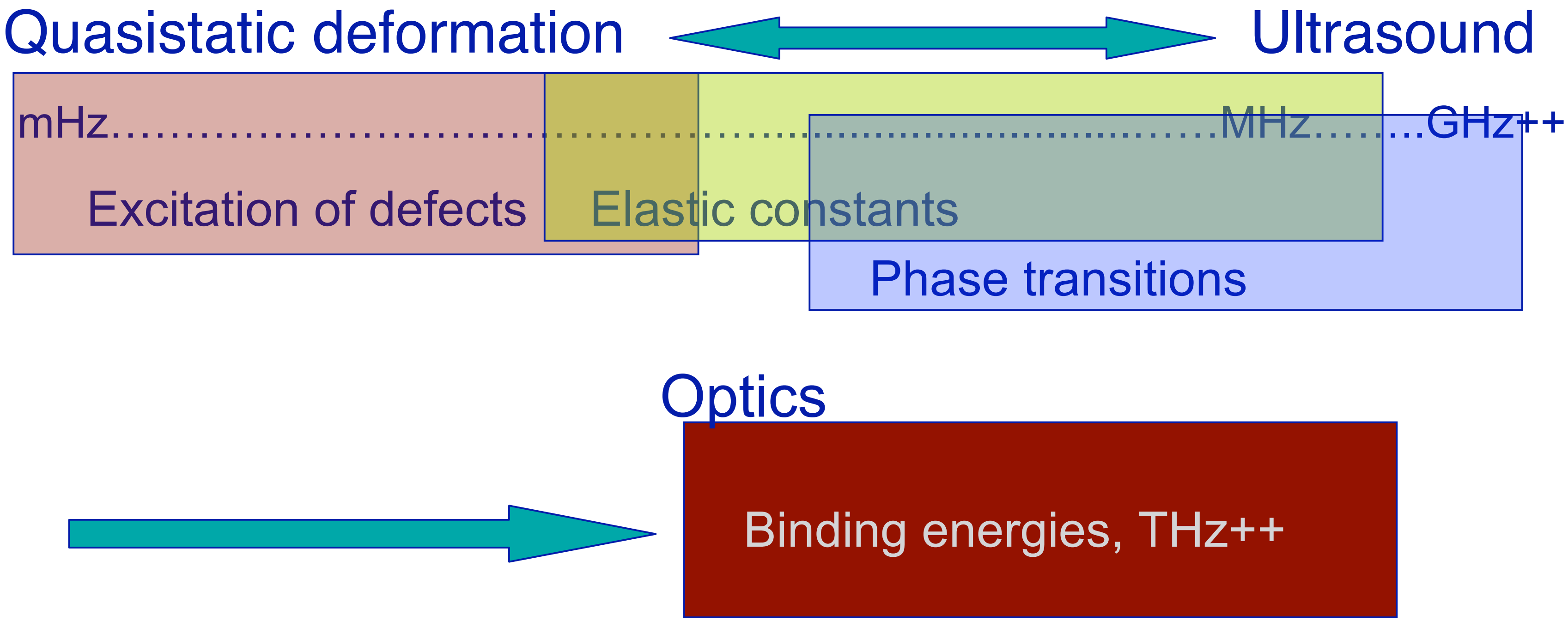
Strain-fields and Catalysis

Arno Wirsig, Carsten Hucho

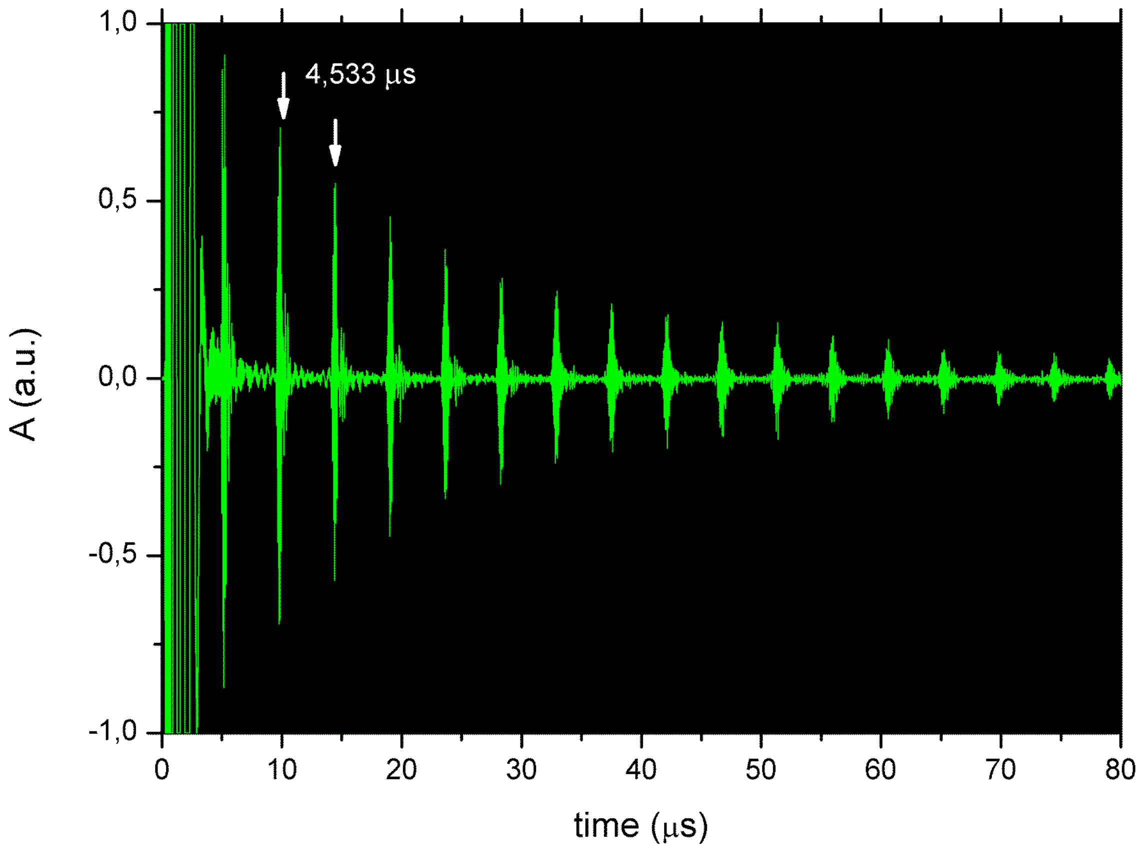
Paul-Drude-Institut für Festkörperelektronik

- Acoustic fields for detection
- Acoustic fields for excitation

information from elastic spectroscopy



Elastic constants



10mm
brass: 4,533
µs =

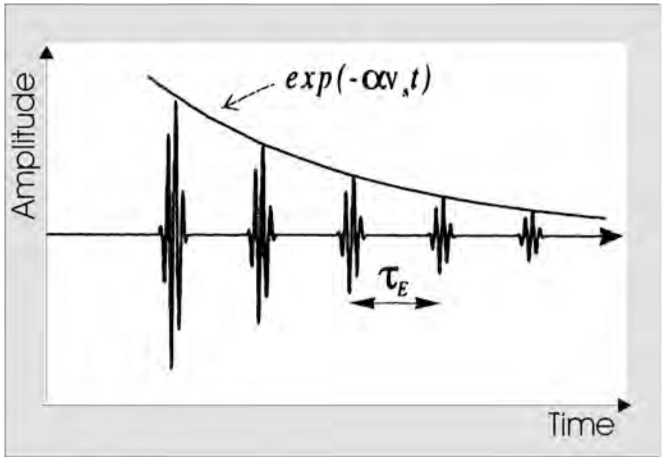
4348m/s

What do the modes mean?

Sound-velocity (resonance frequency) carries information on

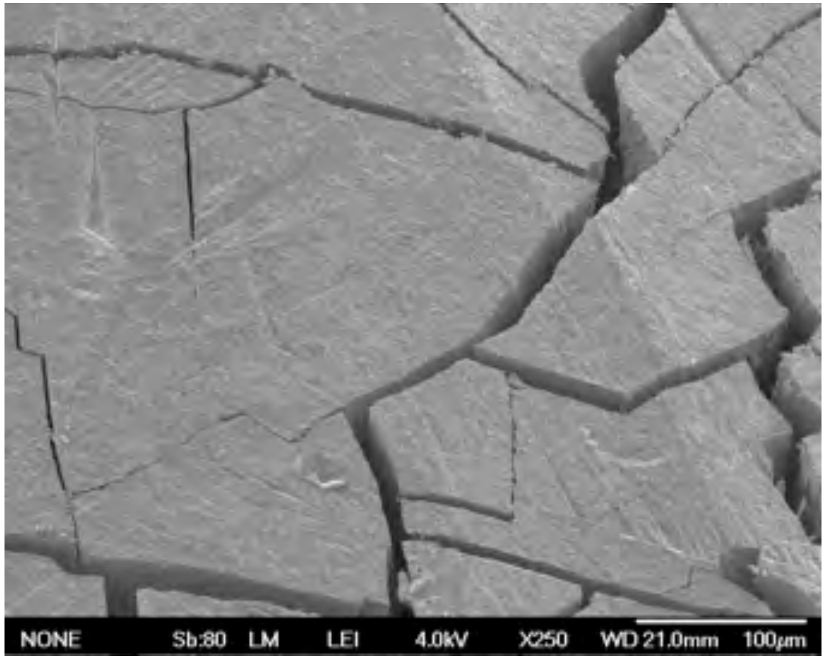
- elasticity
- thermal expansion
- Interfaces
- Coupling

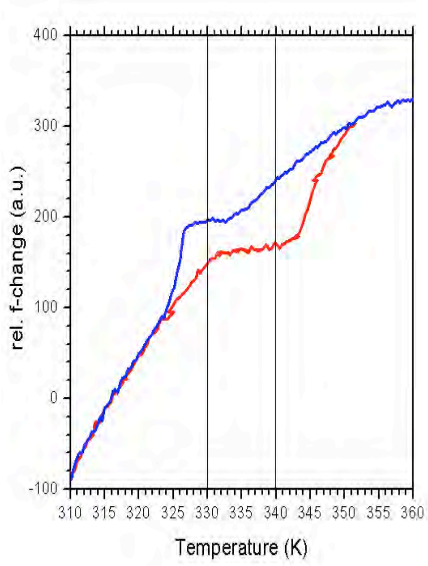
Ultrasound attenuation gives insight into loss- and scattering-mechanisms

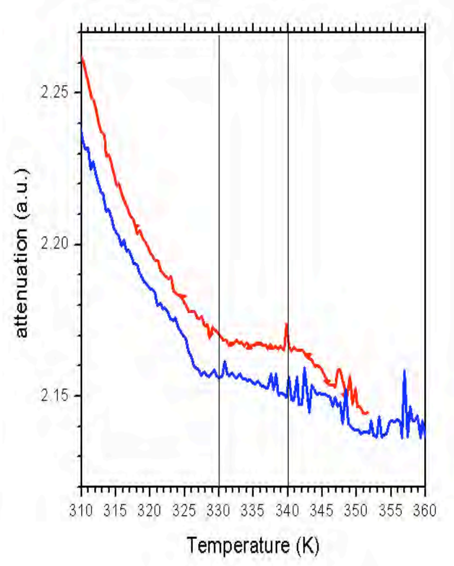


Phase transitions

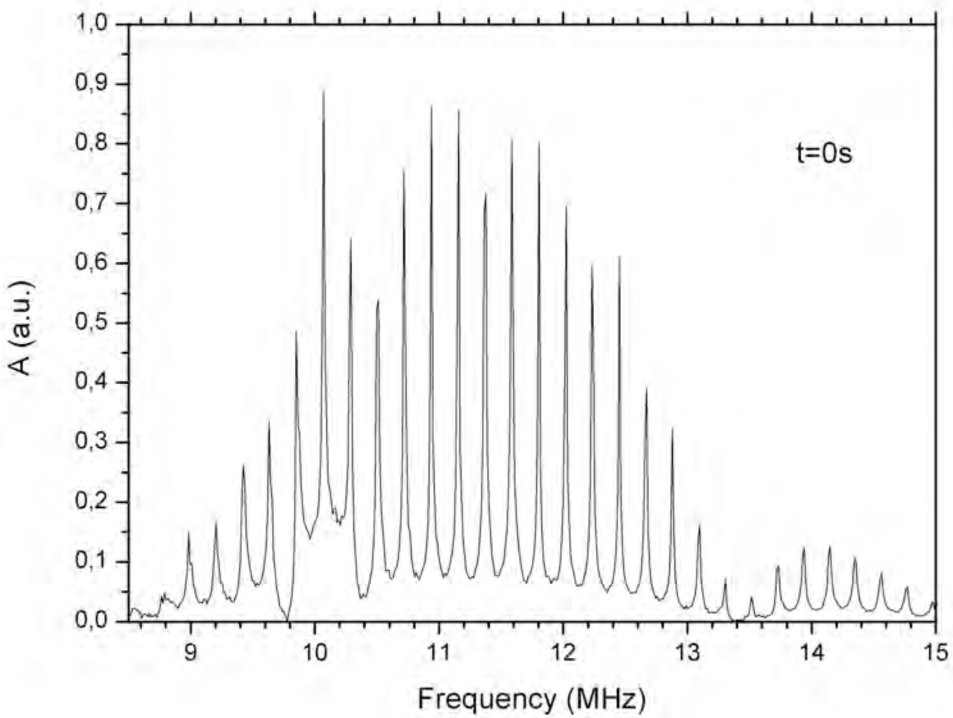
Metal-insulator transition in VO_2 at 335K





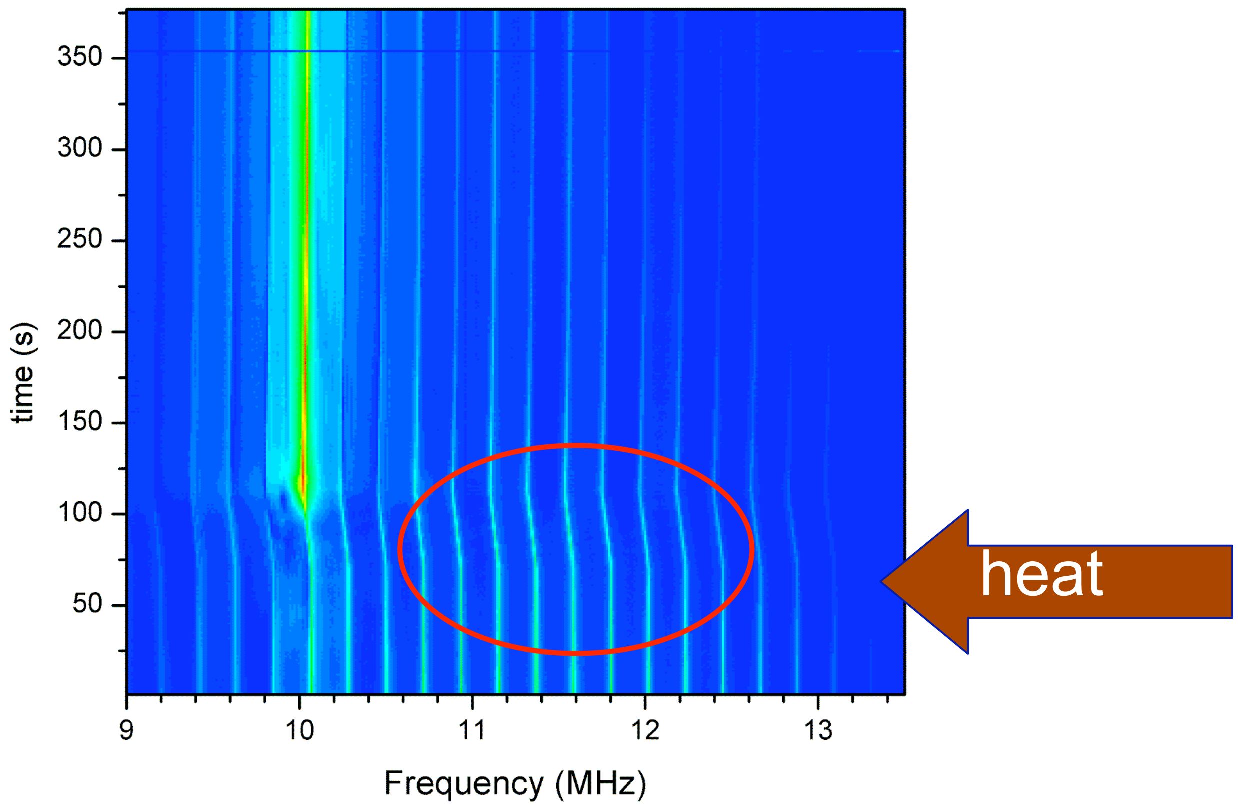


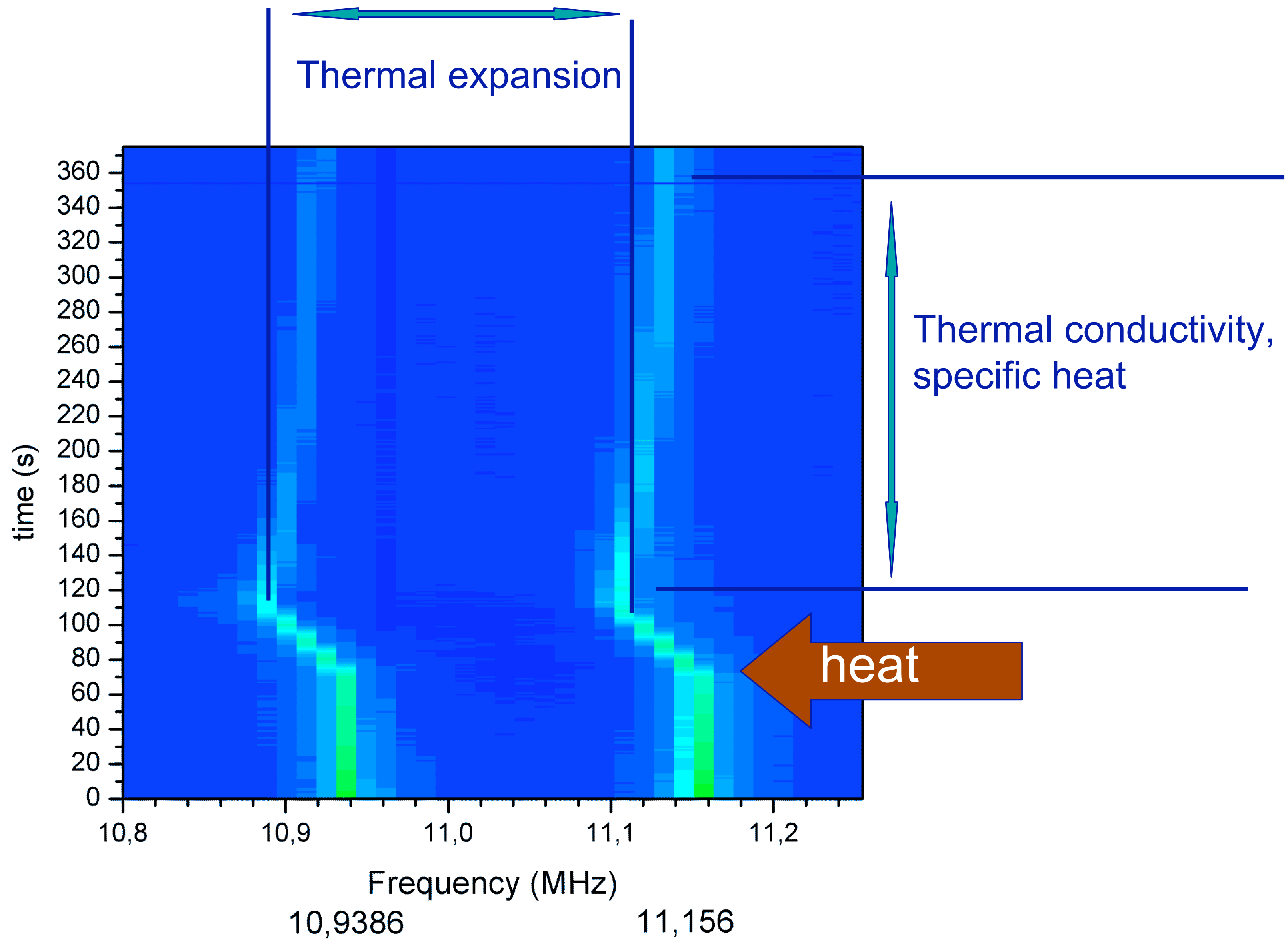
Ultrasound spectroscopy for in-situ characterization



$v=(2*l)\Delta f$

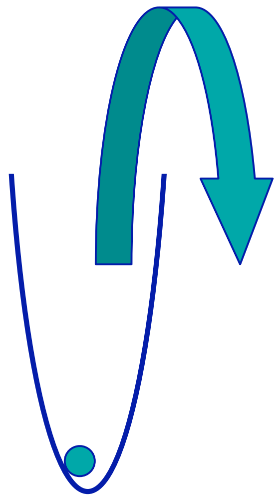
Crystal-growth - In-situ ultrasound





Thermal expansion
Thermal conductivity,
specific heat
heat
time (s)
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
10,8
10,9
11,0
11,1
11,2
Frequency (MHz)
10,9386
11,156

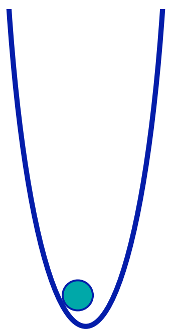
Defects and sound

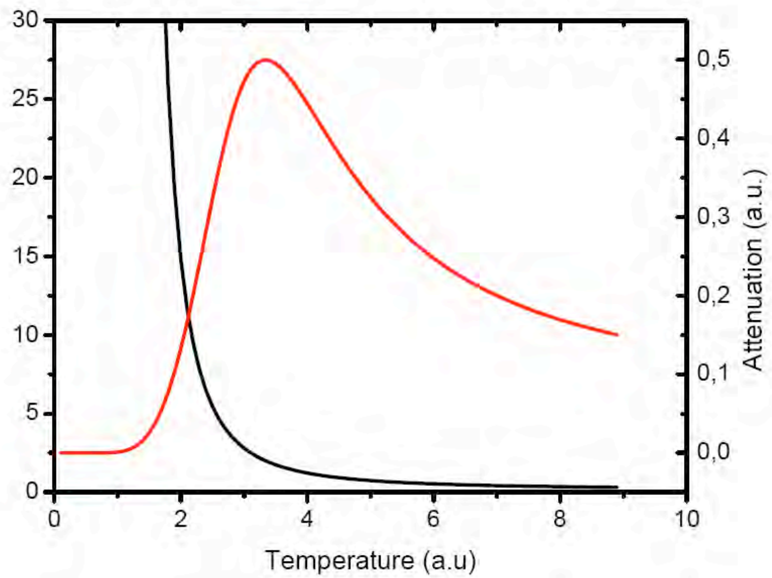


Internal friction

The mechanical loss spectrum associated with the anelastic relaxation of a structural defect is described by

$$Q^{-1} = \Delta \frac{\omega\tau}{(1+\omega^2\tau^2)}$$ ‚Debye-peak‘, with $\tau = \tau_o \exp(E/kT)$

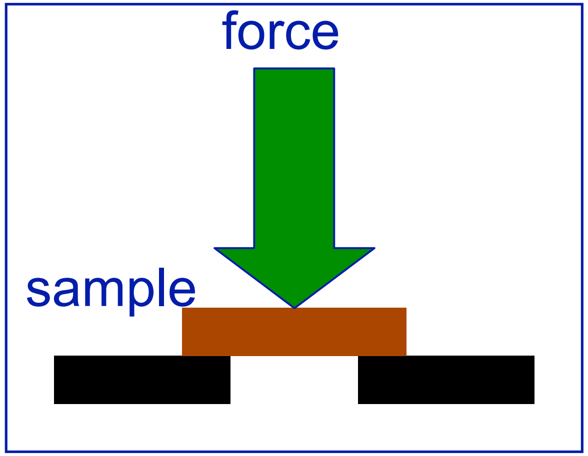


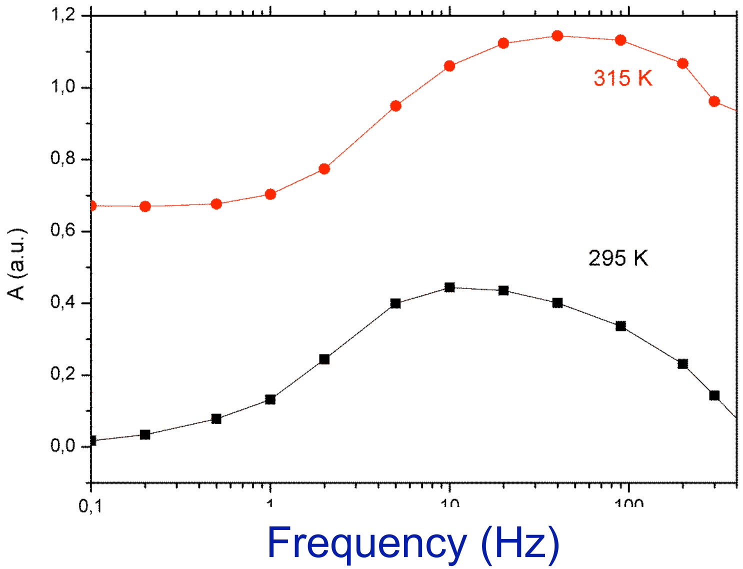


Conventional approach

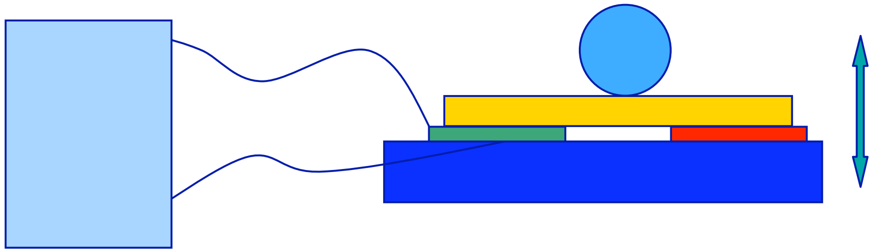
1. **Torsion pendulum**
   - High sensitivity
   - Large samples
   - Limited frequency-range
2. **Vibrating reed**
   - Standardized sample-shape
   - Limited frequency-range

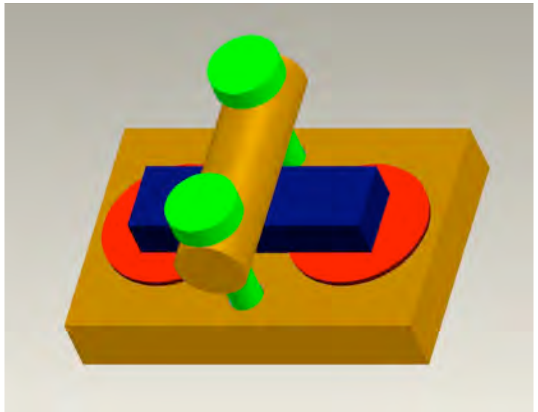
modified approach

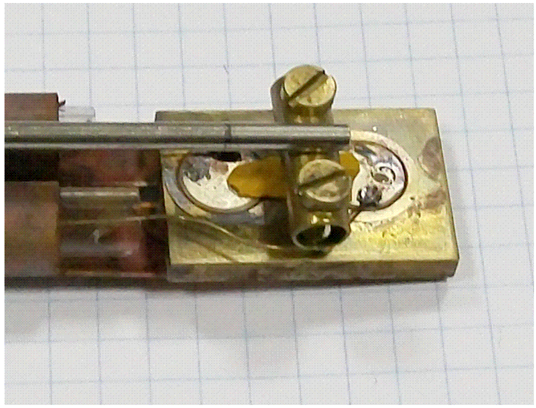




Internal friction setup

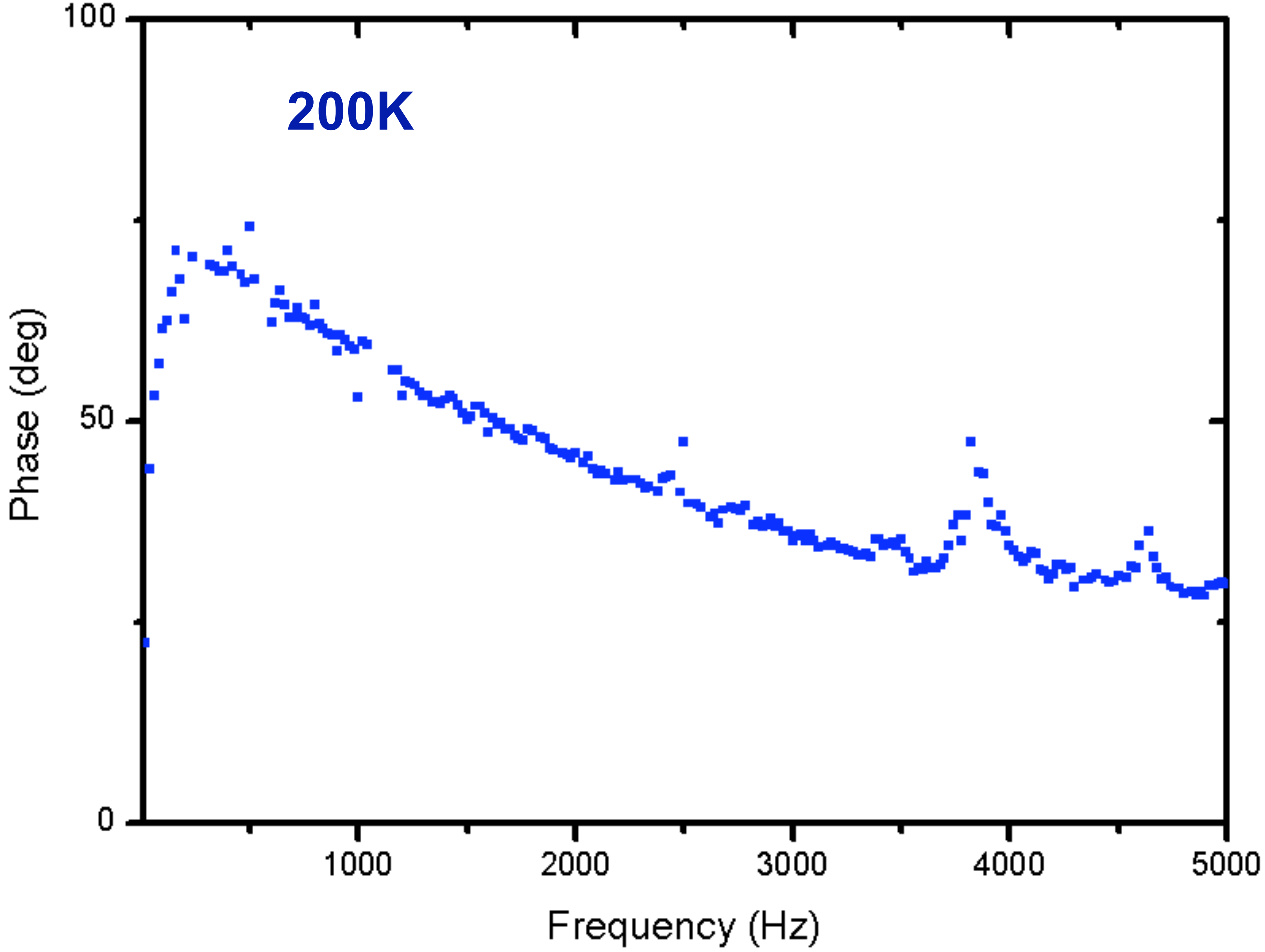




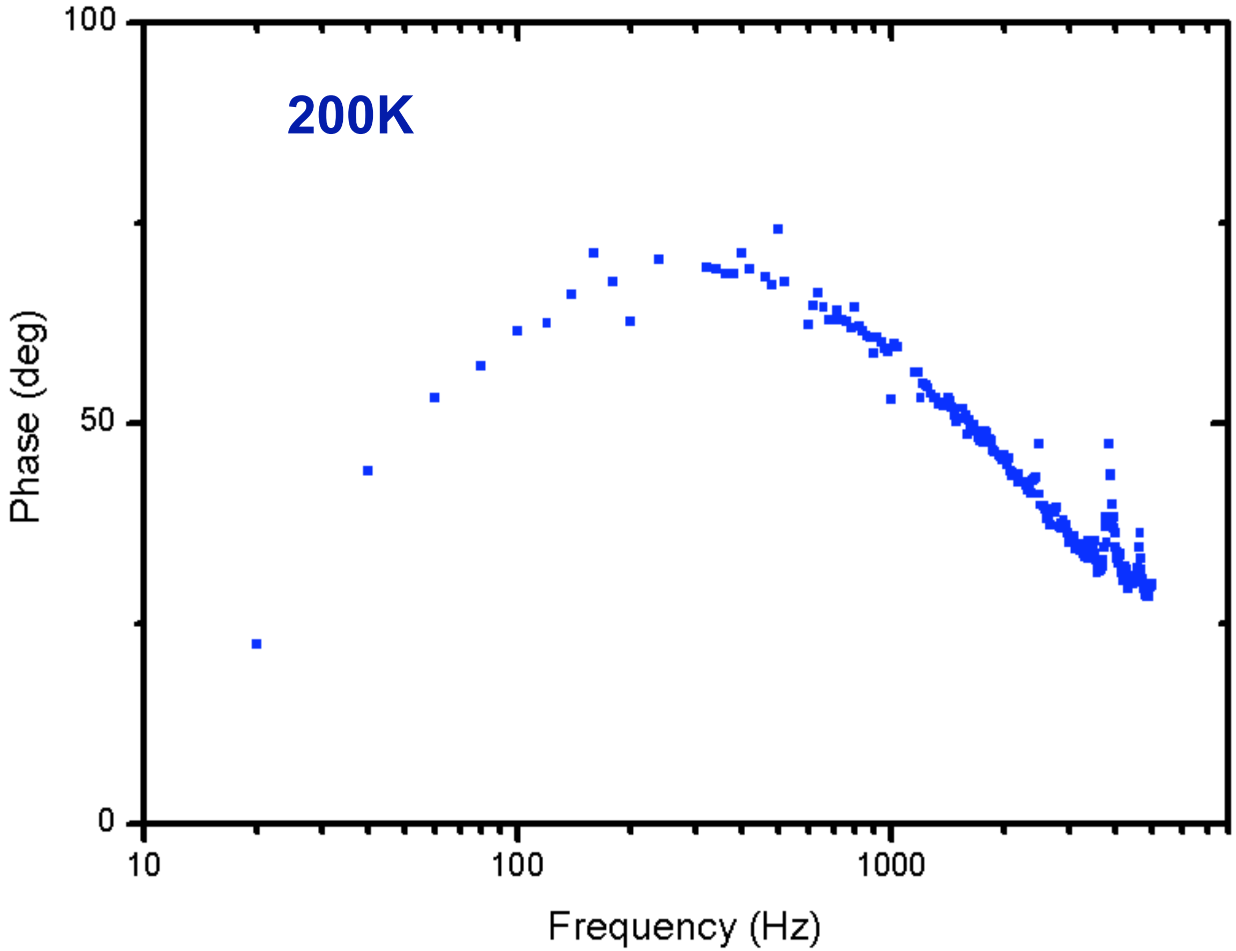


- frequency-range 1Hz – 10kHz++
- no moving parts
- strictly linear regime

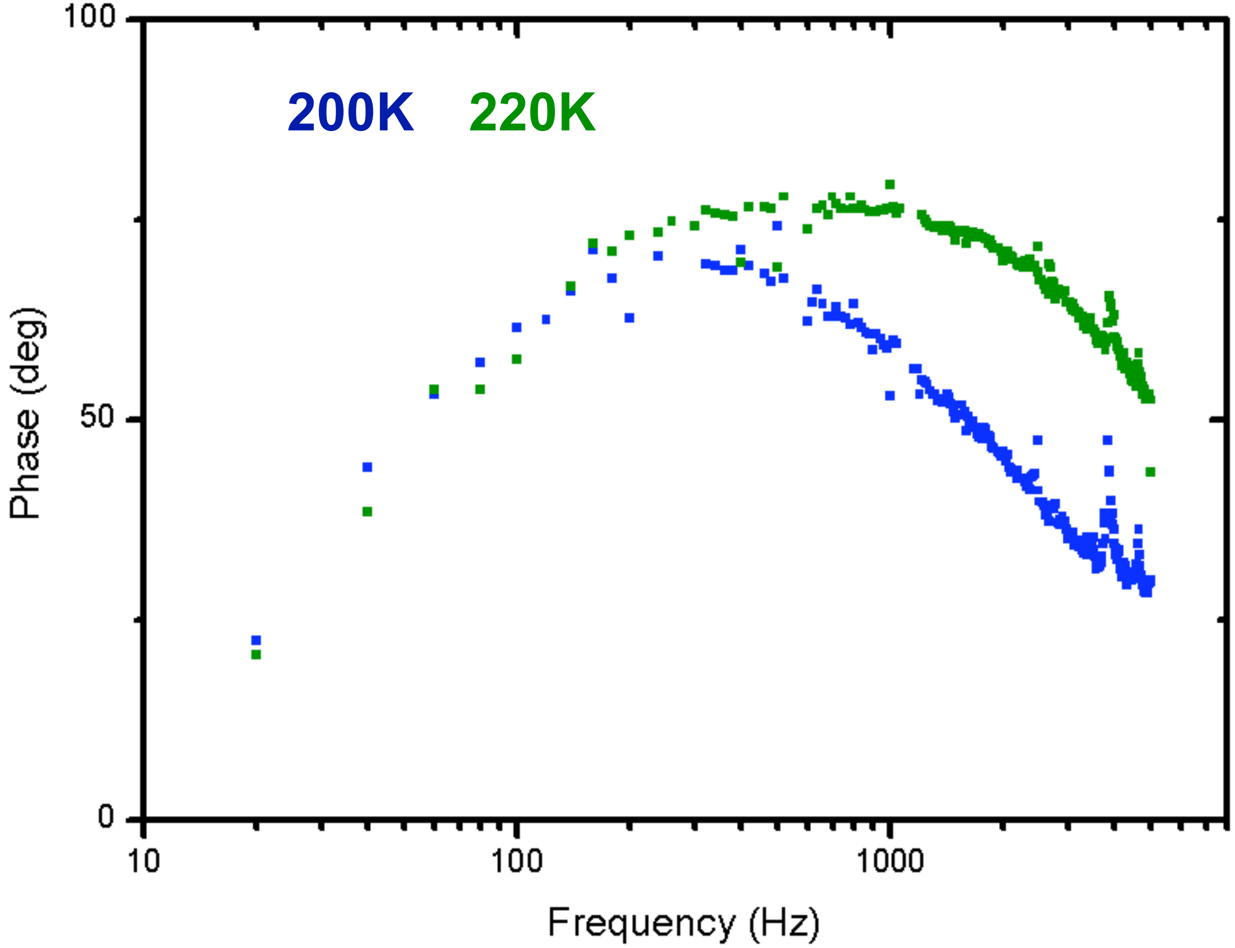
V_2O_5 sintered sample



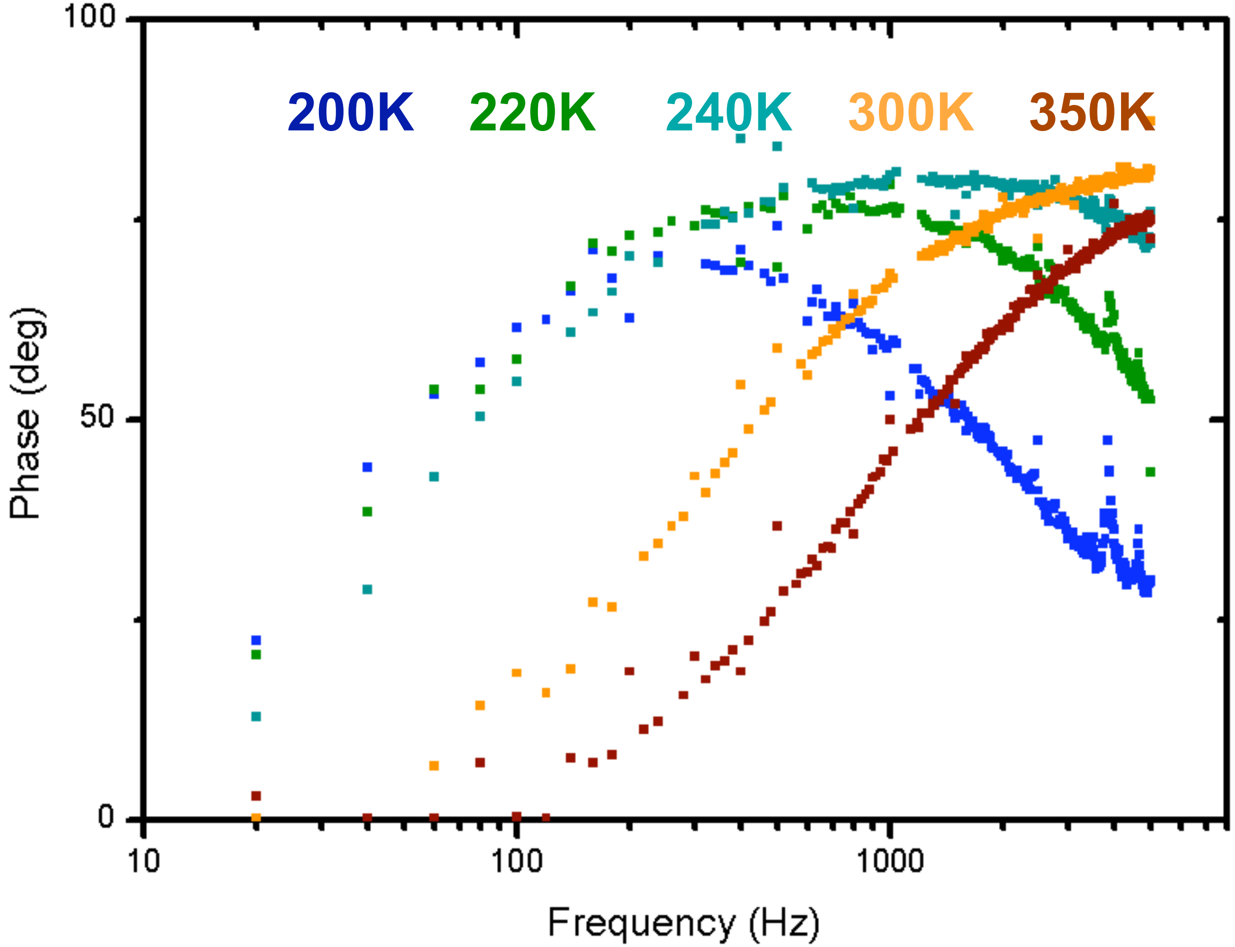
V_2O_5 sintered sample

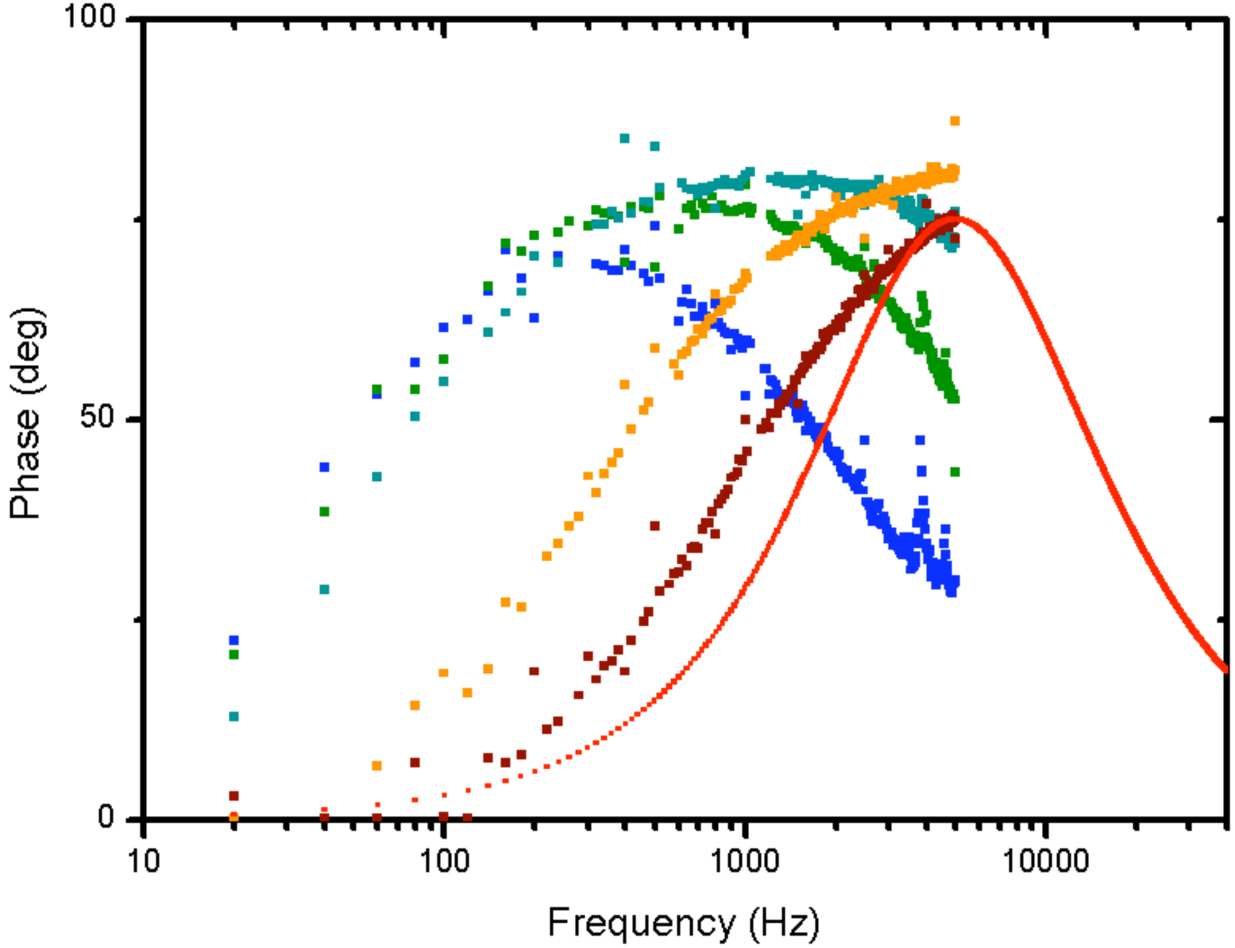


V_2O_5 sintered sample

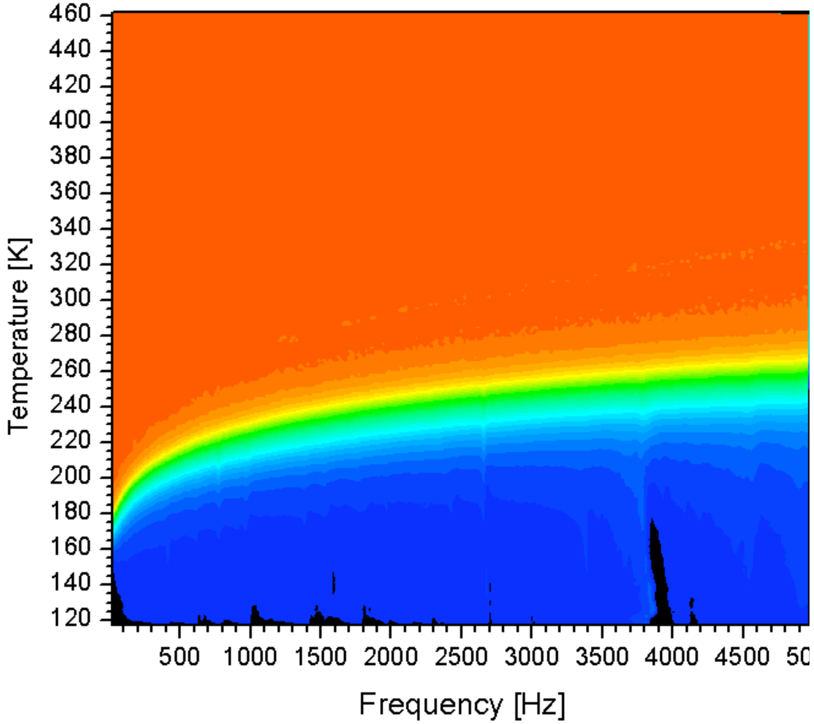


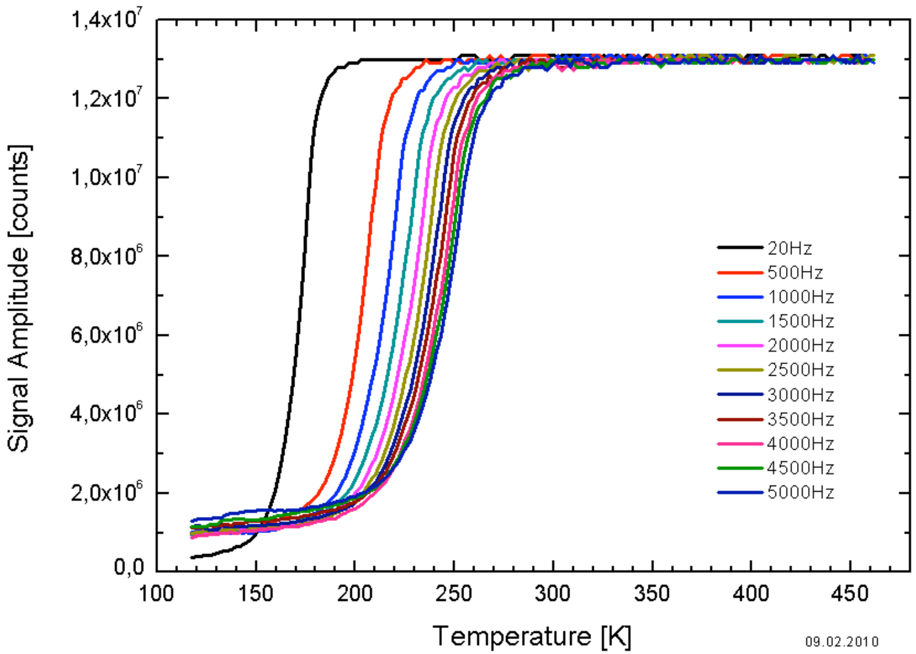
V_2O_5 sintered sample

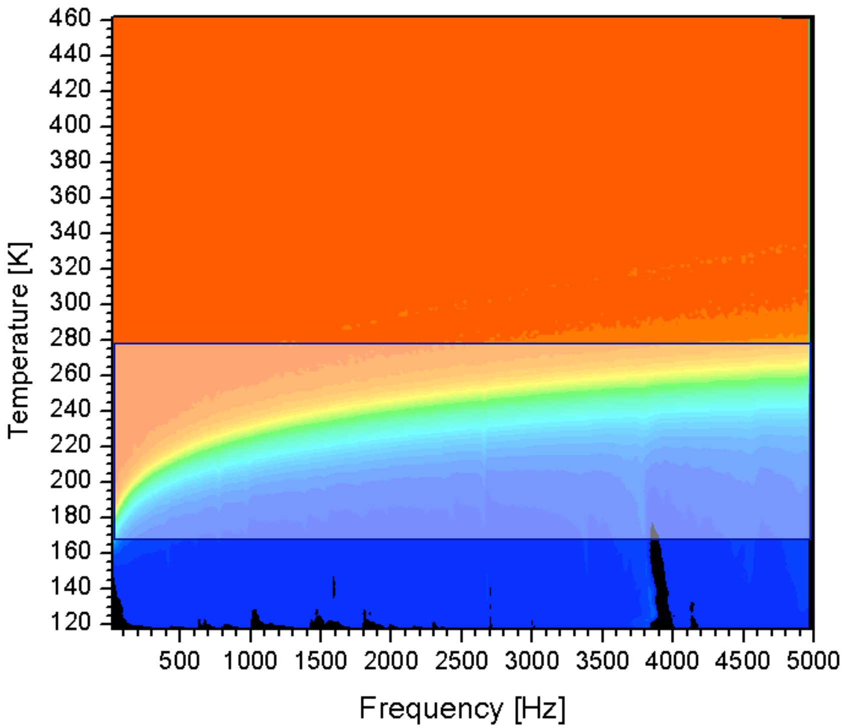



100
50
0
Phase (deg)
10
100
1000
10000
Frequency (Hz)

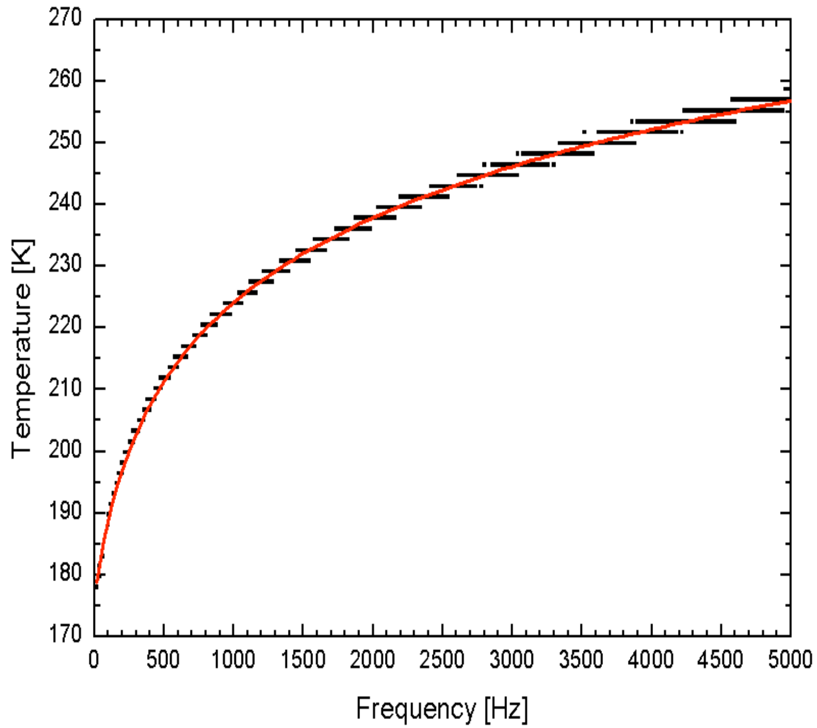
corresponding amplitude





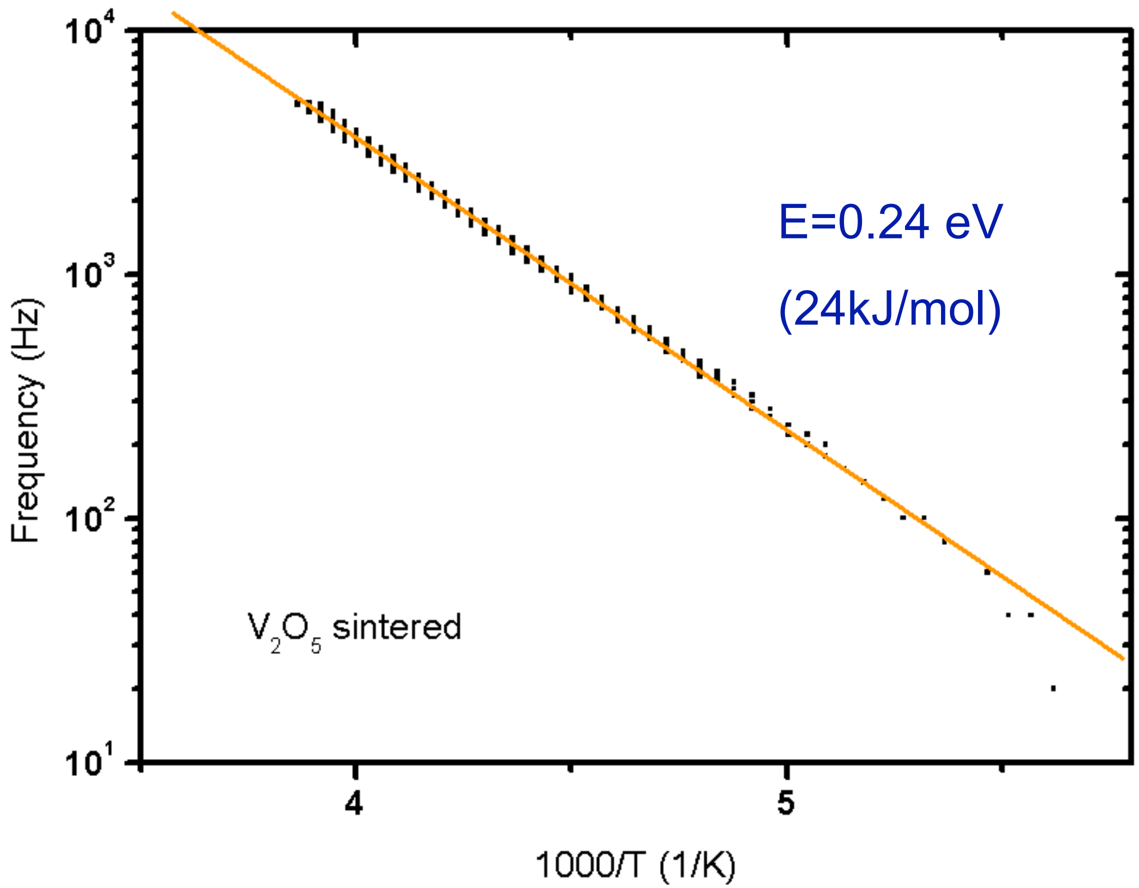


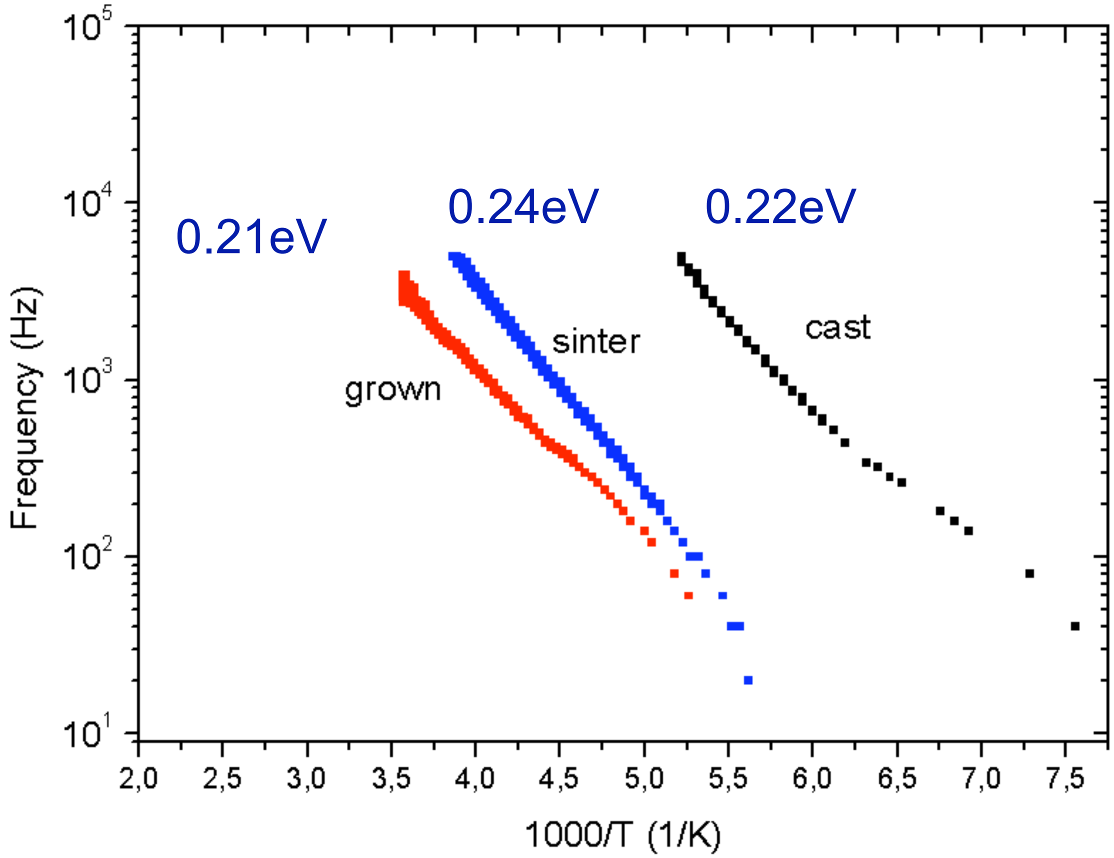
Temperature [K]
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Frequency [Hz]



Temperature [K]
270
260
250
240
230
220
210
200
190
180
170
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Frequency [Hz]

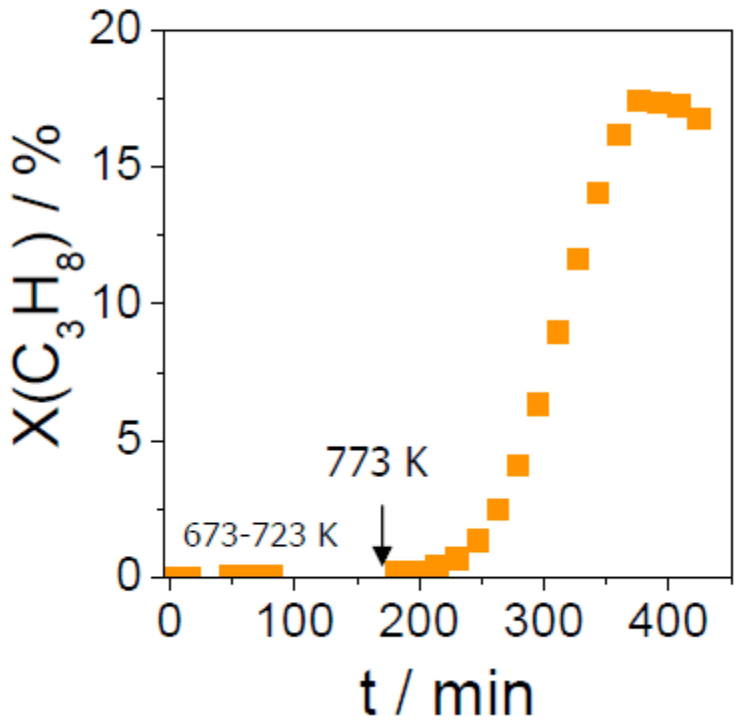
$$\tau = \tau_o \exp(E/kT)$$



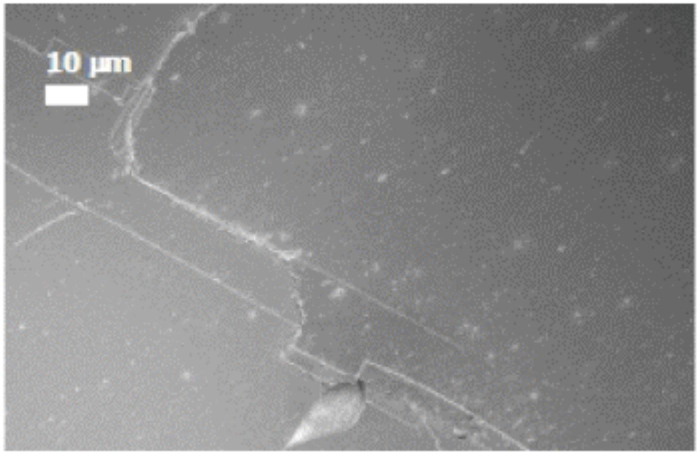


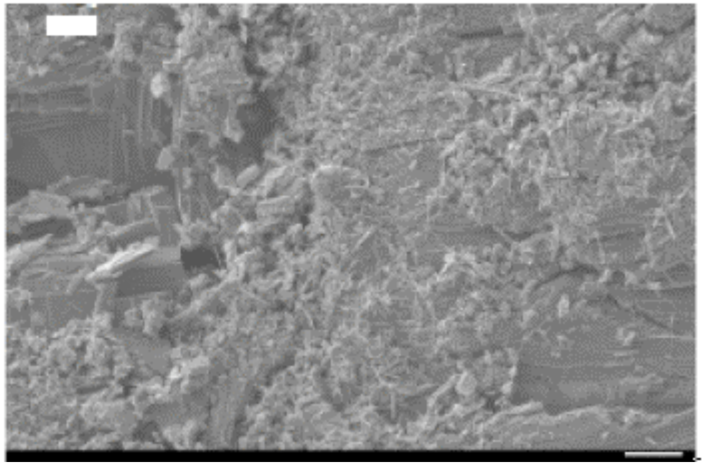
0.2eV = 20kJ/mol = 2200K = 50THz

Sound-waves and catalysis



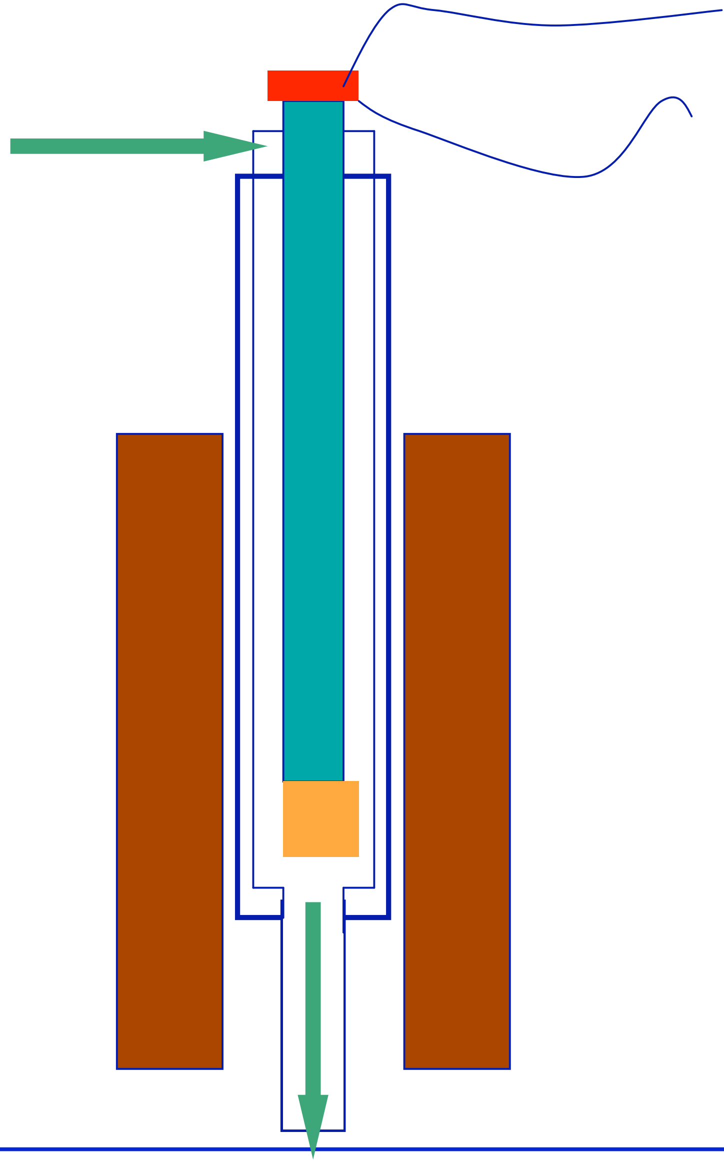
(Kondratenko/Ovsitser)



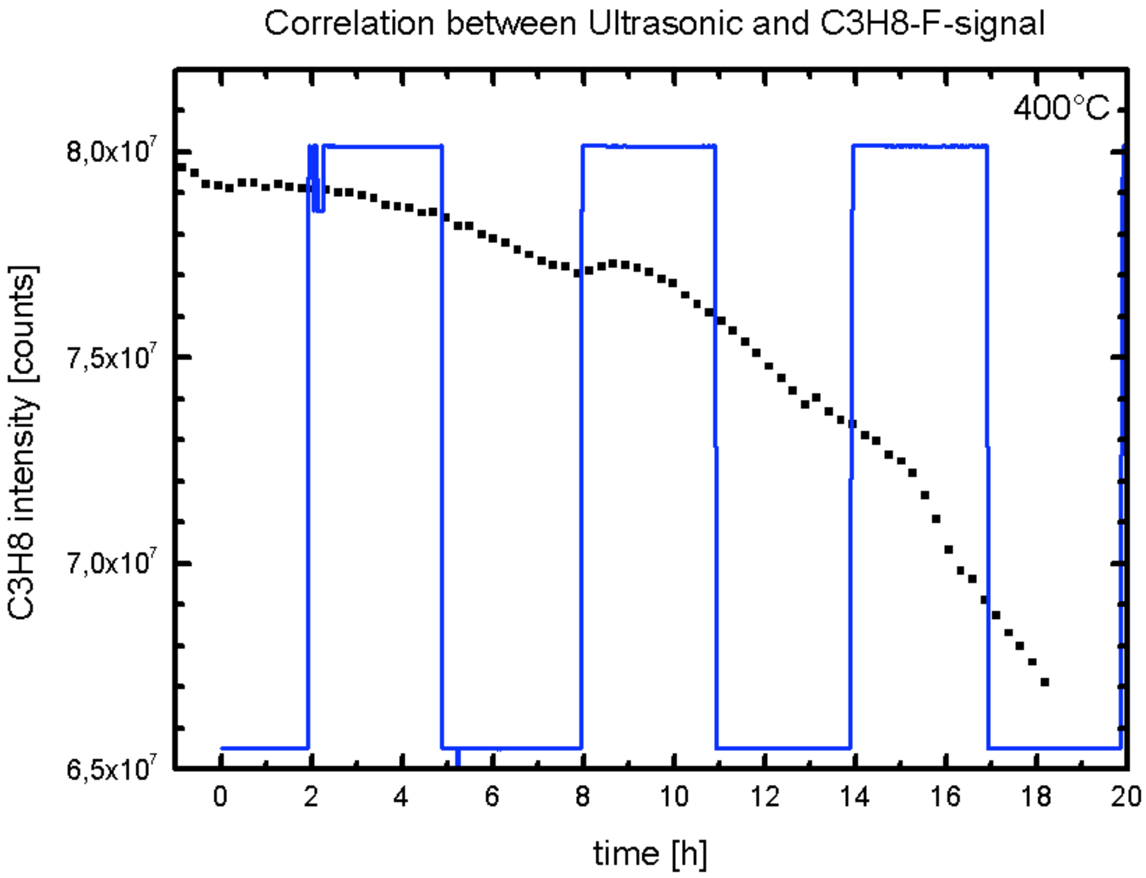


Treatment	S_{sp} /m^2g^{-1}
V_2O_5 initial	0.008
V_2O_5 after 7 hours under ODP (773 K)	0.375

(Kondratenko/Ovsitser)



Influence of sound on conversion



Conclusion

Elastic properties:

- Elastic constants
- Phase transitions
- In-situ characterization
- Defect-characterization

Sound-induced catalysis:

- First results