

Bio-Nano-Med & Chemical Analytics at RECENDT

Markus Brandstetter

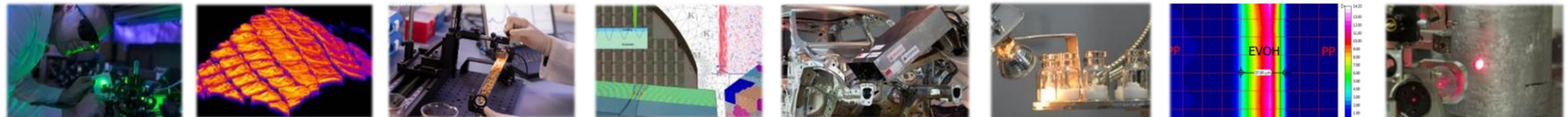


Annual Forum 2025, October 7th, Linz



www.recendt.at

Member of
UAR INNOVATION
NETWORK

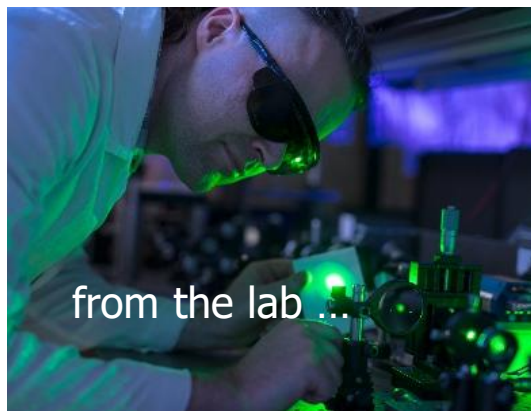


RECENDT - REsearch CEnter for Non-Destructive Testing

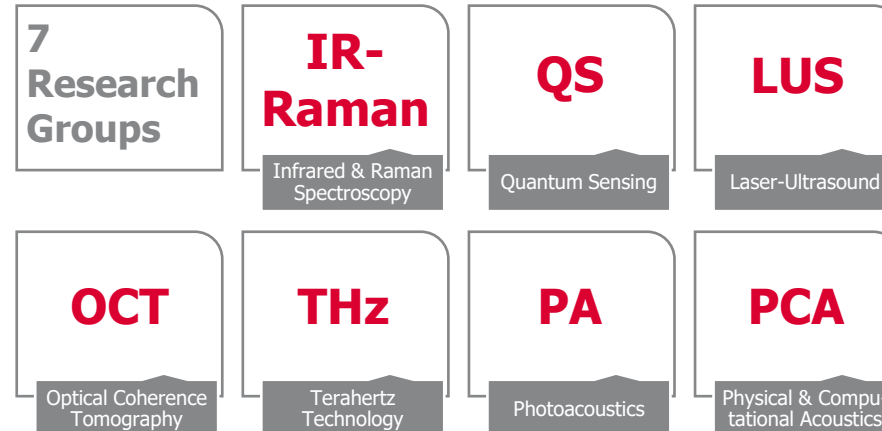


Science Park
@ Johannes Kepler University **Linz, Austria**

- **Research & Technology Organization**
- Founded in 2009
- >40 Researchers
- **100% Project Financed**
- Funded Research
 - National: FFG, FWF, Christian-Doppler Laboratory, EFRE, FTI
 - Europe: H2020, HEU, Doctoral Networks (Marie-Curie ITN)
- Contract Research for Industry & Academia



from the lab ...



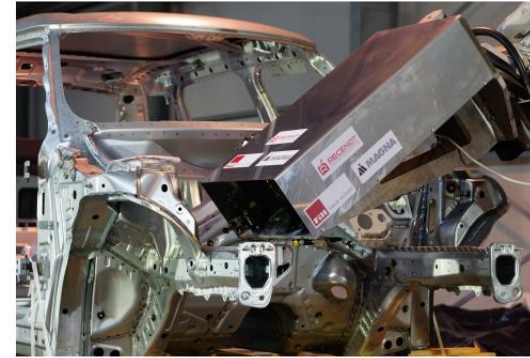
... to the industry

What we do

Research & Technology Development



Material Characterization



Process Analytics



We develop and implement customer-specific **non-destructive sensing** (& non-contact) solutions ...

... **across** R&D development **phases**

... **across** industrial **branches**



Often via partners!
(e.g. K-Centers CHASE, WoodKplus, CBmed, FFoQSI, RCPE, ...)

Research & Technology Development

- **From scratch:** start with theory & simulation → experiment
- **Early adopters** of novel technologies enabled by lean structure
- **Multi-modal** approaches by combination of in-house technologies (Infrared, Raman, OCT, THz, LUS, ...)



Research & Technology Development

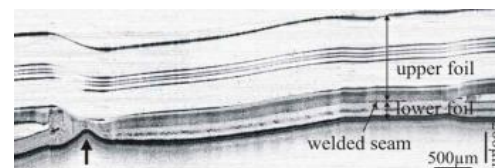
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Optical Coherence Tomography (OCT)

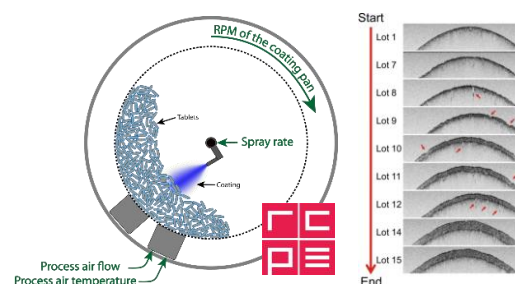
- **Sub-surface imaging**
- **Structural** information
- Analysis of hidden structures & defects
- Layer thicknesses

Closing the blind spots with novel **mid-infrared** laser technology

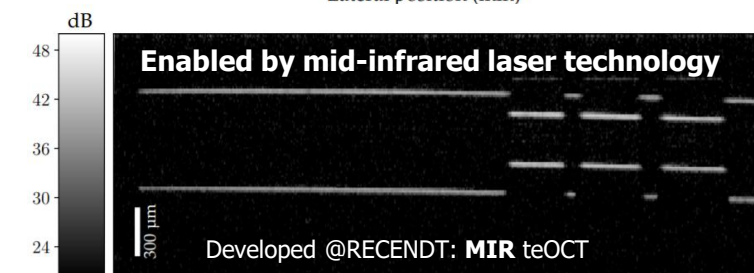
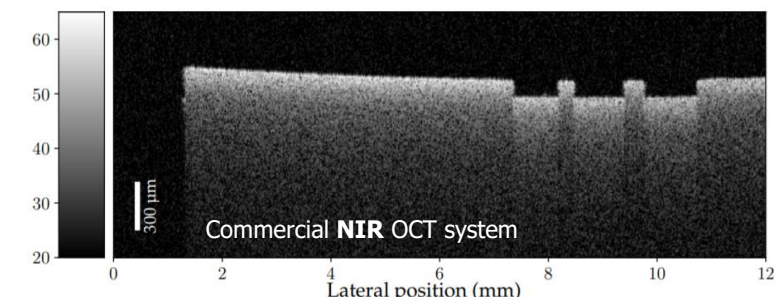
Multilayer polymer film



Drum coater for tablets: inline coating control



Additive manufacturing process with ceramics



Research & Technology Development

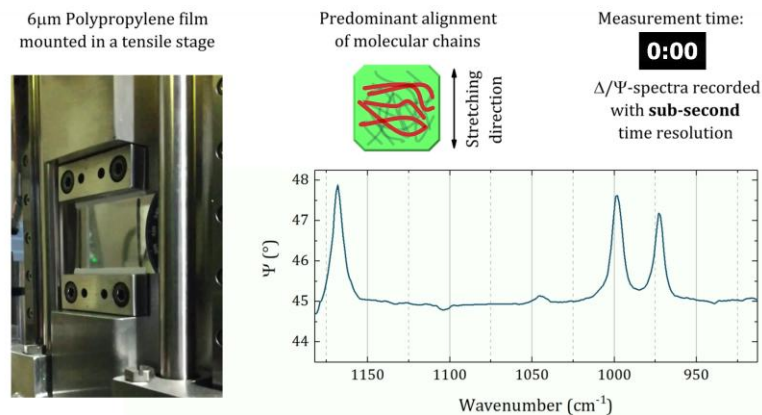
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Mid-Infrared Spectroscopic Ellipsometry

- Structural & chemical information
- Information of **orientation of molecular chains**
- Layer thicknesses
- nm-resolution (axial) and μm -resolution (lateral)

Increasing Measurement Speed by
a Factor of ~70.000 enabled by Mid-Infrared
Laser Technology

Live-monitoring of molecular chains
reorientating in a PP-film during stretching



Live-monitoring of molecular chains
reorientating in a BOPET-film during stretching & rupture

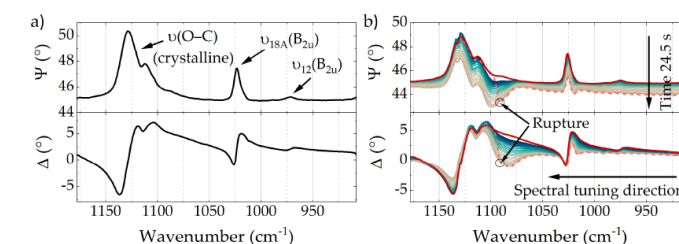


Figure 4. (a) Δ, Ψ -spectra of a 2.5 μm BOPET film recorded in a normal incidence transmission measurement. Band assignment according to literature [48]. (b) Ellipsometric monitoring of a BOPET film during stretching. The experiment took 24.5 s until the film tore during acquisition of the dashed spectra. While the blueish to brownish graphs were recorded during stretching, the red graph indicates the spectra after rupture.

JYU

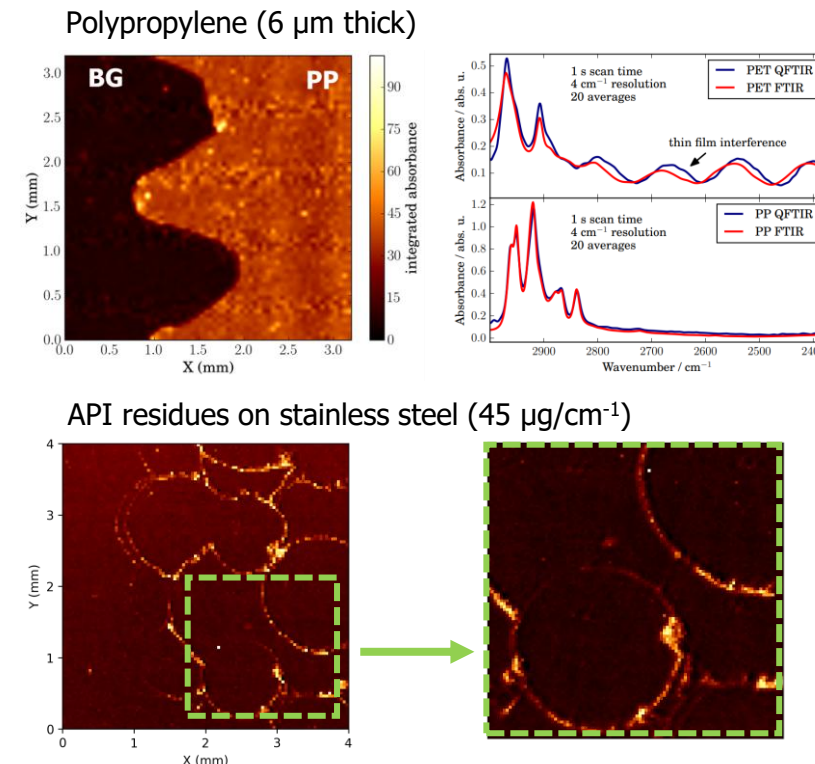
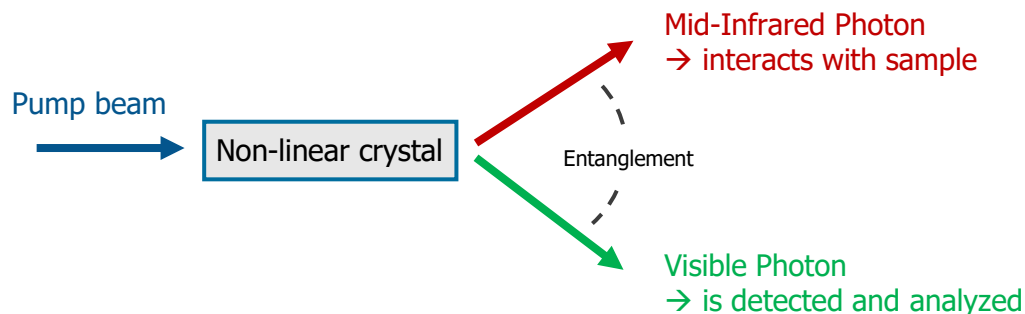
Research & Technology Development

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Quantum Sensing with entangled photons

- Structural & chemical information
- Sample interaction of mid-infrared photons – Detection of visible photons

Ultra-low power levels (**pico-Watt instead of milli-Watt**)
→ ideal for sensitive biological / clinical samples



September 2025



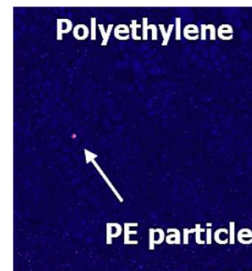
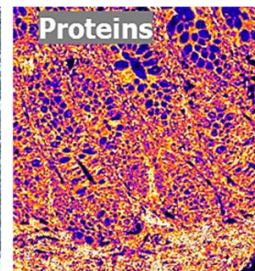
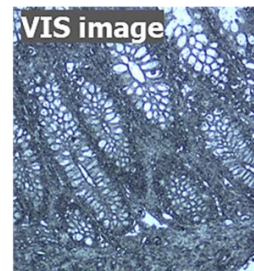
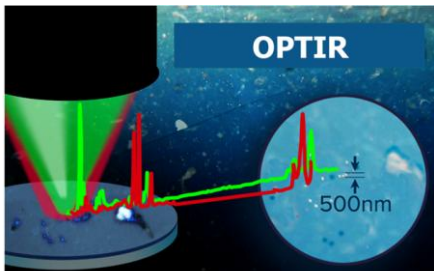
<https://doi.org/10.1177/00037028251340945>

Research & Technology Development

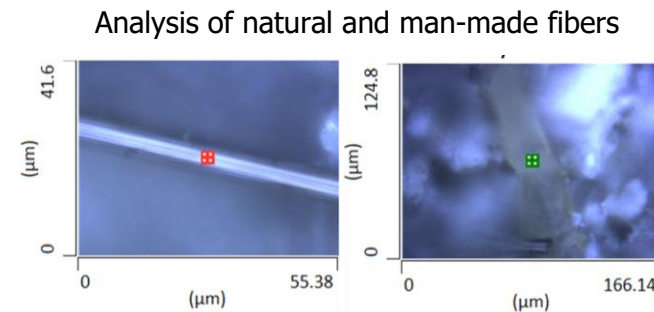
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Nano-Scale Chemical Imaging

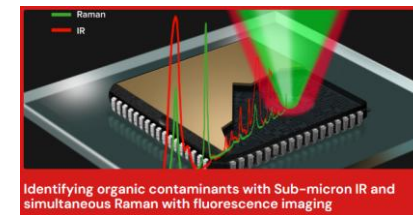
- 2D chemical microscopy by OPTIR (Optical Photothermal Infrared Spectroscopy)
- Artifact-free infrared imaging far below the diffraction limit: **Factor 20**
- **Label-free**, non-destructive, contact-free, **no sample preparation**



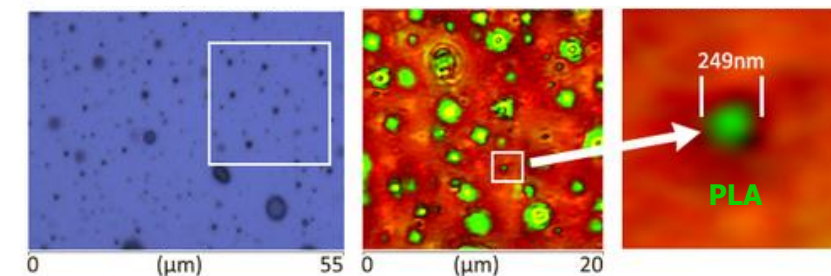
Micro- and nanoplastic analysis in clinical tissue samples



Semiconductor industry



Phase dispersions of polymer mix

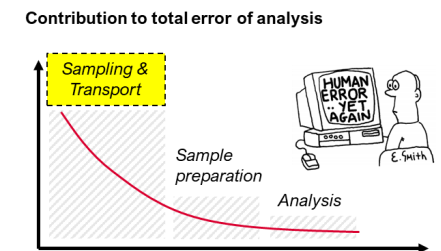
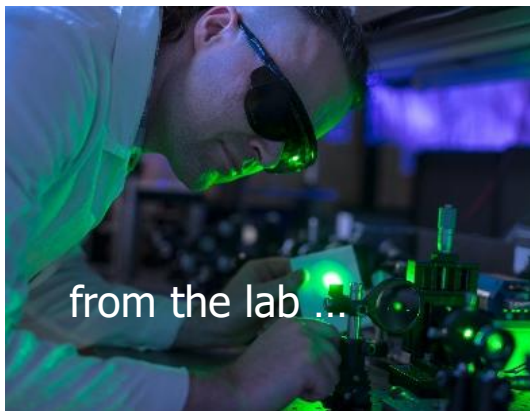
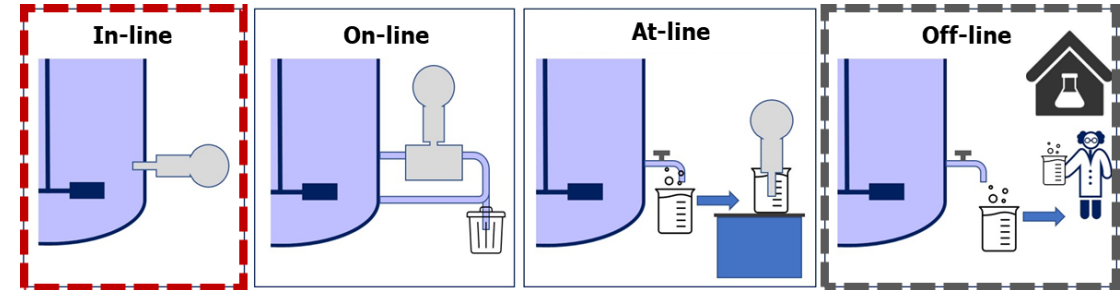


ACM (Acrylic Rubber)

Industrial Implementation & Process Analytics

- **Small**
- **Cheap**
- **Rugged**

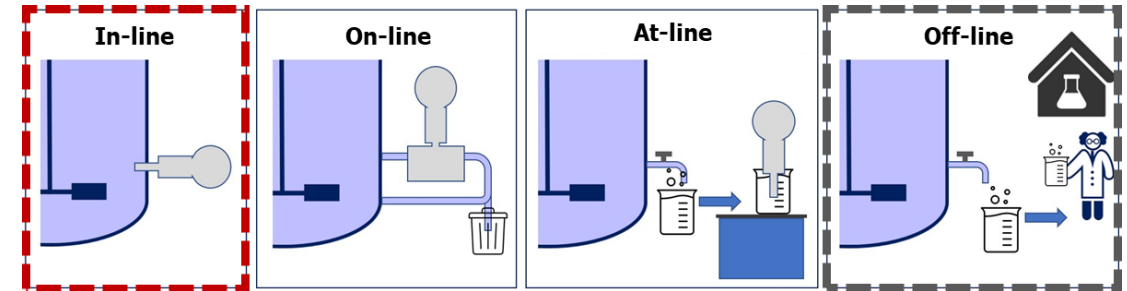
Instead of taking the sample to the lab -
take the lab to the sample



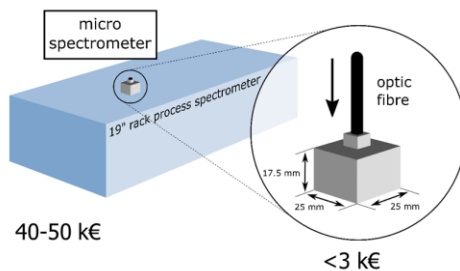
Industrial Implementation & Process Analytics

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Instead of taking the sample to the lab -
take the lab to the sample



- **Key methods** are Near-Infrared (NIR) Spectroscopy and Raman Spectroscopy
→ Both provide **chemical information** of a sample and offer **inline capability**
- **MEMS technology** provided a huge push towards miniaturization, cost-reduction and ruggedness → **MEMS Microspectrometers**

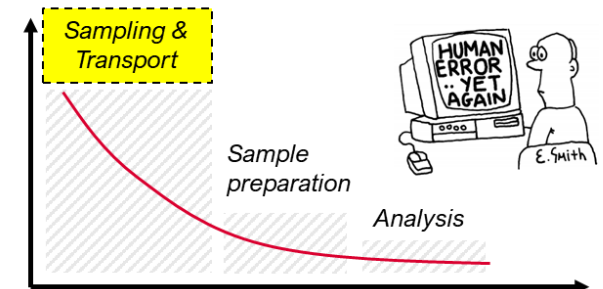


MEMS ... Micro-Electro-Mechanical-System

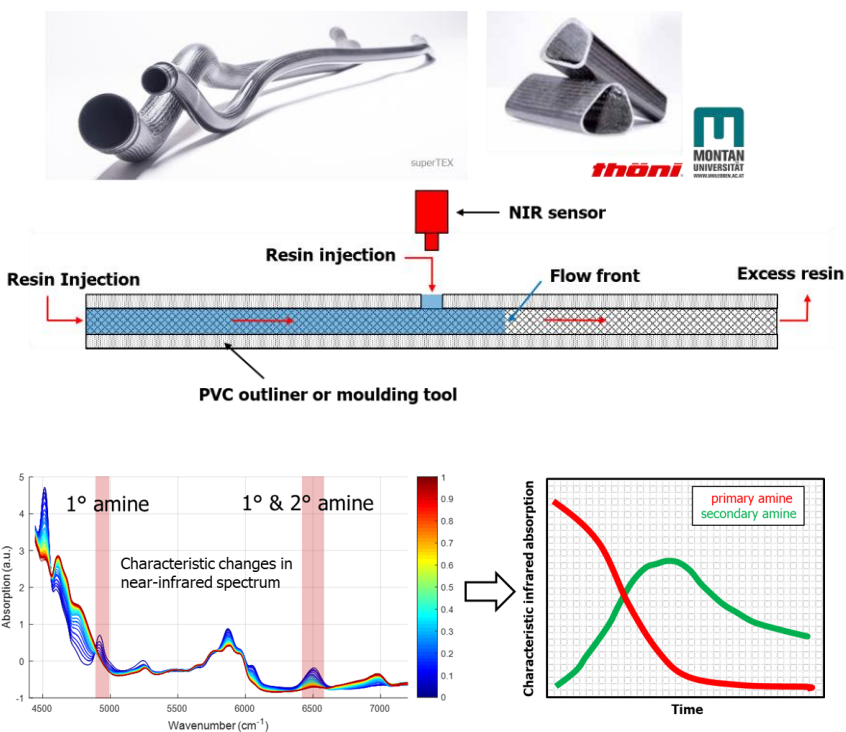
Examples for MEMS-based microspectrometers



Contribution to total error of analysis

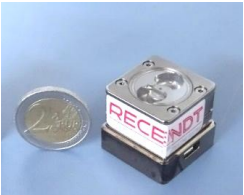


Monitoring of curing process in CFRP production



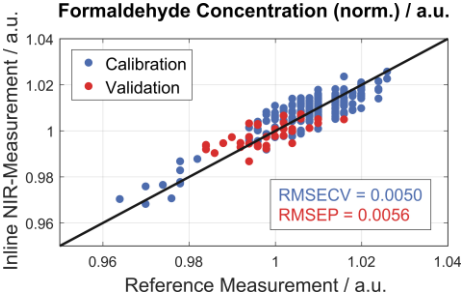
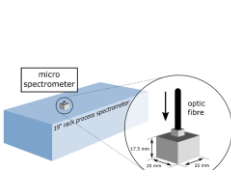
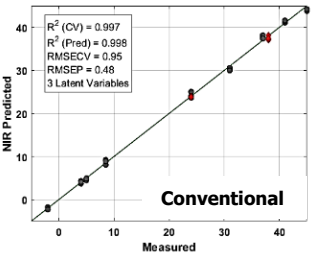
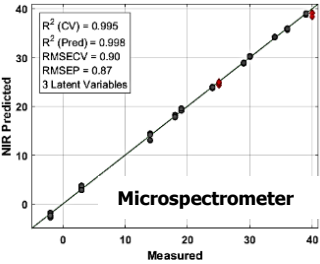
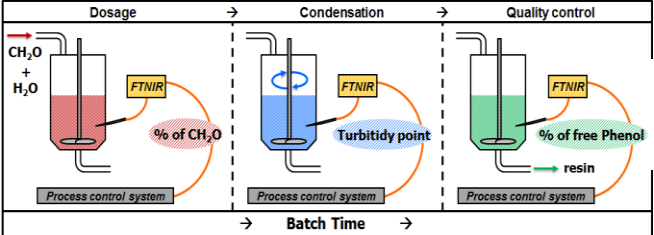
Monitoring of ...

- 1) Curing
- 2) Mixing ratio (purity)
- 3) Flow front detection

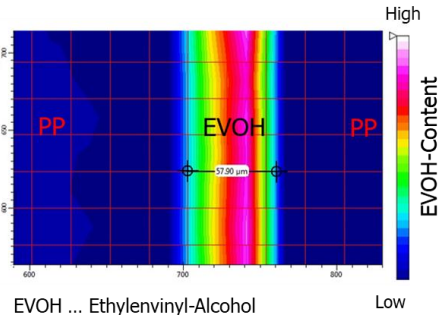
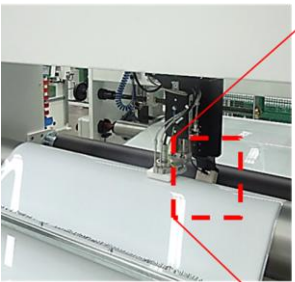


**MEMS-based
microspectrometer**

Inline process control in chemical industry (24/7)



Inline-monitoring of packaging film: oxygen barrier layer (EVOH)



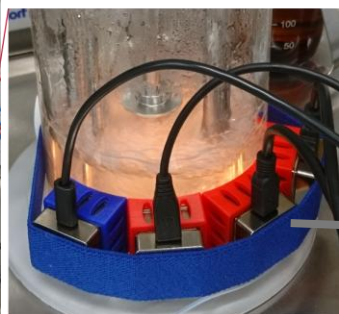
EVOH ... Ethylvinyl-Alcohol
(=Oxygen barrier layer)

PP ... Polypropylen (mechanical support layers)

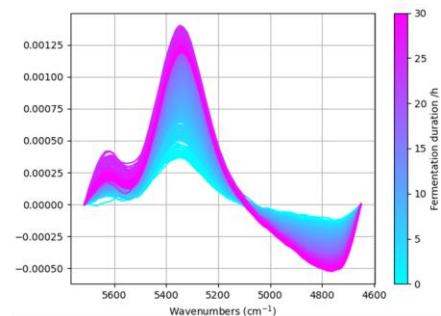
Bioprocess monitoring



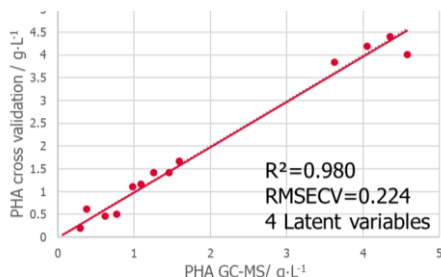
Non-invasive monitoring of a *Cupriavidus necator* fed-batch fermentation process for production of biopolymers (PHA)



WOOD
KPLUS

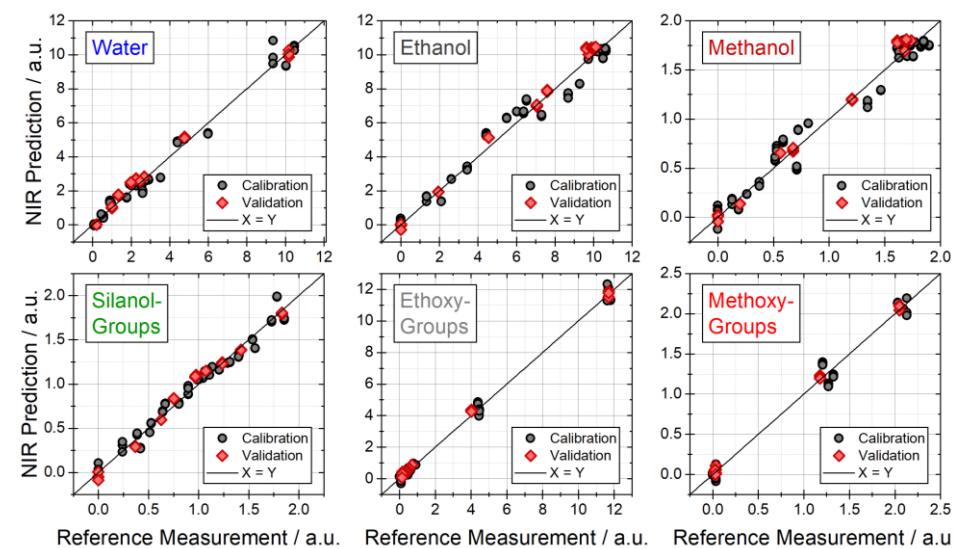


Validation of NIR spectroscopy with GC-MS reference



<https://doi.org/10.1007/s00216-019-02227-w>

Inline monitoring of a complex sol-gel reaction



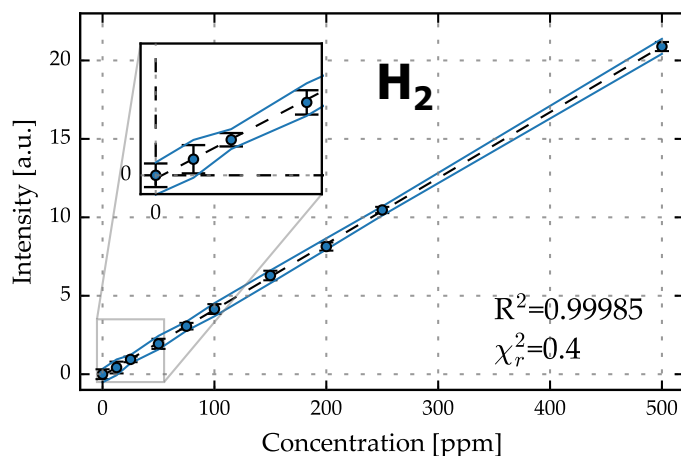
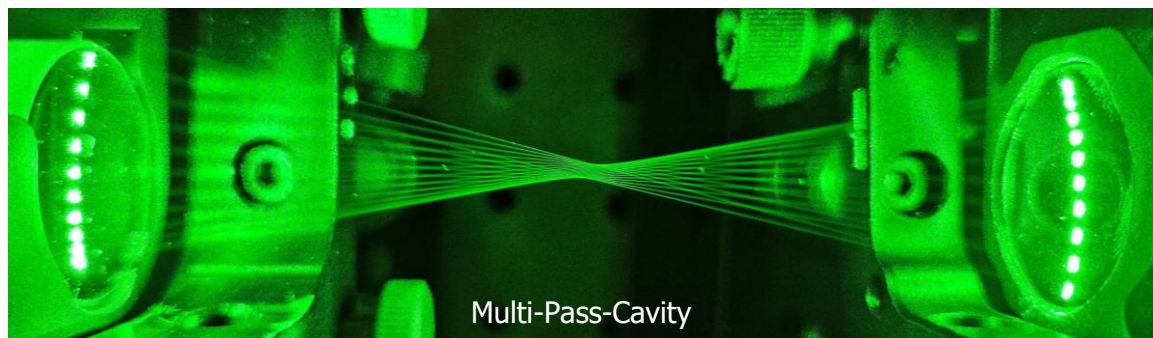
- **6 chemical entities** determined from **one spectral measurement**
- High accuracy
- Label-free, non-destructive, **NO sampling**

JYU

<https://doi.org/10.1021/acs.langmuir.3c00601>

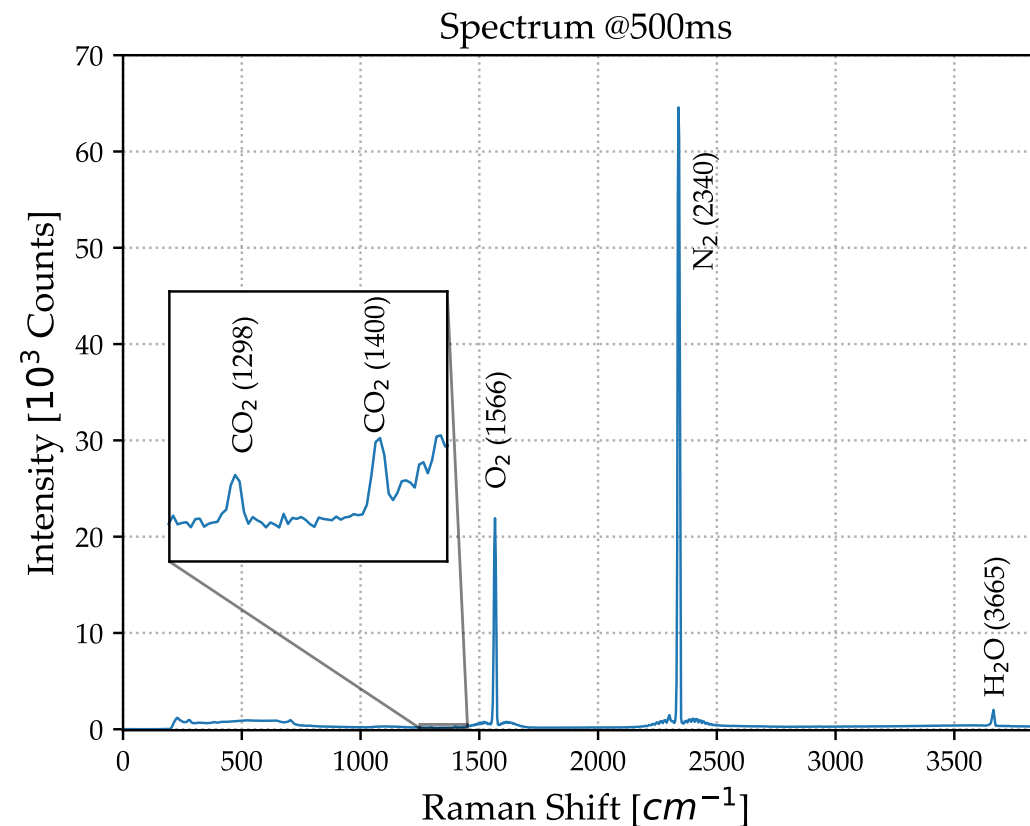
Highly sensitive multi-gas analysis

Laser-Based Mid-Infrared or Raman Spectroscopy

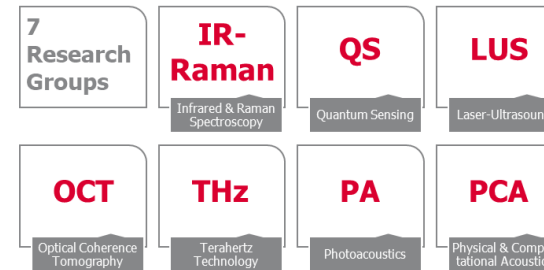


- Compact design & high sensitivity
- **Raman**: ideal for homonuclear gases (H₂, O₂, N₂, ...)
- **Fingerprint spectrum** for simultaneous detection of **multiple** gases

Achievable limits of detection for H₂, O₂, N₂:
< 10 ppm (parts per million)



- Non-destructive sensing solutions for a **wide range of applications**



- Chemical and structural information: **Bio-Nano-Med & Chemical Analytics**

(Bio-) Process Analysis
Inline Gas Analysis (Hydrogen, ...)

Quantum Sensing



24/7 Inline Process Control

Sub-Surface Analysis (Layers, Defects, ...)

Nanoscale Chemical Imaging (from clinics to semiconductor industry)

Thank you!



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Always open for collaborations!

