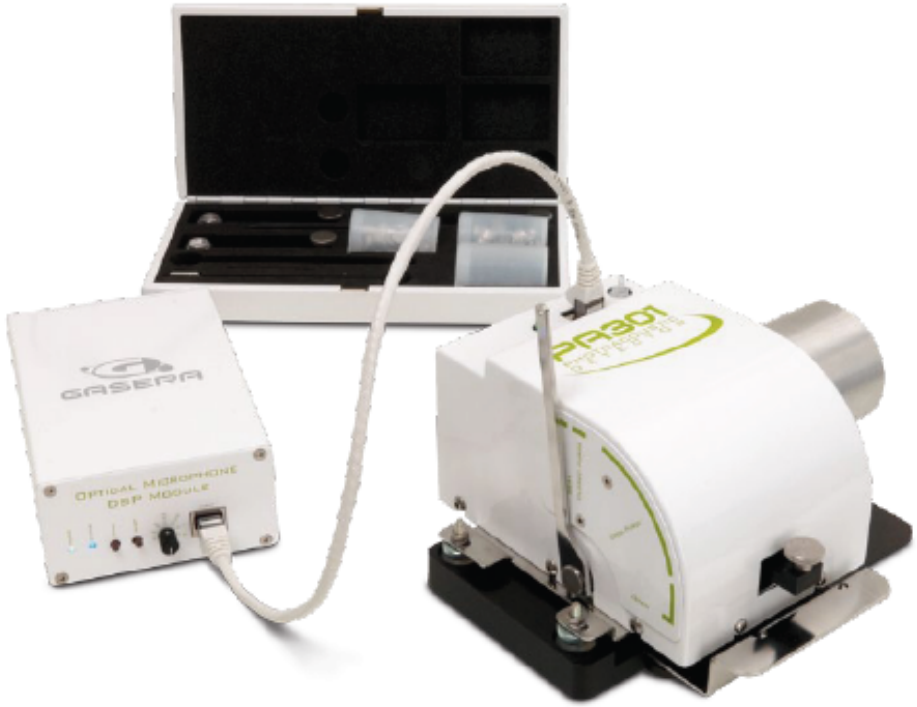
Product presentation

FTIR accessory: PA301



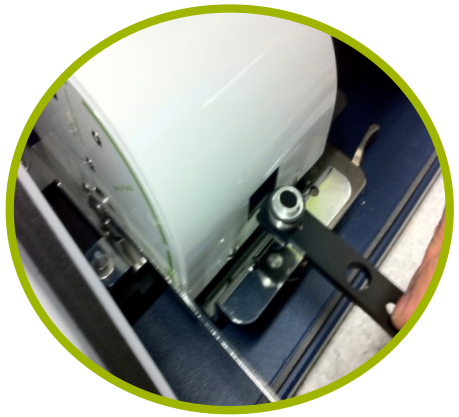
Ultra-high performance photoacoustic detector
for solid, semi-solid and liquid samples

Product concept

- PA301 is a photoacoustic FTIR accessory that can be used for the measurement of **solid, liquid** and **semi-solid** samples
- PA301 detector improves laboratory productivity and safety by enabling extremely versatile and rapid analysis of solid and liquid samples in any form without sample preparation
- PA301 is utilizing Gasera's patented cantilever based optical microphone technology that provides ultra high sensitivity

Usage

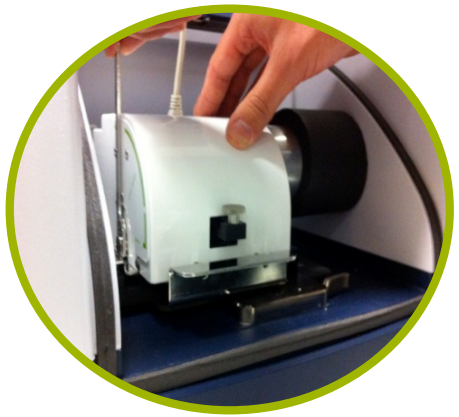
Install PA301 in to the sample compartment



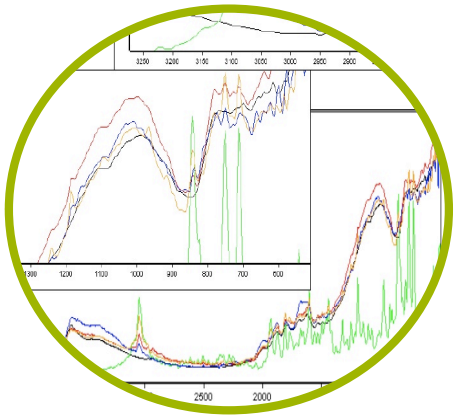
Measure Carbon Black reference

Insert sample into the sample cup

Slide in the sampling sledge

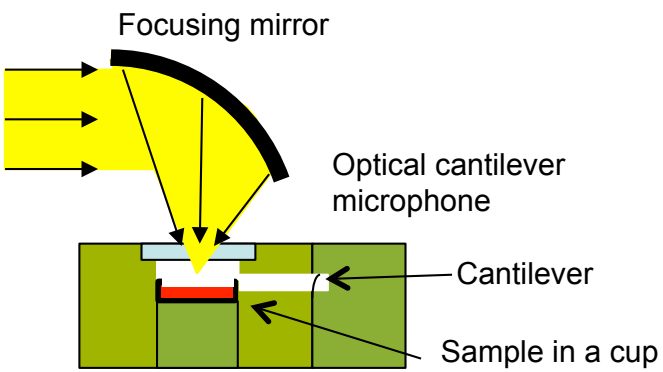


Seal the chamber for measurement



Run spectra and Analyze results

Photoacoustic detection

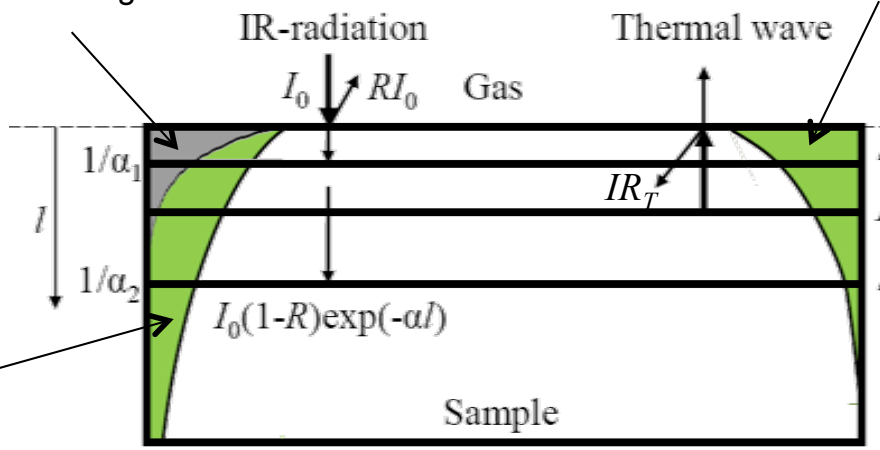


Photoacoustic cell

- Photoacoustic spectroscopy directly measures a sample's infrared absorption. The absorption of infrared radiation in the sample creates heat which is transferred into the surrounding gas and a photoacoustic signal is generated via thermal expansion
- The expansion of gas is then detected with a cantilever pressure sensor

Light intensity decay in a strong absorbing sample.
Depth is limited by $1/\alpha$

Thermal diffusion length limits the sampling depth with optically transparent samples.
Depth is limited by L.



$$\Delta T_{Gas} \propto I_0(1\text{-}R)(1\text{-}R_T)\,\alpha\,\exp(-\alpha l\text{-}l/L)\mathrm{d}l$$

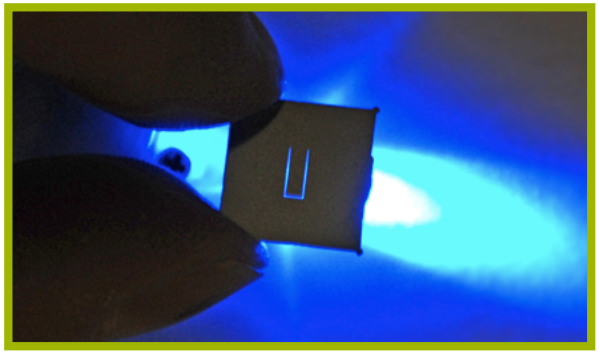
$$\Delta T_{Surface} \propto I_0(1\text{-}R)\,\alpha\,\exp(-\alpha l\text{-}l/L)\mathrm{d}l$$

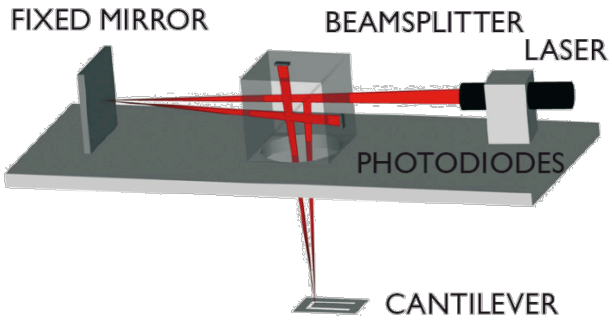
L

$$\Delta T \propto I_0(1\text{-}R)\,\alpha\,\exp(-\alpha l)\mathrm{d}l$$

Light intensity decay in a transparent sample,
$\alpha_2 << \alpha_1$

Ultra sensitive optical cantilever microphone





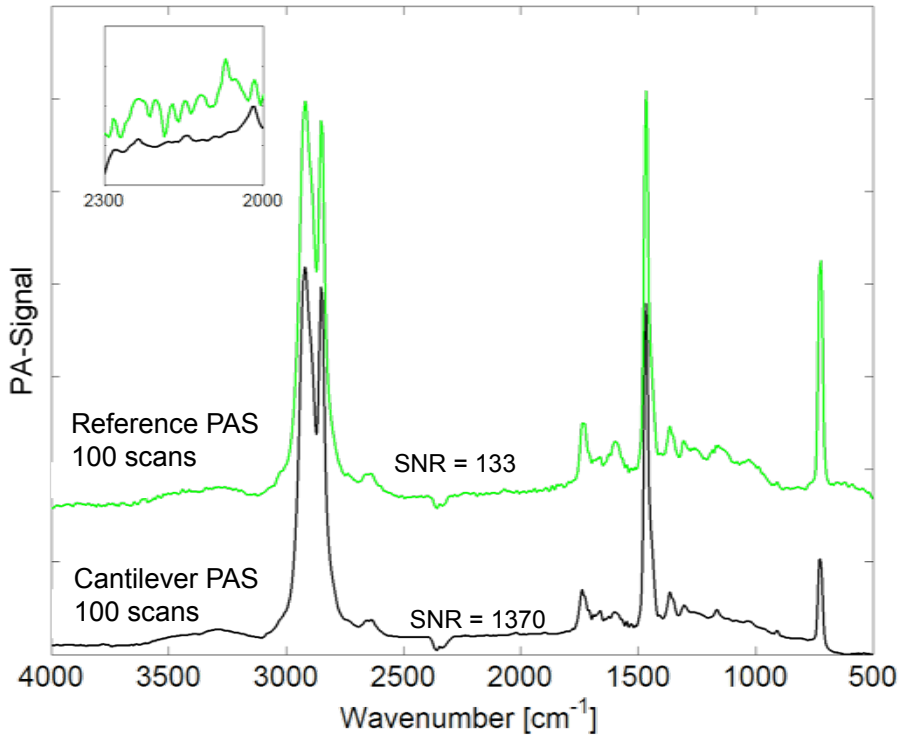
- The heart of the system is the patented optical microphone comprising of a MEMS cantilever coupled with a laser readout interferometer
- It is capable of digitally measuring microscopic movements of the cantilever sensor, having a dynamic range greater than any analog circuitry can ever obtain

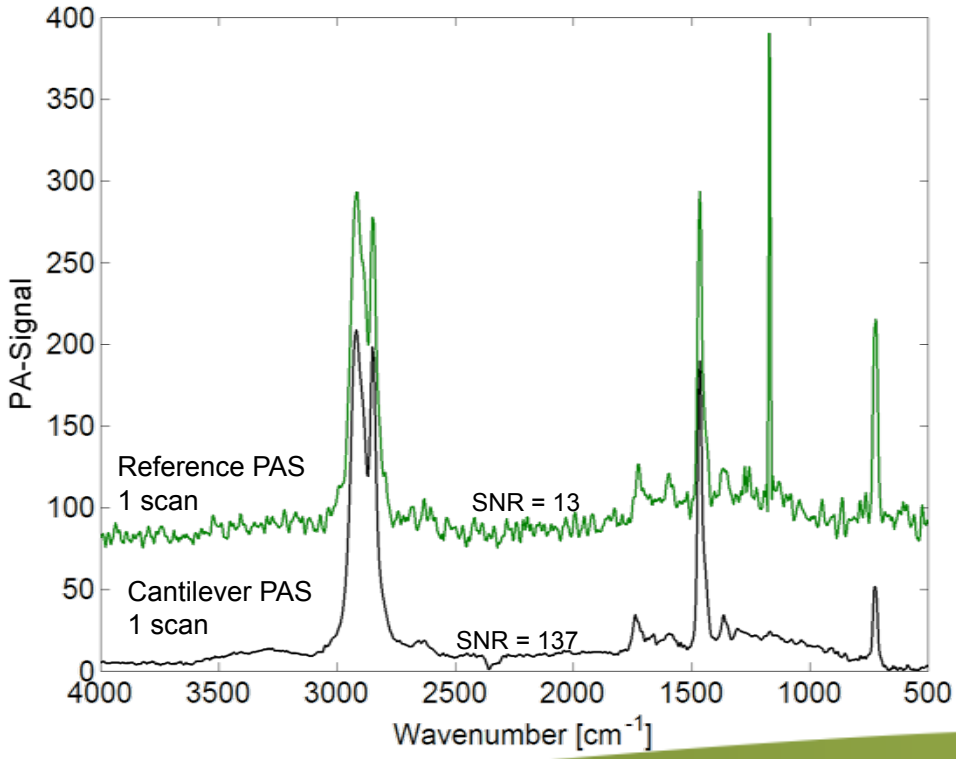
Δx [m]	Δp [Pa]	ΔT [K]	Δm [g]
2×10^{-12}	2×10^{-7}	2×10^{-9}	4×10^{-12}

With 1s measurement time.

PA301 Performance

- Due to the ultrasensitive cantilever microphone, the SNR of PA301 is ten times higher than with other photoacoustic detectors using condenser microphone.
- This means that same SNR is received in 100 times shorter time scale.
- It also means that equal SNR without helium purge is still achieved 10 times faster.
- Cantilever microphone also does not lose its performance over the time.

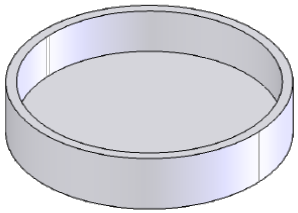


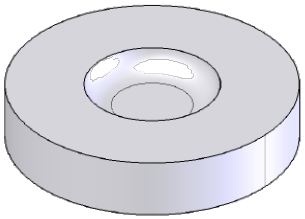


Versatility

- PA301 can measure any kind of samples with minor or no sample preparation
- The spectra can be used for qualitative and quantitative analysis of samples
- Commercial transmission spectrum libraries can be used for material identification
- PA301 can be connected to nearly any existing FTIR device

Easy sampling



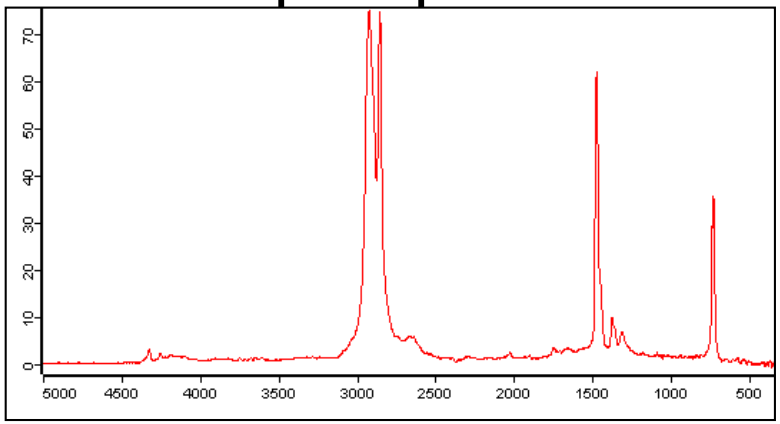


- Insert sample to the cup, slide the cup inside the PA301 and press measure.
- No sample preparation is needed. The only requirement is that sample fits into the sample cup (10 mm in diameter and 9 mm in height)
- Sample is not pressed, grinded, dissolved, mixed with KBr or even contacted.
- Samples are not consumed, which saves valuable or delicate samples.
- Sample cups are replaceable and washing up can be avoided.
- Helium purging is made easy with, no external flow meters are required

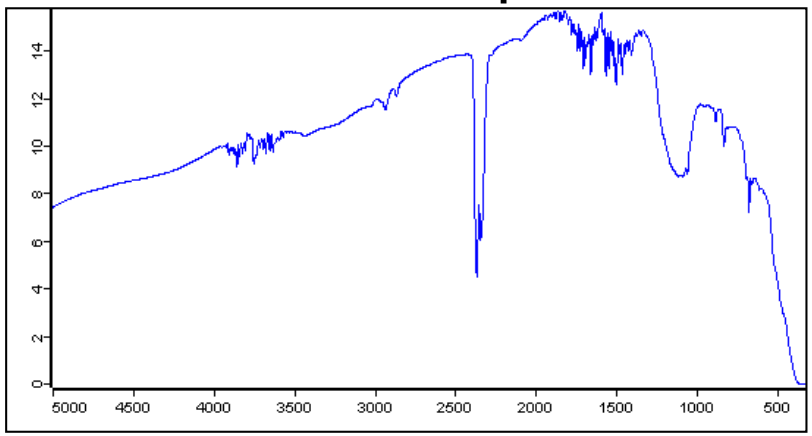
Normalization

- Sample spectrum is divided with a carbon black reference spectrum, i.e. normalized
- This cancels out the instrument contribution from the spectra

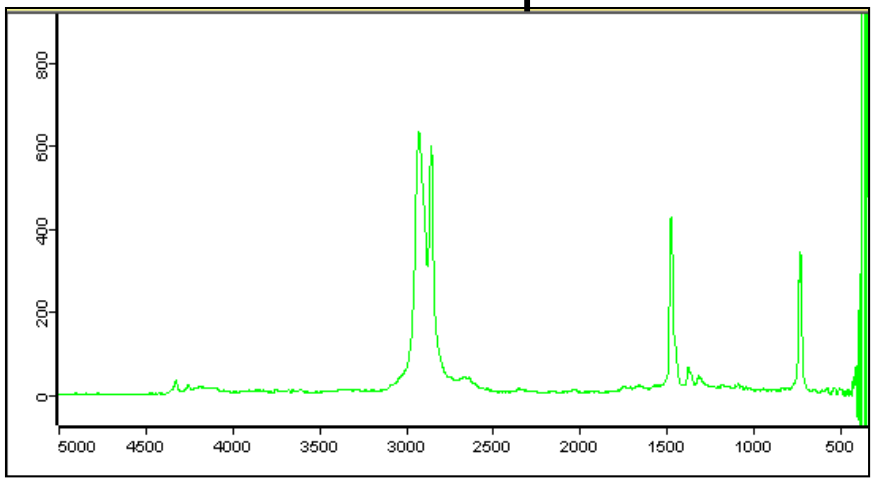
Sample spectrum



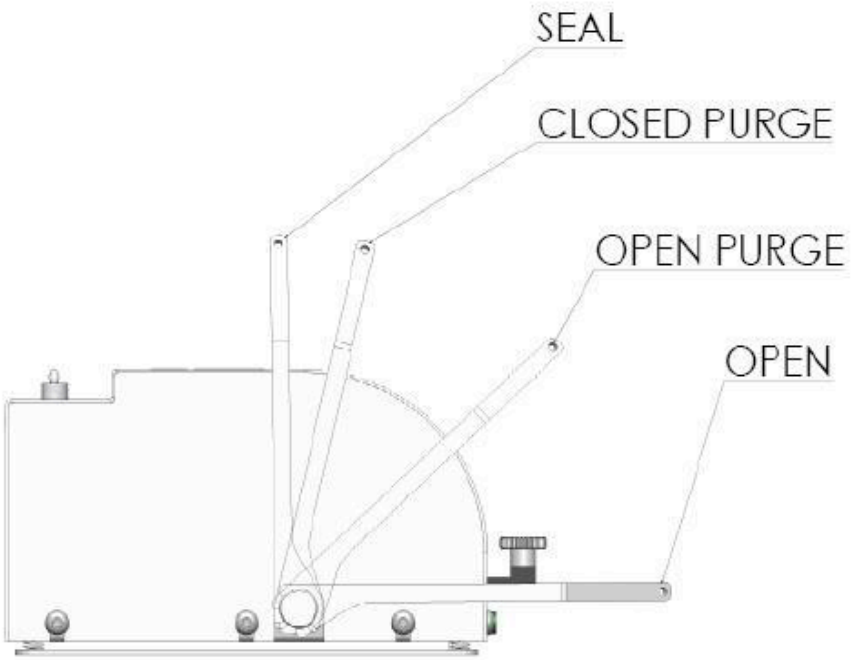
Carbon black spectrum



Normalized spectrum



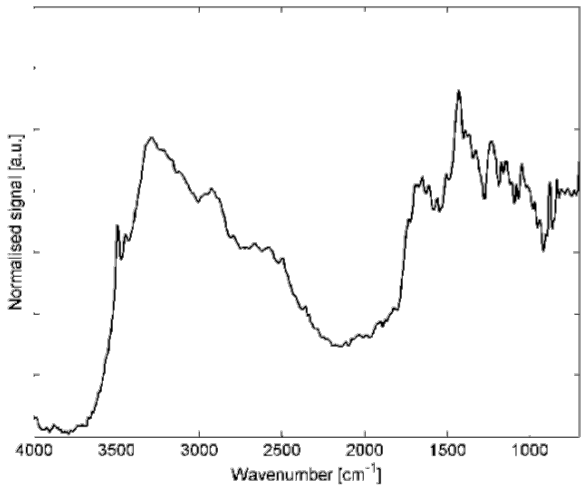
Purging



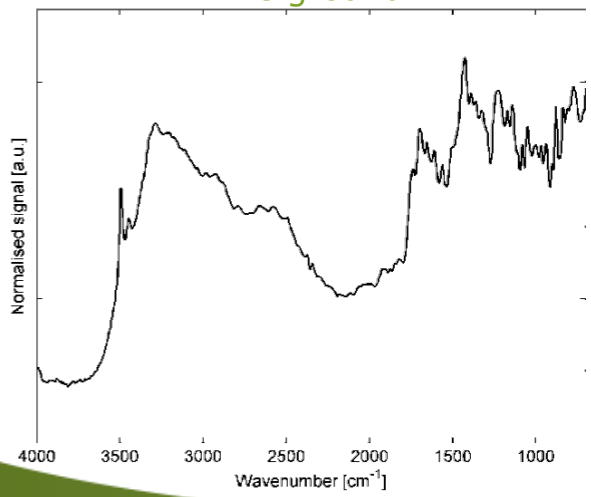
- The sample space can be purged with N2/He in order to remove H2O vapor and carbon dioxide
- Helium purging increases the signal by a factor of 2-3

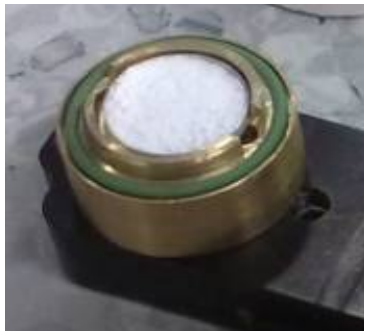
Insensitive to sample morphology

Broken tablet



Fine ground



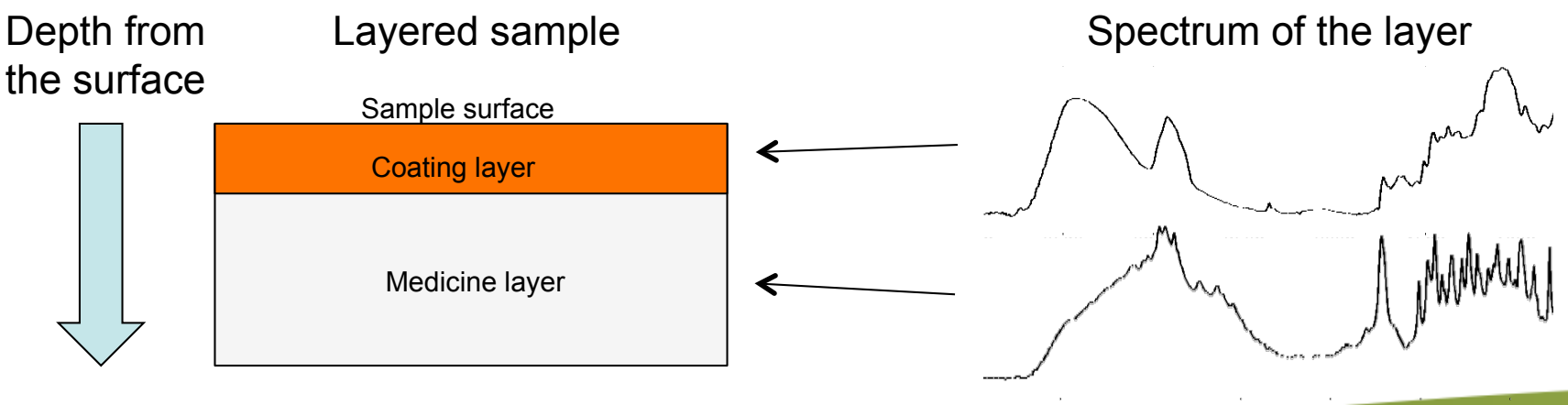


- Makes sampling easy
- Makes quality control easy
- Fibers, single particles, powders and large solid samples can be directly measured

Depth profiling

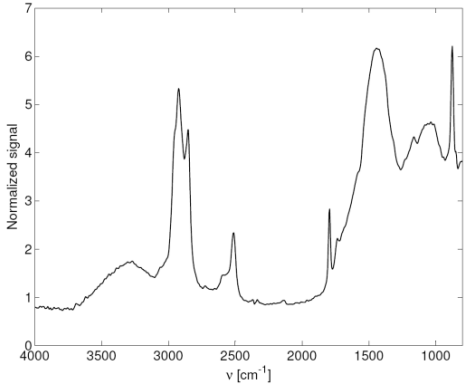
coated tablet

- Depth varying information can be obtained with photoacoustic spectroscopy.
- Depth scale is selected by varying the mirror velocity or modulation frequency in the FTIR interferometer and phase of the spectra.
- It is possible to vary depth from range of below 1 µm to few hundreds of micrometers.
- Spectra from different depth ranges can be measured.
- Depth of different layer interfaces can be determined.
- Distance between different layers can be determined with higher resolution by using the phase data.
- Spectra from two different layers can be separated from each other.

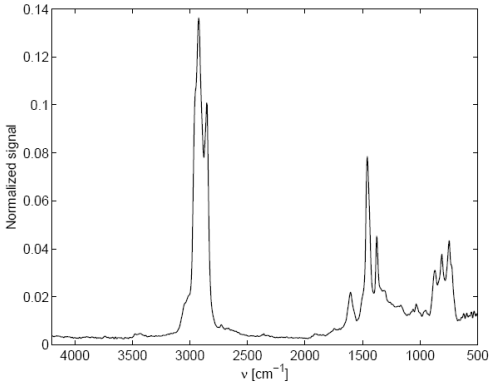


Application: Black samples

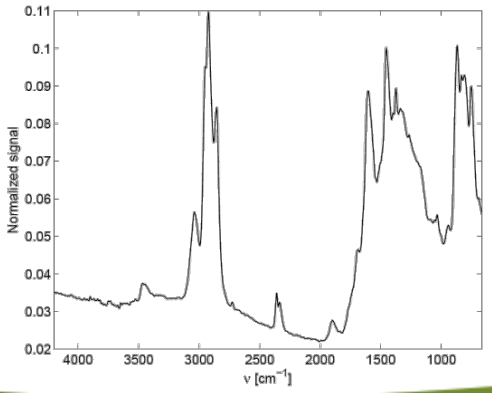
Bitumen



Heavy fuel oil



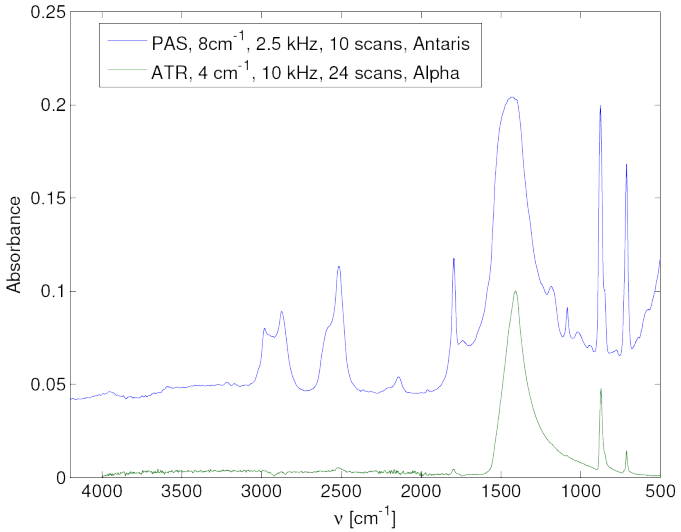
Deposit from heat exchanger



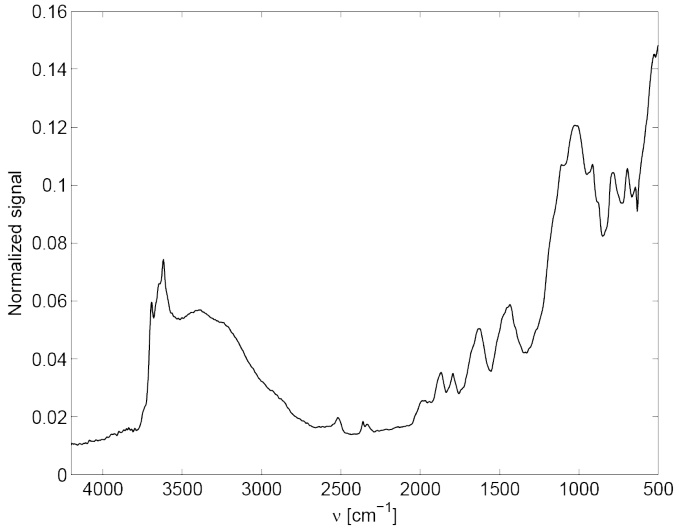
- PAS suits extremely well for the measurement of dark samples that have low transmittance or reflectivity on a wide spectral range.
- The reason for this is that PAS is a direct absorption measurement technique – the higher the absorbance the higher the signal.
- With other techniques (transmission, ATR, DRIFT) proper spectra are difficult to obtain from dark samples due to the high absorption.
- With PA301 accessory no sample preparation is needed and contaminated sample cups can be discarded after the use.

Application: Soil and mineral samples

Ca,Mg carbonate

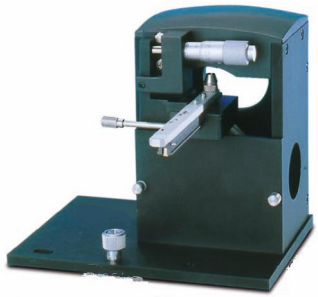


Clay soil sample



- PAS is an advantageous method for the measurement of soil and mineral samples since it is contactless measurement and insensitive to the sample morphology.
- In PAS, no sample preparation is needed such as for example mixing with KBr in diffuse reflectance.
- Mineral samples typically have a very hard surface, and therefore, a proper optical contact is hard to obtain with ATR method even with a diamond ATR.

PAS, ATR, transmission and diffuse reflectance intercomparison



- ATR vs. PAS
  - Non-deformable solids give weak signals with ATR because of bad optical contact.
  - PAS is extremely good with hard and optically opaque samples which are not suitable for ATR.
  - PAS can measure any samples with any shape or morphology while ATR might destruct the sample.
  - Short sampling depth, e.g. emulsions do not give representative results. PAS has variable sampling depth.
- DRIFTS vs.PAS
  - Cantilever PAS has better sensitivity than DRIFTS with any kind of samples. Samples of diffuse reflectance often need to be powders or even mixed with e.g. KBr, because spectrum is a combination of transmission and reflection spectra.
  - PAS has simple optics that does not need basically any adjustments after initially attached to the FTIR interferometer, while in DRIFTS sample or mirrors have to be regularly adjusted.
- Transmission vs. PAS
  - With PAS the sample preparation is very minimal while with transmission method the sample preparation takes huge amount of time and may require many toxic materials.
  - Transmission measurements are difficult with optically opaque samples.

Other typical applications

- Dark samples (eg. bitumen, rubber, heavy oil, etc.)
- Study of carbons, coals, hydrocarbons, hydrocarbon fuels
- Corrosion
- Clays and minerals
- Wood and paper
- Polymer layers
- Food products
- Biology and biochemistry
  - e.g. Proteins
  - Bacteria
  - Fungi
- Medical applications
  - Human tissue
  - Drug characterization and penetration
  - Teeth, hair and bacteria
- Nondestructive measurement of carbonyl compounds, textiles, and catalysts

MADE TO MEASURE.