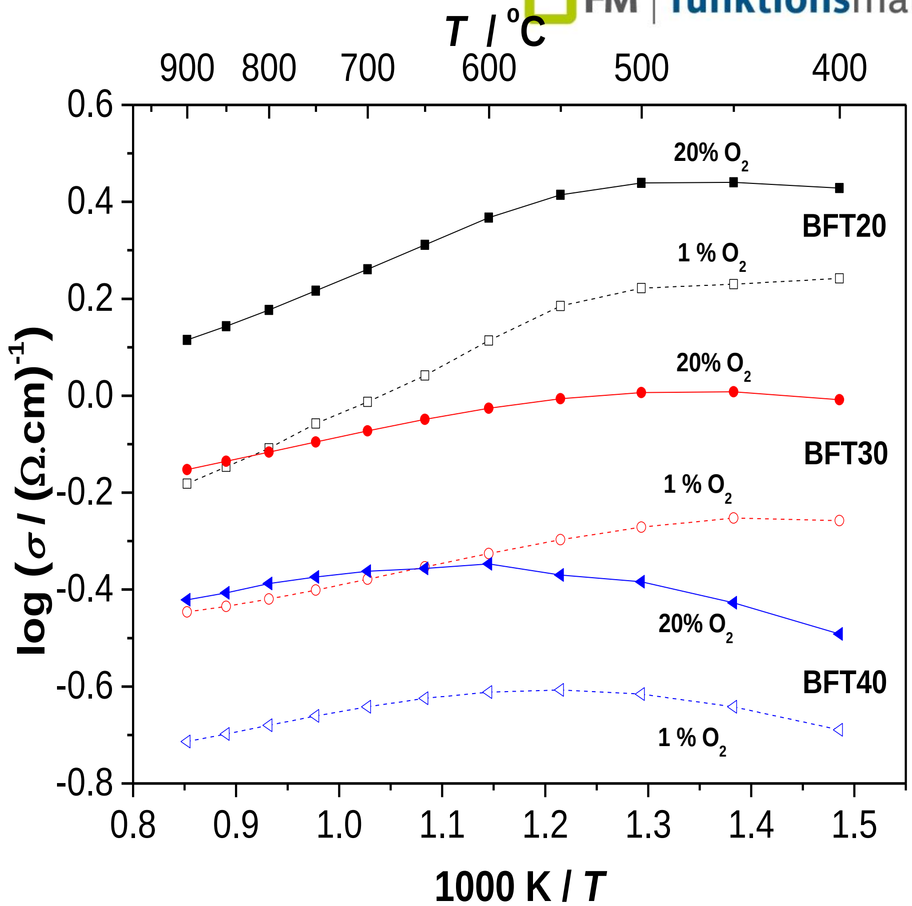


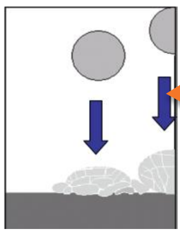


BFT30 is a good candidate to be a temperature independent oxygen sensor at high temperatures.

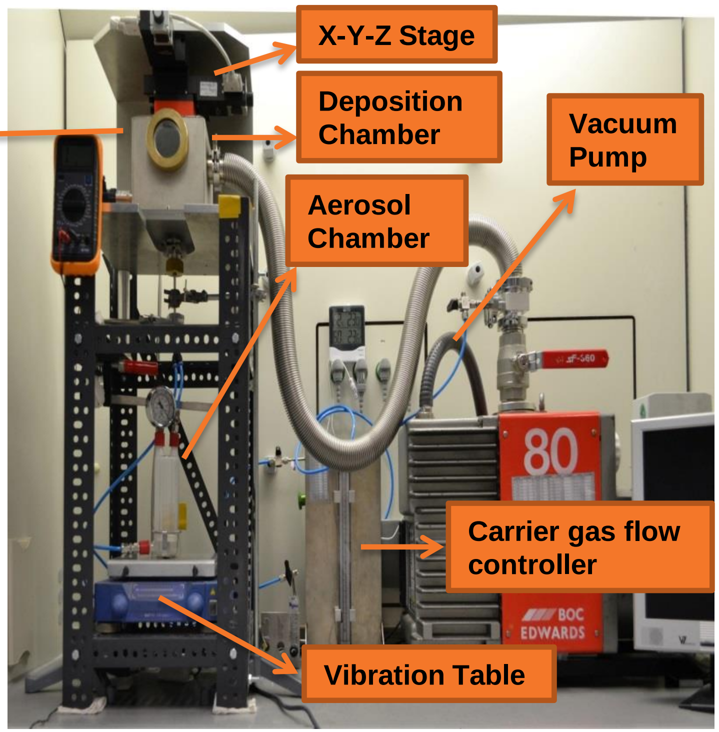
[1] M. Bektas, D. Schönauer-Kamin, G. Hagen, A. Mergner, C. Bojer, S. Lippert, W. Milius, J. Breu, R. Moos, $BaFe_{0.8}Ta_{0.2}O_{3-\delta}$ - A material for temperature independent resistive oxygen sensors, Sensors and Actuators B 190 (2014) 208-213.

2. Experimental

- Aerosol Deposition Method
  - **$BaCO_3$, Ta_2O_5 and Fe_2O_3 were precursor powders,**
  - **Mixed-oxide method was used,**
  - **Thick film samples were produced at room temperature by Aerosol Deposition Method (ADM).**

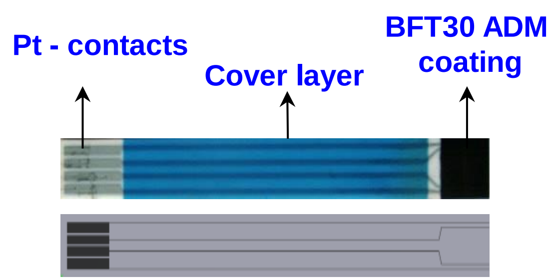


Particle behaviors in an aerosol jet flow near substrate on AD method [1].



Picture of our ADM system.

- Dense ceramics without high-temperature process
- Completely cold method
- Layers in the range of 1 to 100 microns
- The particles are accelerated and impinge on the substrate.

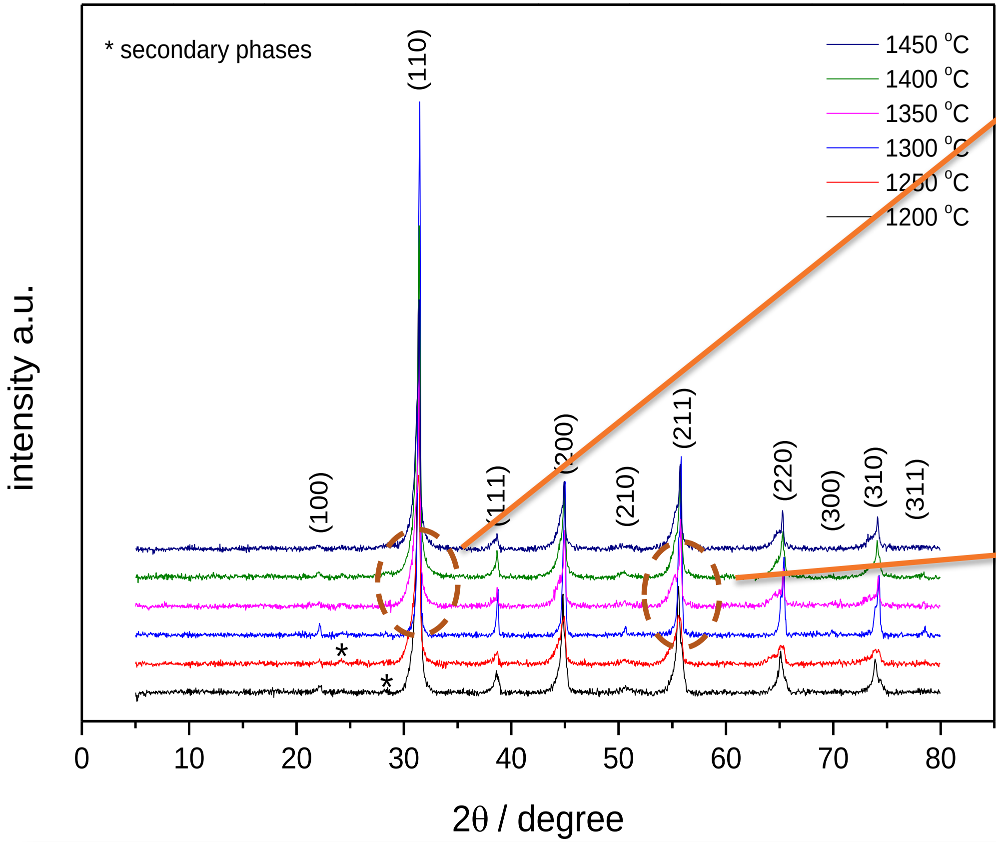


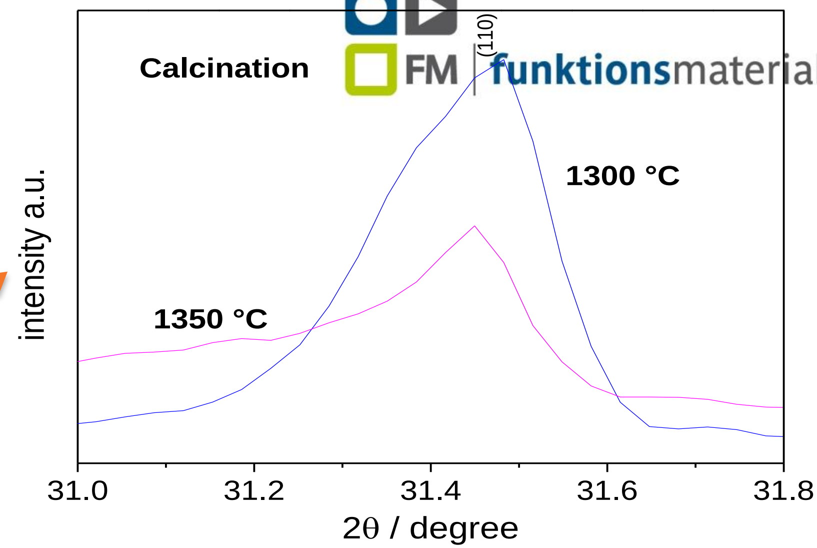
Top view of sensor setup

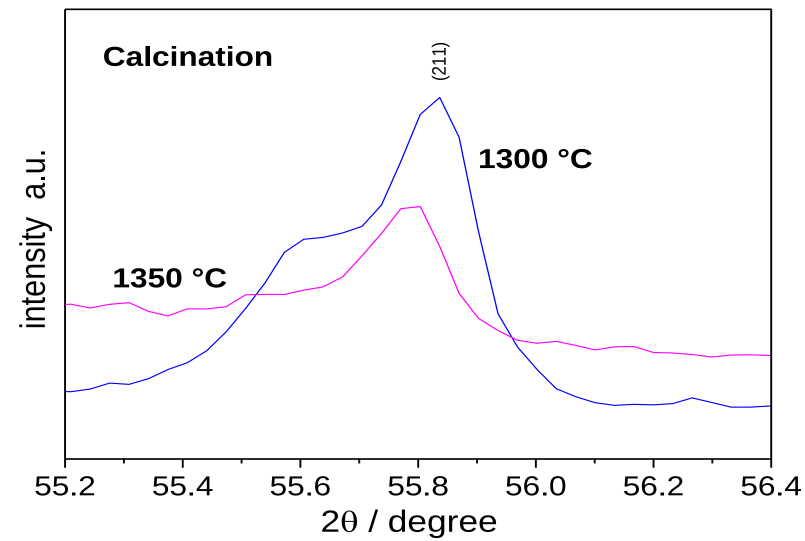
[1] Jun Akedo, Aerosol deposition of ceramic thick films at room temperature: densification mechanism of ceramic layers, J. Am. Ceram. Soc.,89 [6], (2006) 1834-1839.

Results

- X-ray Diffraction (XRD)







BFT 30 perovksite structure
Some indication for secondary phases if the powder is calcined below 1300 °C.

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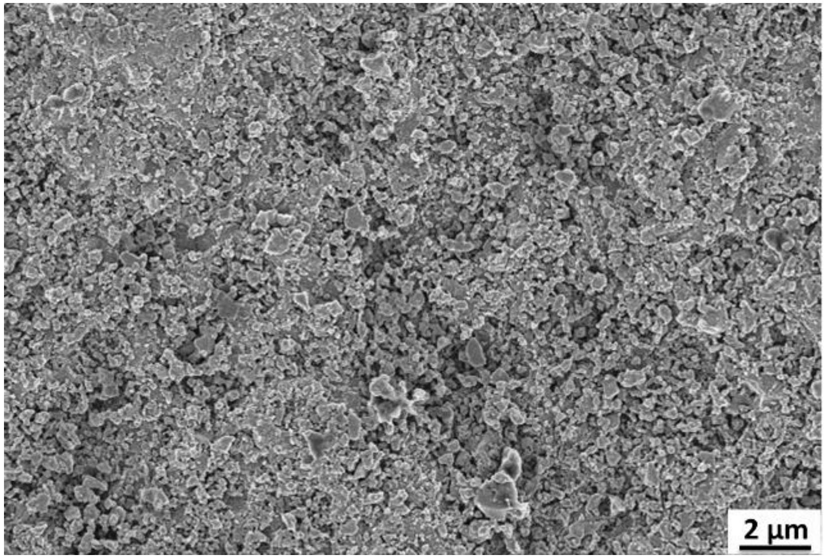
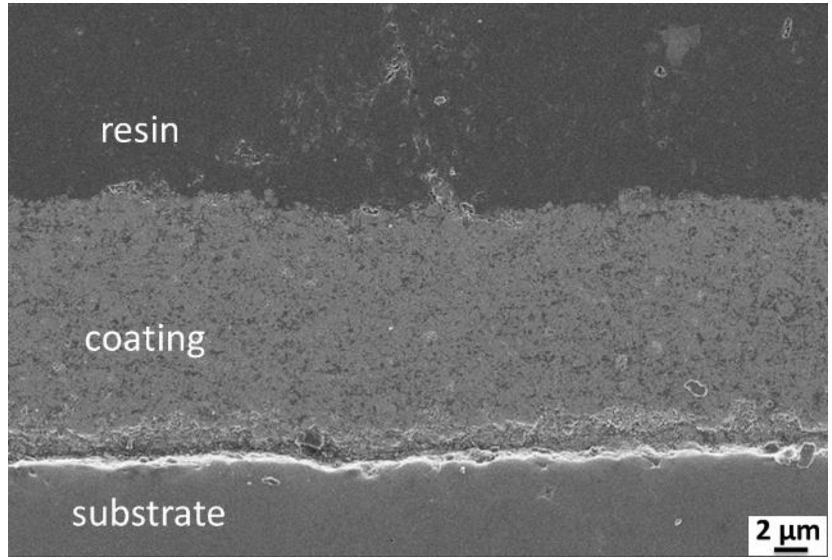
• Scanning Electron Microscopy (SEM)



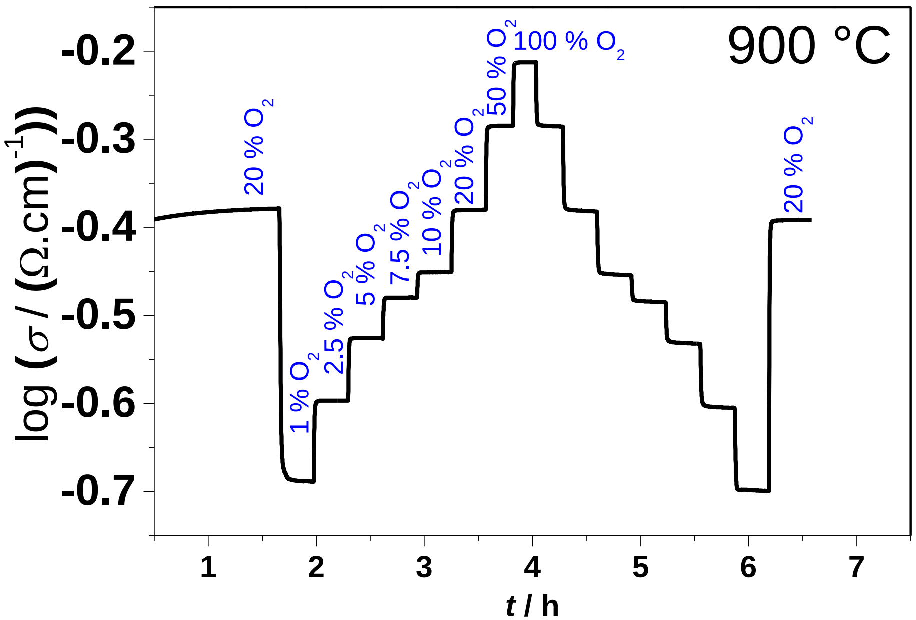
ADM sample - 10000*x* from surface

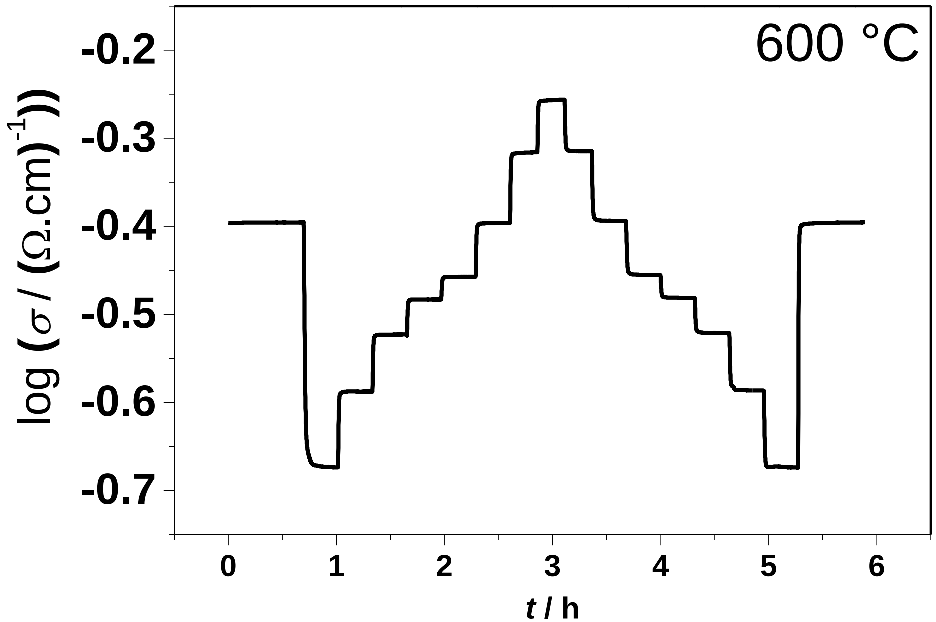


ADM sample - 2500*x* from cross section area

Dense and homogenous films of BFT30 made by aerosol deposition method (ADM) at room temperature.

• Electrical Conductivity Measurements

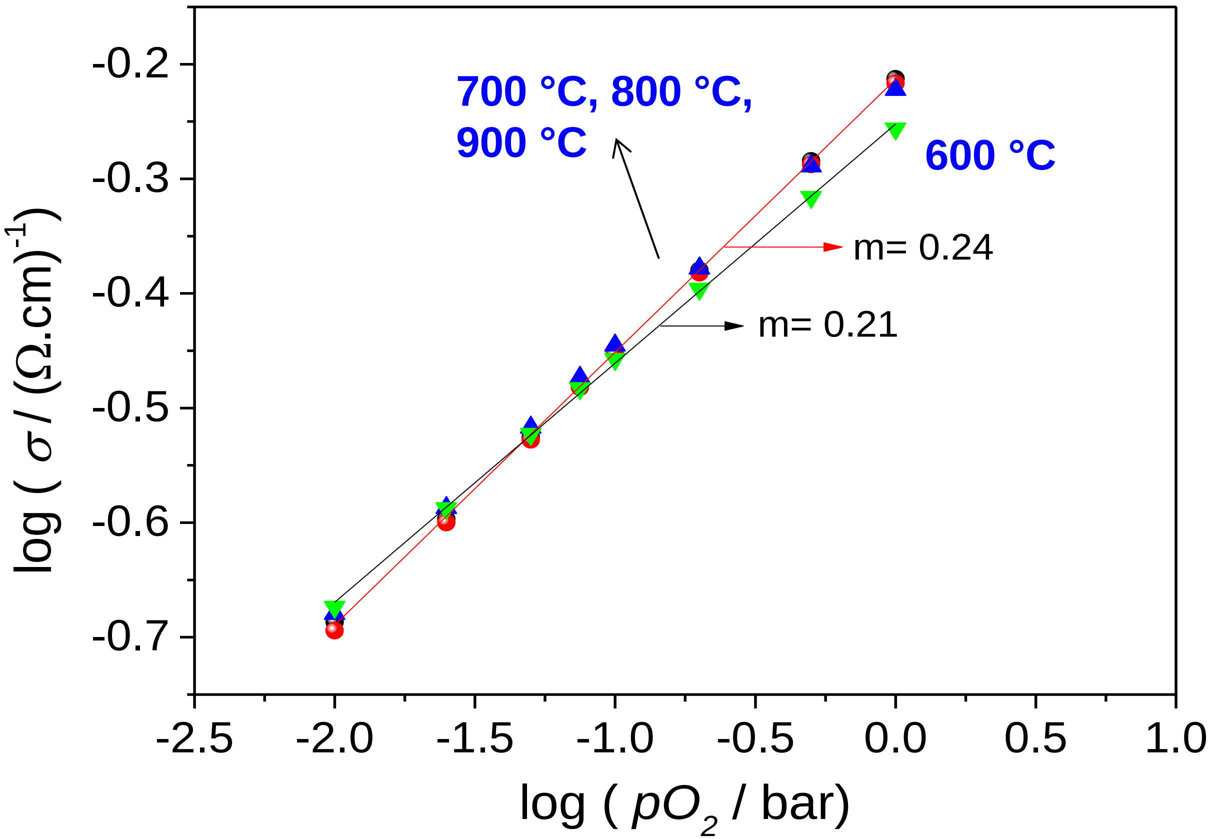




BFT30

- *p* type conductor
- conductivity increases with pO_2

BFT30 ADM coated sensor responds fast, stable and reversibly



Temperature independency between 700 and 900°C

Temperature dependency starts around 600 °C

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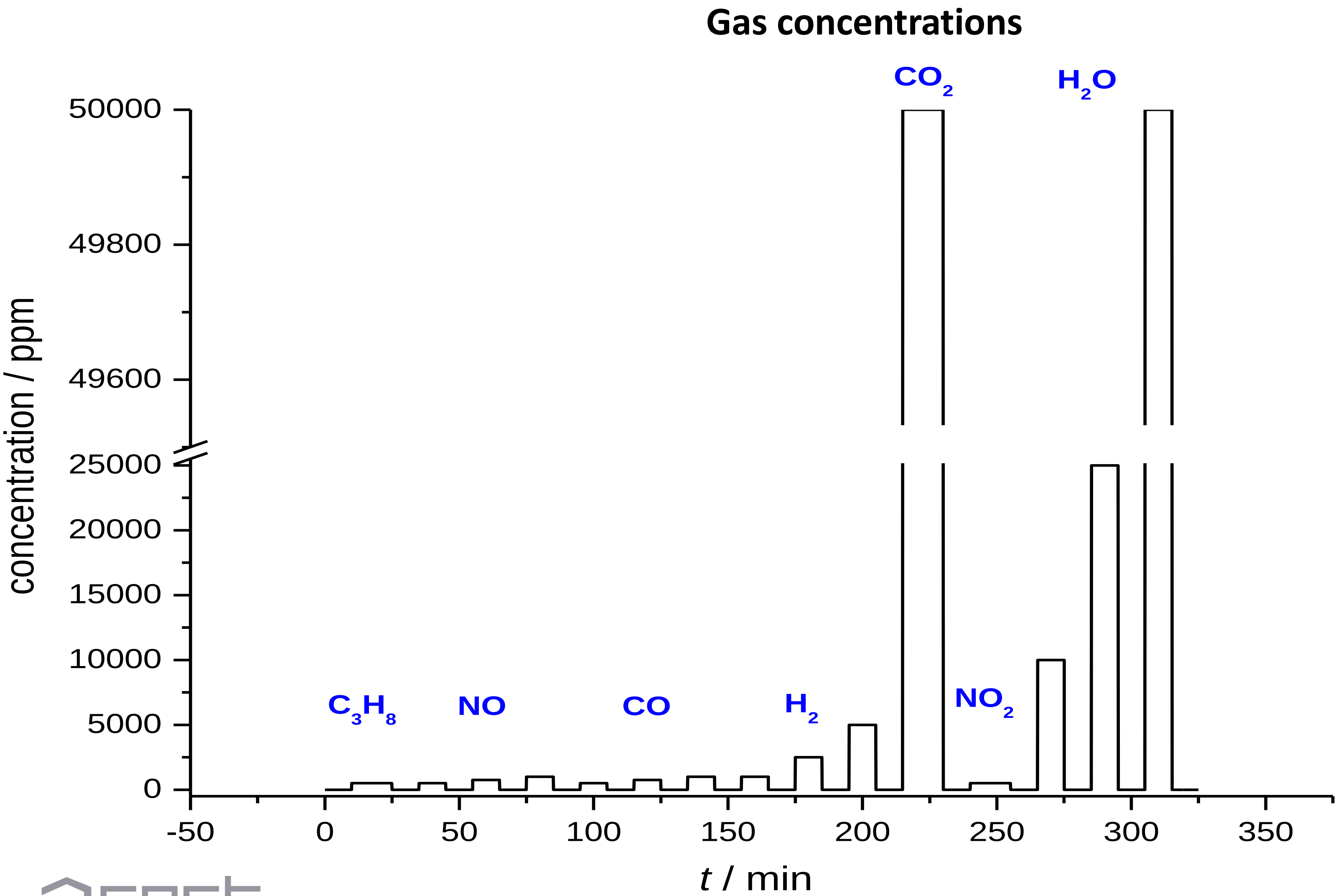
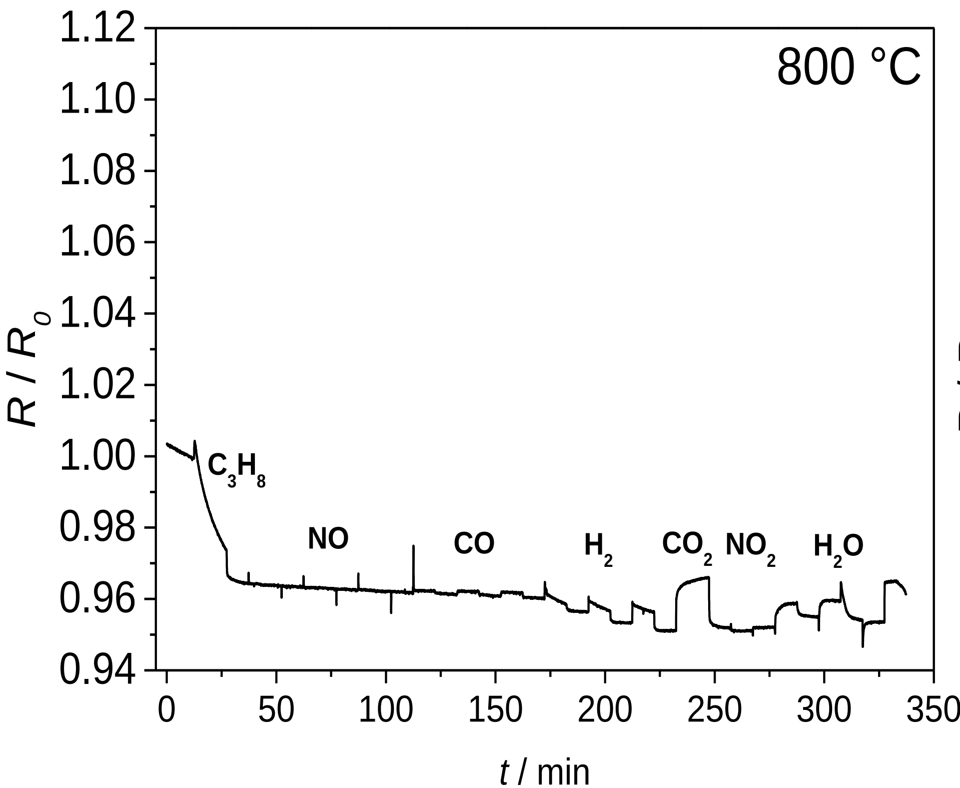
What happens at lower temperatures?

Are there sensitivities to other gases?

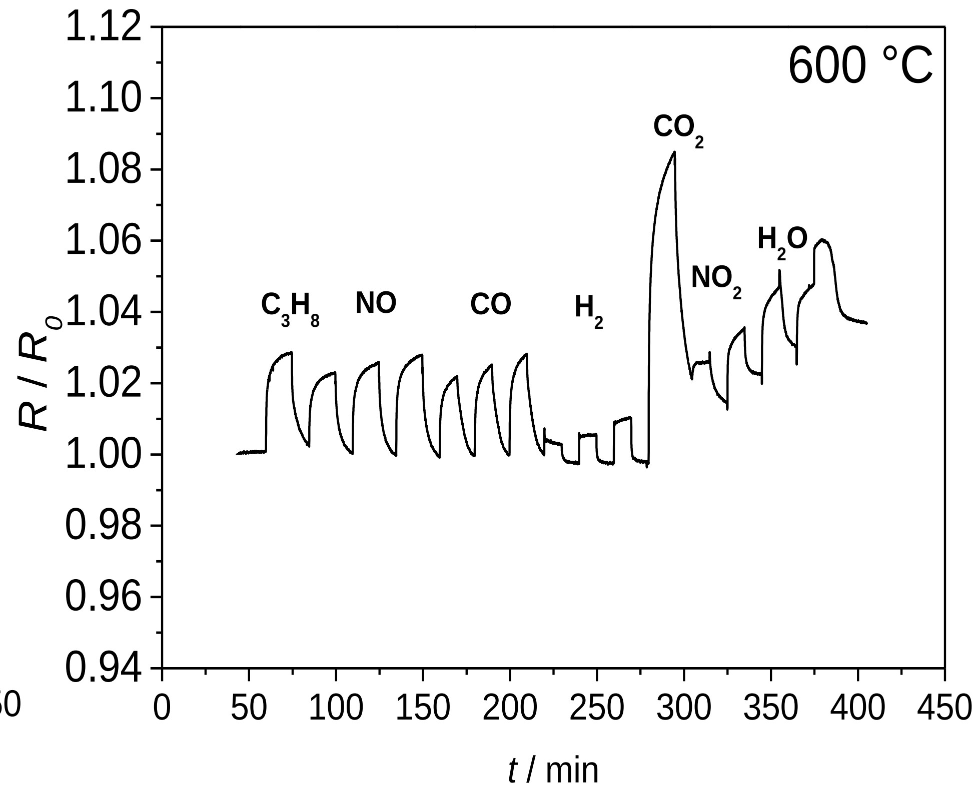
- Sensitivity to the other gases



Sensitivity at 800 °C

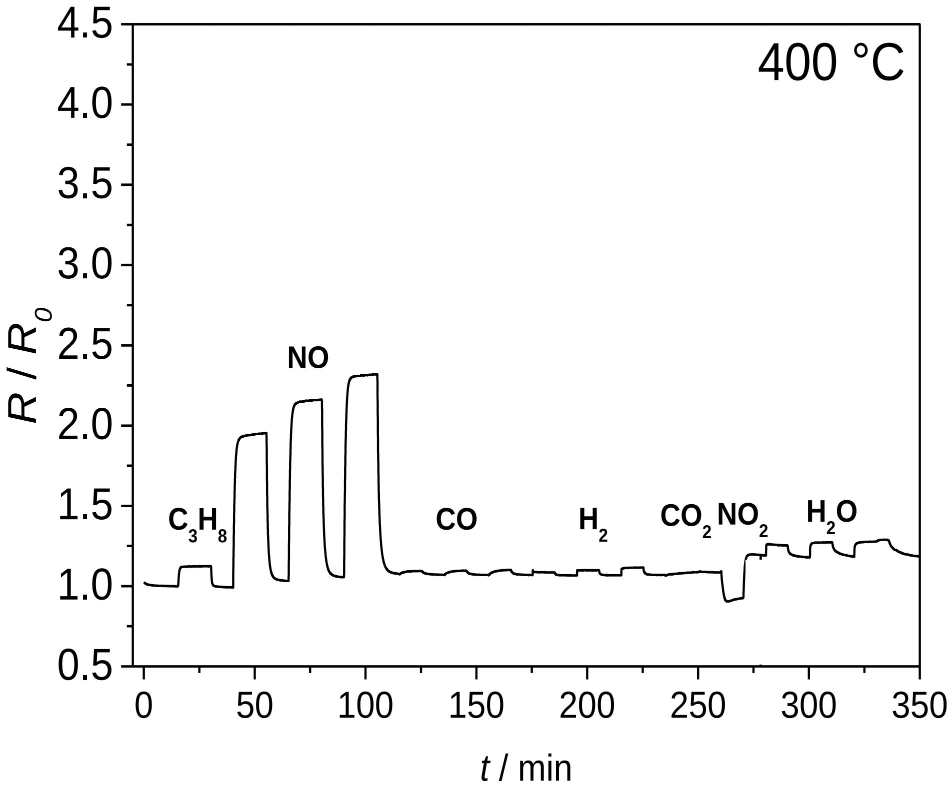


Sensitivity at 600 °C

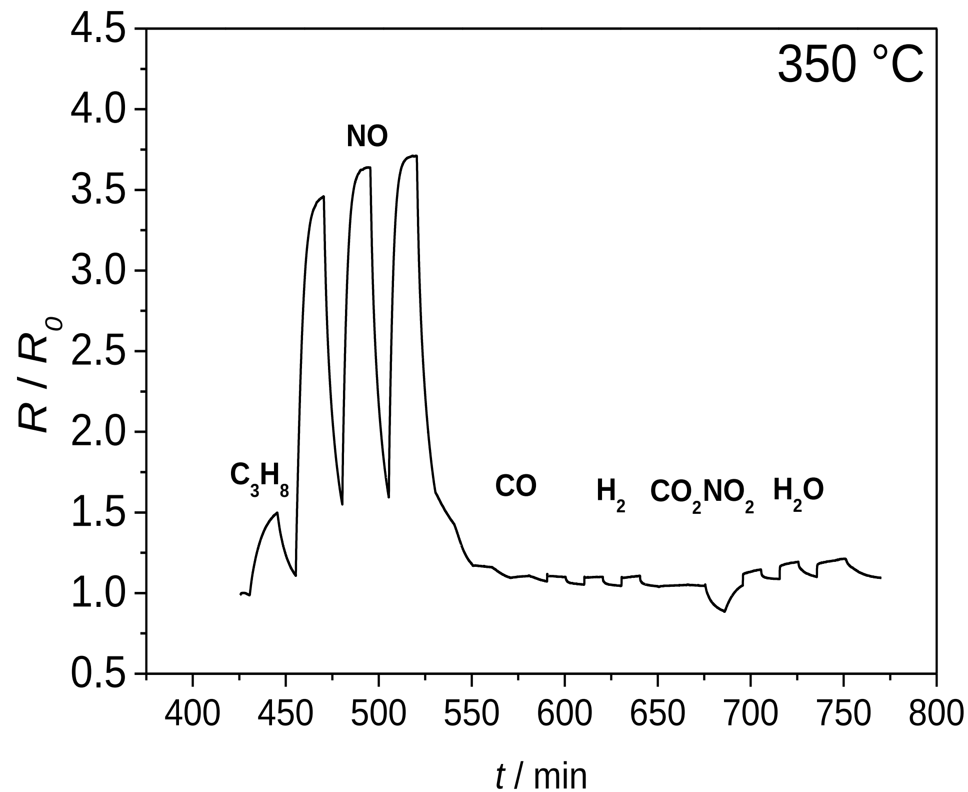


- BFT30 has almost no cross-sensitivity to the other gas species between 600 and 800 °C.

Sensitivity at 400 °C



Sensitivity at 350 °C



- BFT30 has a fast and reproducible response to NO at 400 °C.
- Although it has a high sensitivity to NO at 350 °C, the response time is too high.

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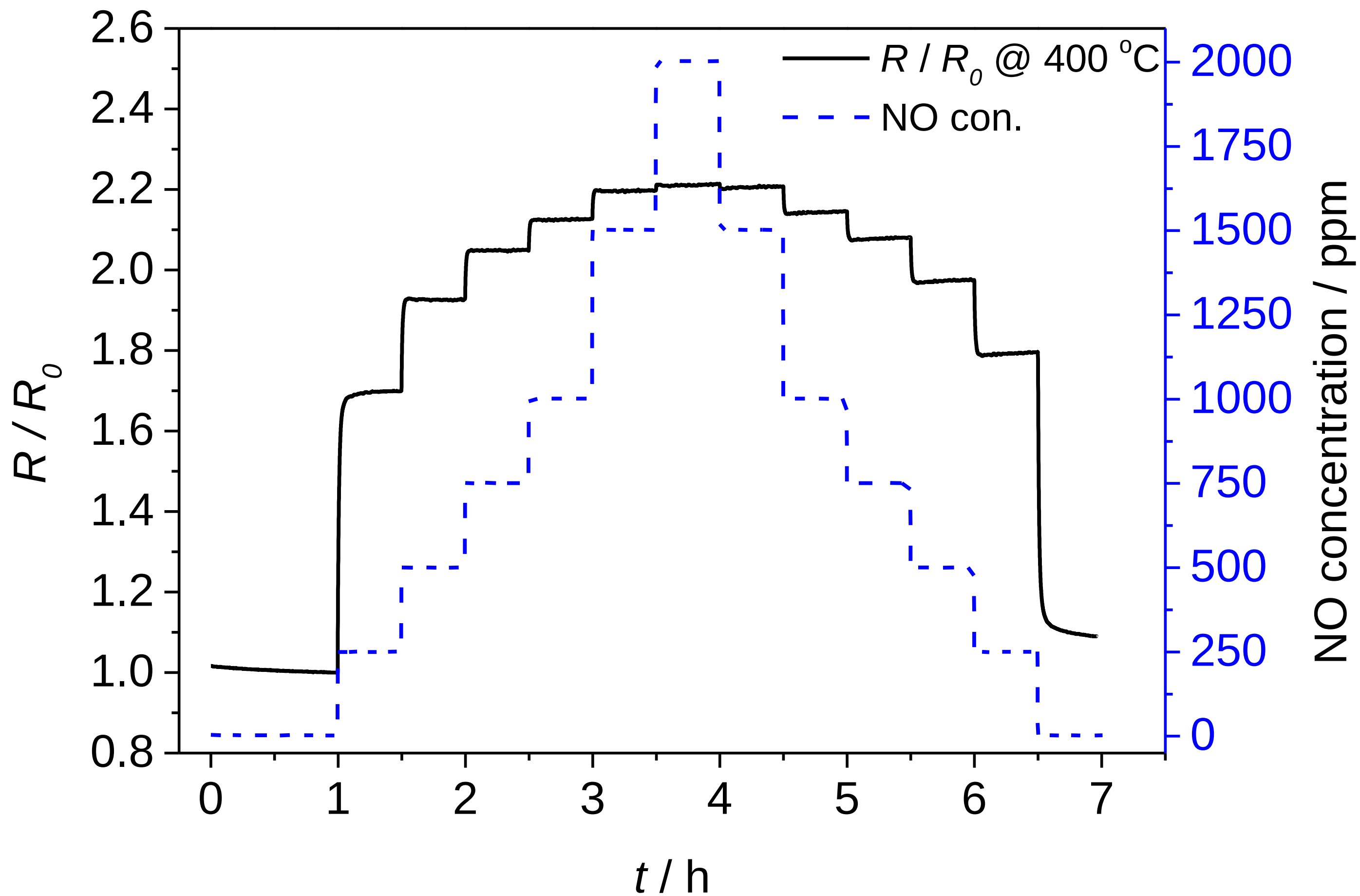
- NO dependence



Fast response to NO between 250-2000 ppm NO in air at 400 °C.

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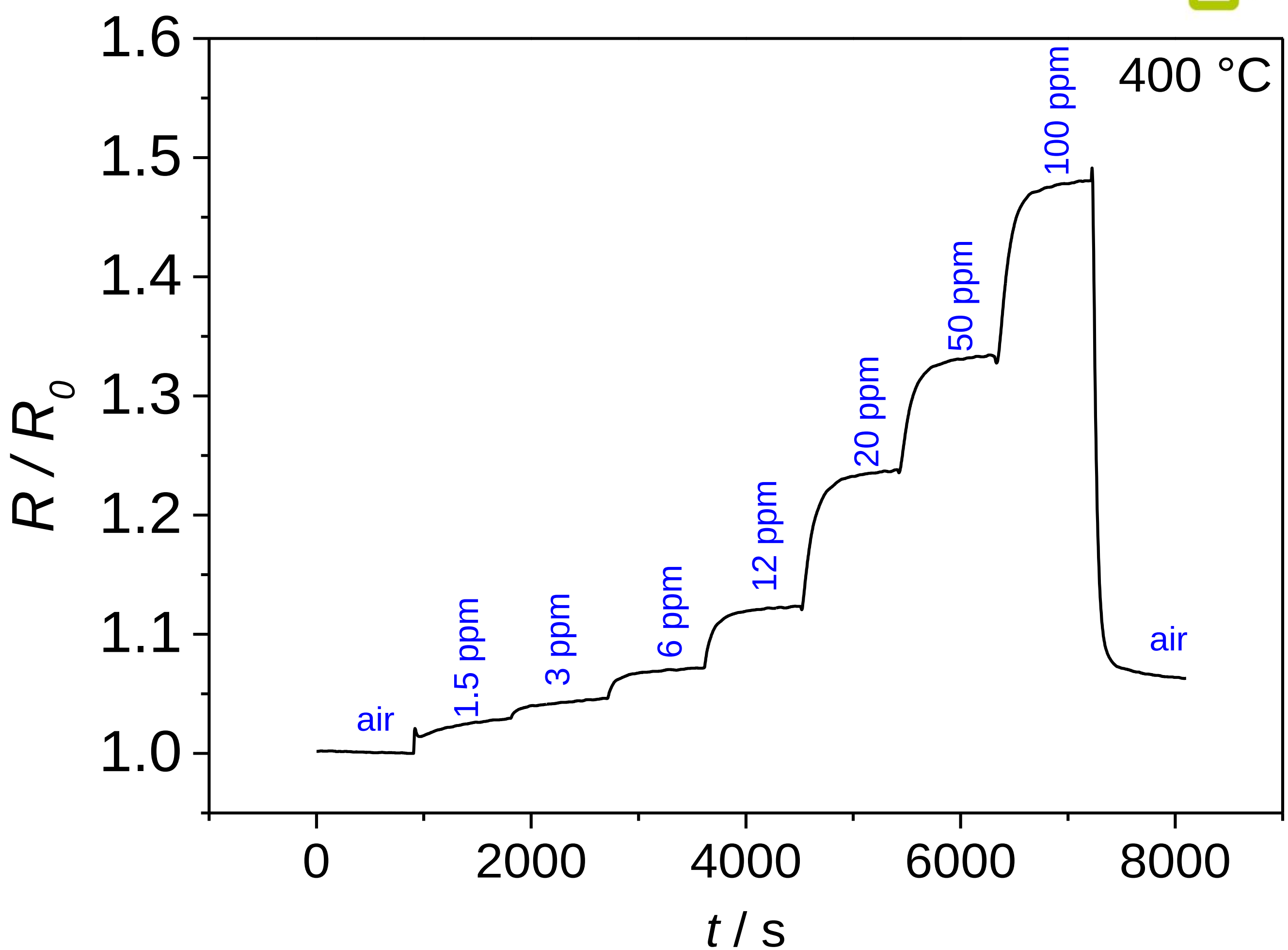

BFT30 has a great sensitivity for low NO concentrations (1.5 – 100 ppm NO) at 400 °C

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Summary

- $BaFe_{0.7}Ta_{0.3}O_{3-\delta}$ (BFT30) powder was coated on aluminum oxide substrates by aerosol deposition method.
- From XRD results, the BFT precursor powder has to be calcined at least 1300 °C, but to improve the phase quality it can be calcined at 1350 °C.
- Electrical conductivity test results show that the sensor is temperature independent between 700 and 900 °C. The temperature dependence starts around 600 °C.
- BFT30 has no cross sensitivity to the other test gas species between 600 and 900 °C.
- BFT30 responds fast and reproducibly to NO at 400 °C.

Outlook

- $BaFe_{1-x}Ta_xO_{3-\delta}$ (x=0.1...0.5) will be ADM-deposited on a substrate which has a self heater.
- Oxygen and NO dependency of these sensors will be investigated.
- Defect chemistry of BFT will be investigated.

Thank you very much for your attention !