

PAT @BIO

Robert Holzer

Research Center for Non-Destructive Testing – RECENTT GmbH



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IEA Bioenergy Task 42
Stakeholder Vernetzungstreffen
Boku Wien

REsearch CEnter for Non-Destructive Testing – RECENDT

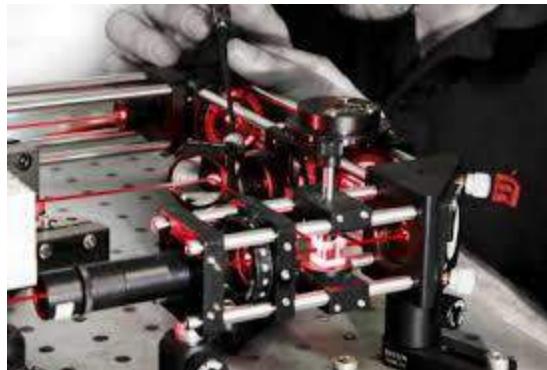
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Science Park Linz, building 2, 2nd floor



~40 employees



6 Research Groups:

- Infrared and Raman Spectroscopy
- Optical Coherence Tomography
- Terahertz Technology

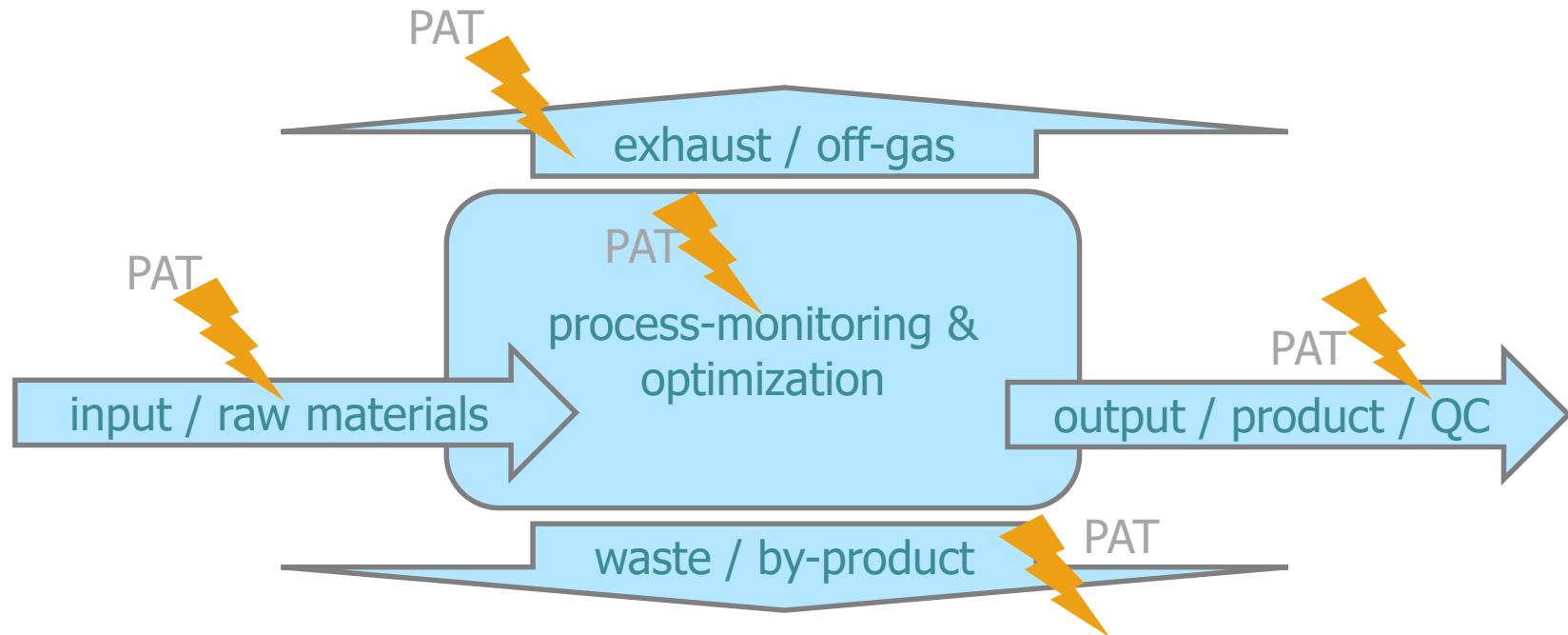
Optics

- Laser-Ultrasound
- Photoacoustics
- Physical & Computational Acoustics

Acoustics

PAT – Process Analytical Technologies
BIO – Bio-process / Bio-refinery

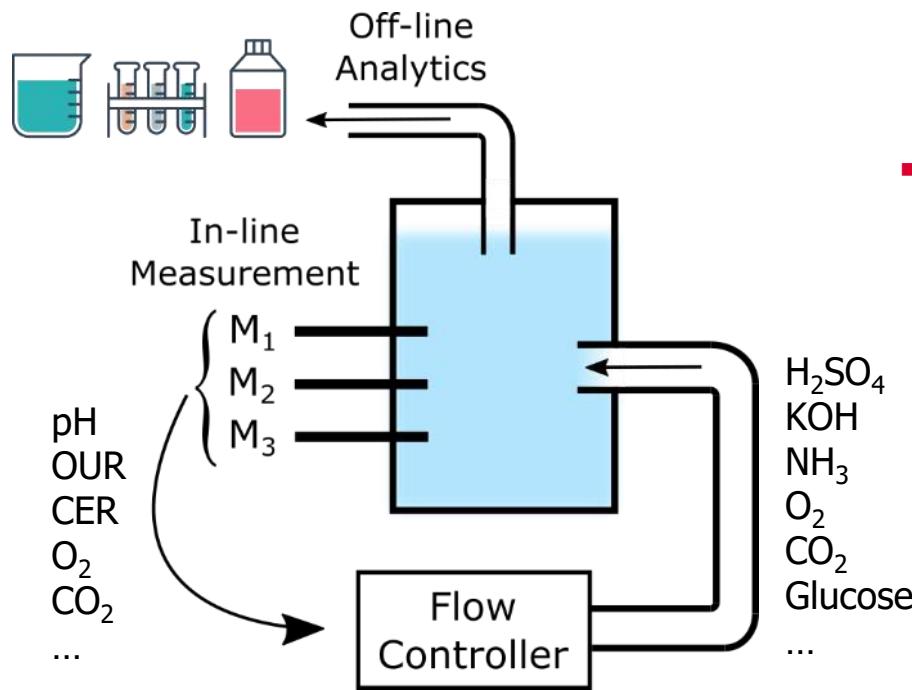
challenge: volatile raw materials
→ variabilities in the processes!



Monitoring of Bioprocesses

Common to all (bio)-processes

→ Knowledge of certain parameters during the process is crucial for **controlling** and **optimizing** process efficiency and amount & quality of the output!

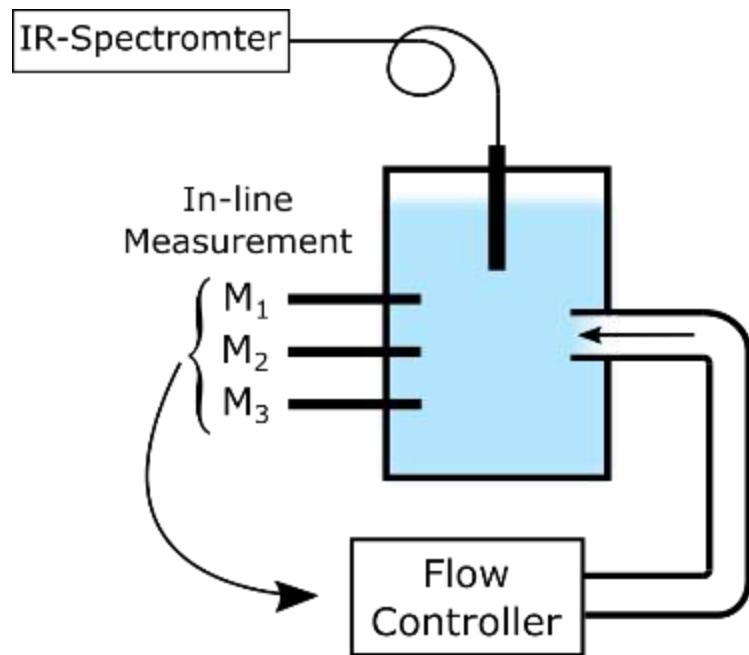


- Off-line analytics methods (GC, HPLC, enzymatic analyzation,...) have many disadvantages
 - Time consuming (typically **>30min**)
 - Invading (sample needs to be taken)
 - High-maintenance
 - Error prone

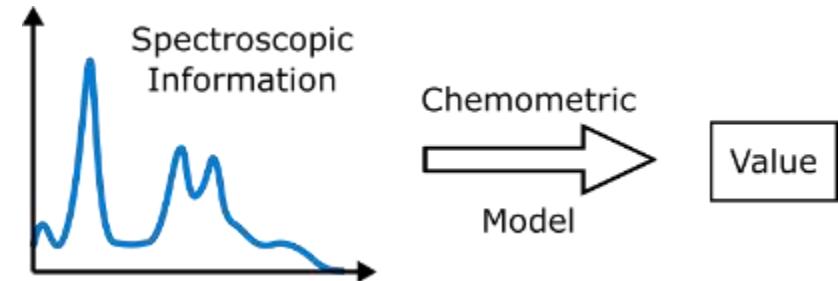
Monitoring of Bioprocesses

Spectroscopy (NIR, MIR, Raman) has already been used to monitor bioprocesses for a couple of decades

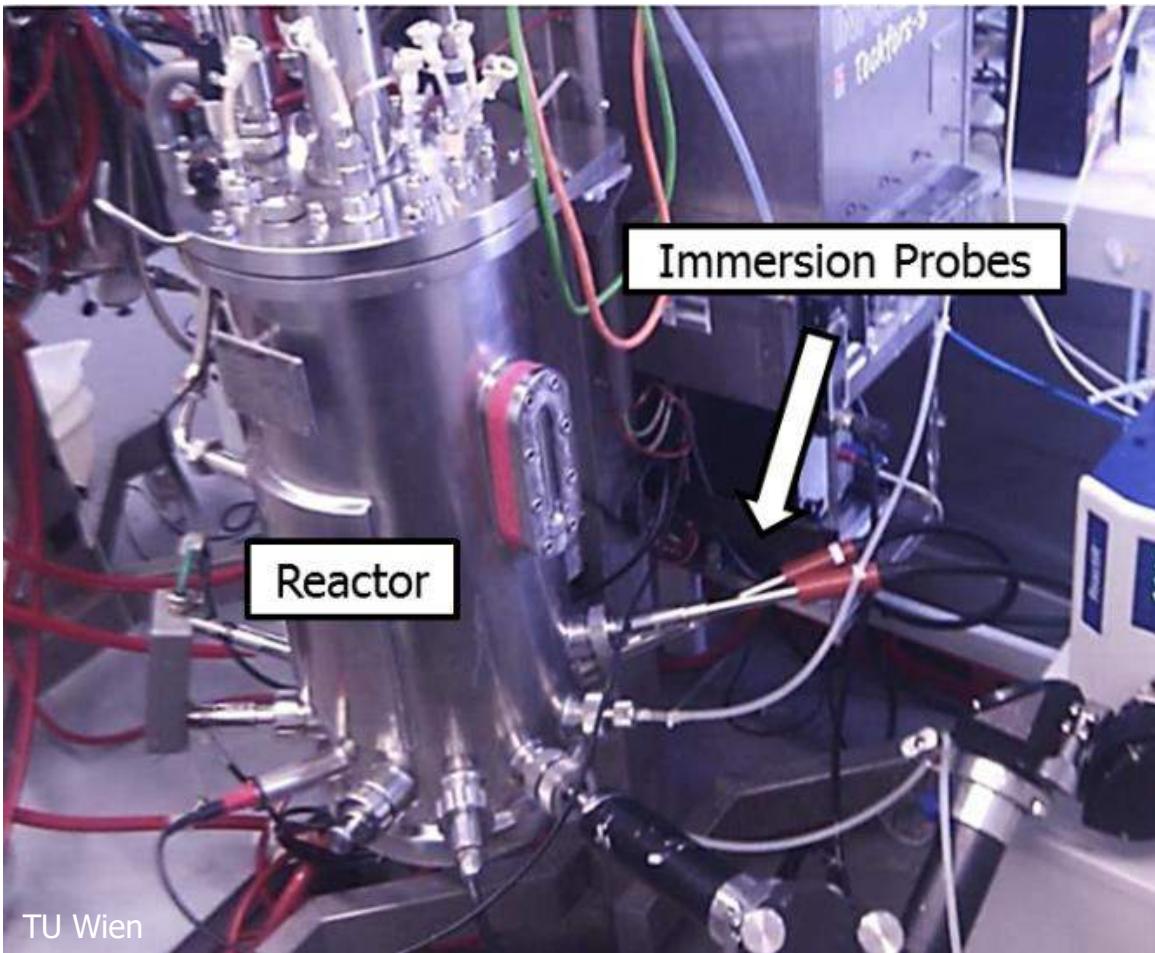
- Non-destructive, non-invading
- **Short measurement time**
- Easy maintenance



Combined with multivariate data analysis it allows **real-time in-line measurements** of certain parameters



FTNIR-Process Spectrometers

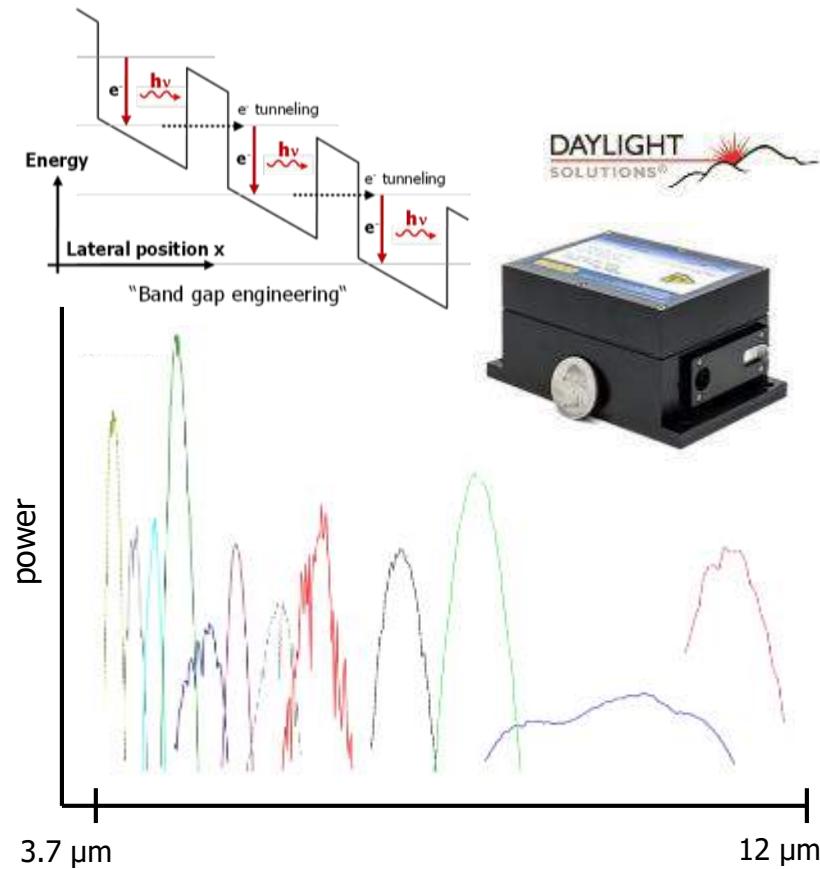


IR-Spectroscopy

- Limitations of IR spectroscopy? Yes, BUT ...
 - ... substantial (disruptive) technological progress during last decade:
 - Versatile and powerful **MIR laser sources**
 - High power
 - High spatial coherence
 - Ultra-fast modulation
 - Fully-integrated spectrometer technology
 - Miniature
 - Low cost
 - Extremely robust
 - Large number of **new optical** technologies on a component level
 - New tools for **data analysis** (e.g. hyperspectral image analysis)

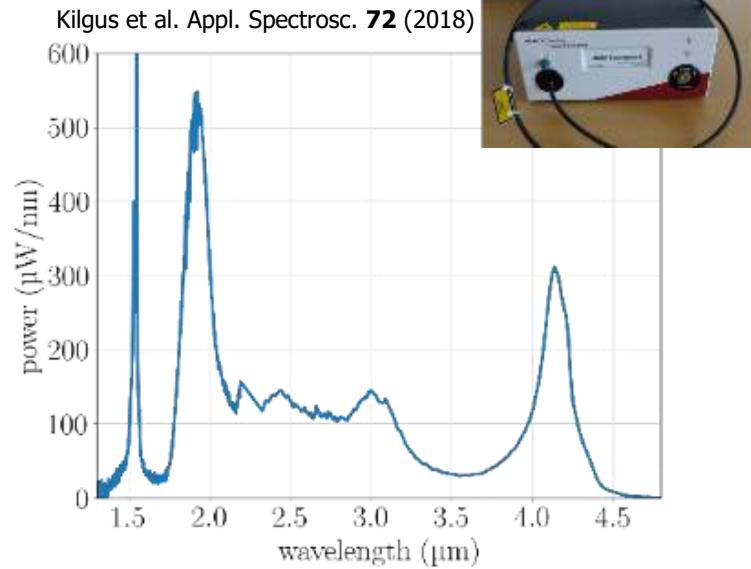
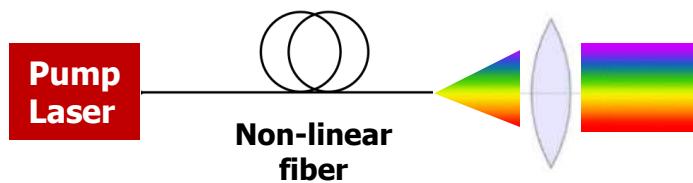
Quantum Cascade Lasers

- **Quantum Cascade Laser (QCL)**



Supercontinuum Lasers

- **Supercontinuum Laser (SCL)**



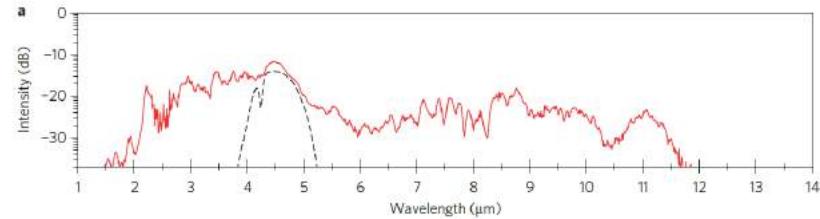
LETTERS

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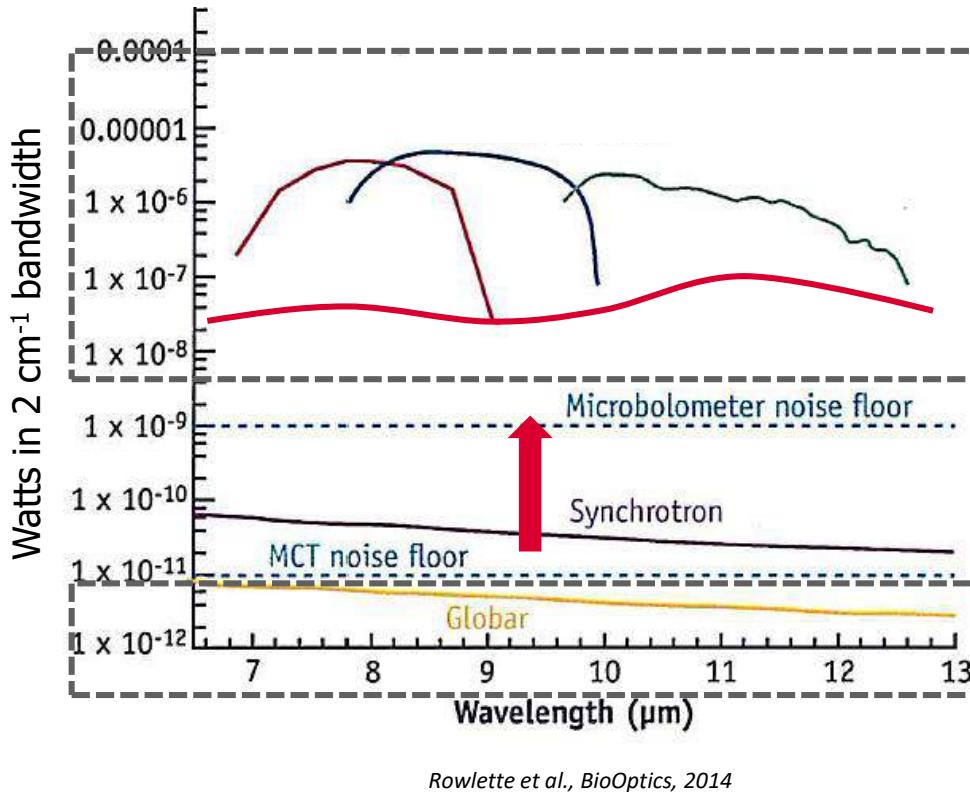
nature
photronics

Mid-infrared supercontinuum covering the
1.4–13.3 µm molecular fingerprint region using
ultra-high NA chalcogenide step-index fibre

Christian Rosenberg Petersen^{1*}, Uffe Møller¹, Irinis Kubat¹, Binbin Zhou¹, Sune Dupont²,
Jacob Ramsay², Trevor Benson², Slawomir Sujecki², Nabil Abdel-Moneim³, Zuoqi Tang³,
David Furniss³, Angela Seddon³ and Ole Bang^{1,4}



IR Laser sources



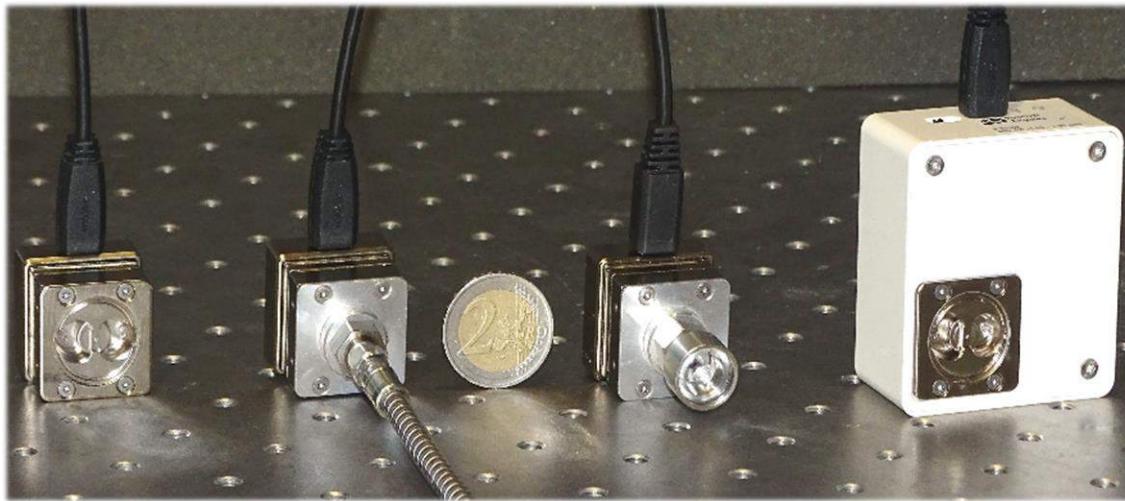
Quantum Cascade Laser (QCL)

Supercontinuum Laser (SCL)

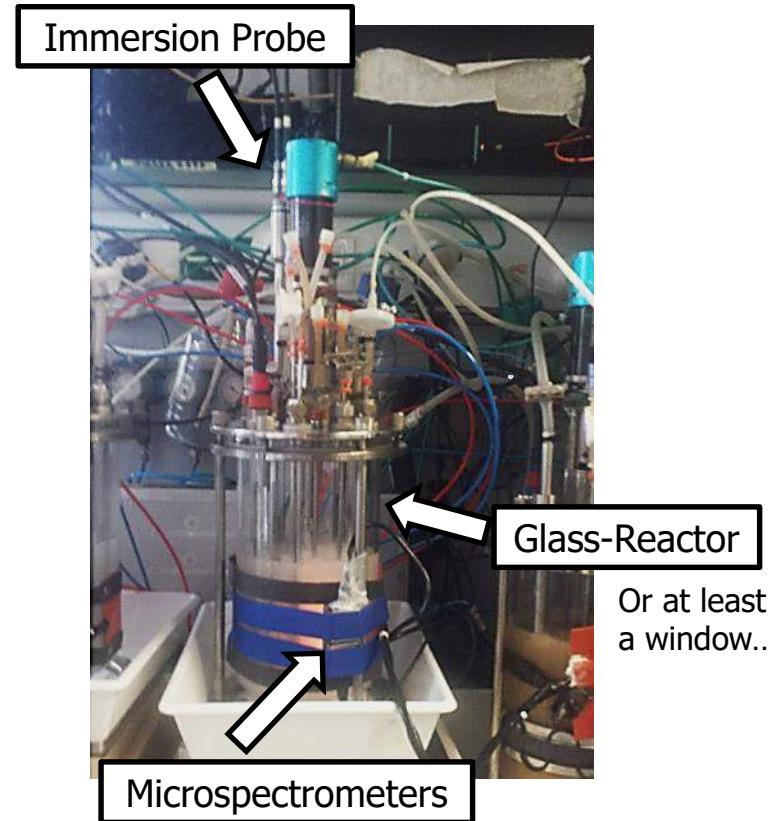
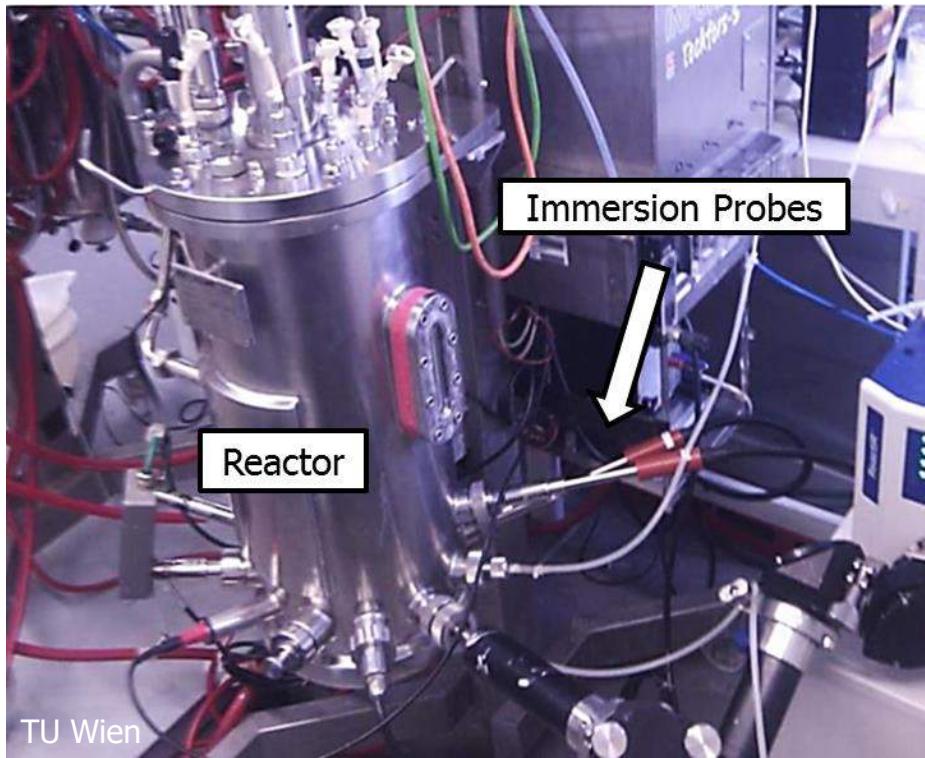
- Up to **10⁵-fold** increased spectral power density (optical power per spectral unit)
- Higher power density than **synchrotron sources**

Microspectrometers

- Microspectrometers have some obvious **advantages** compared to process spectrometers
 - Smaller size (only 25 x 25 x 17.5 mm³)
 - Lower-costs (2k€ vs. > 40k€)
 - Robustness (no moving parts)
- Limitations:
 - Smaller wavelength range (1.35 – 2.45 µm range is covered by 4 devices)
 - Lower resolution (about 14 – 30 nm FWHM depending on the wavelength)

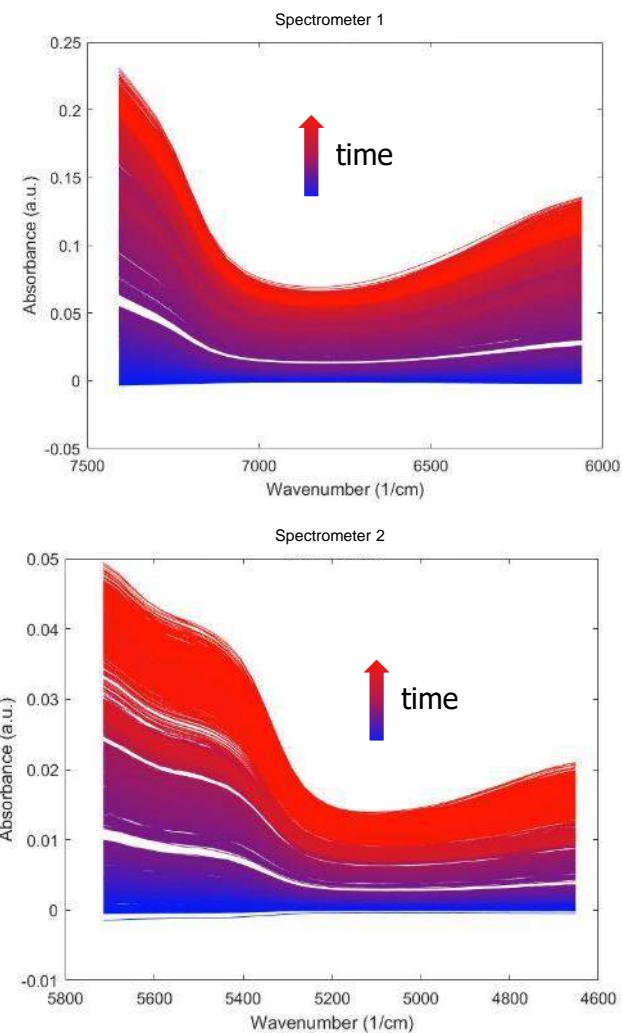
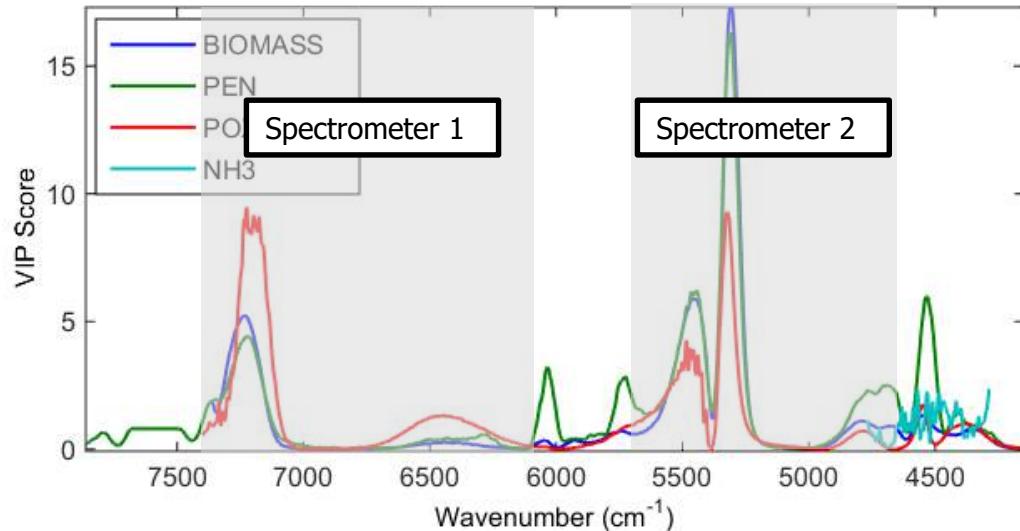


Bioprocess Monitoring



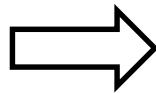
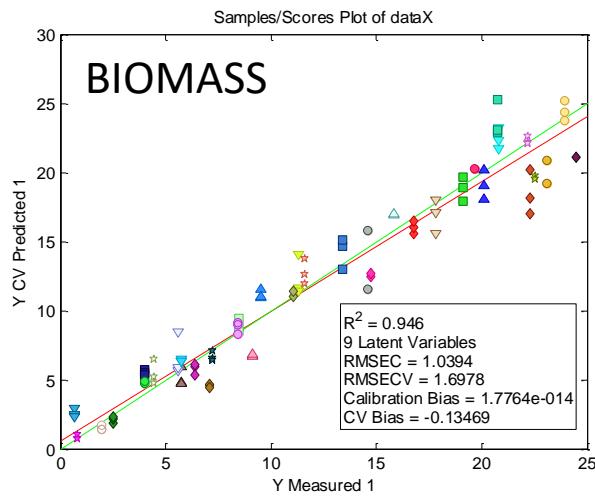
<https://doi.org/10.1007/s00216-019-02227-w>

Bioprocess Monitoring

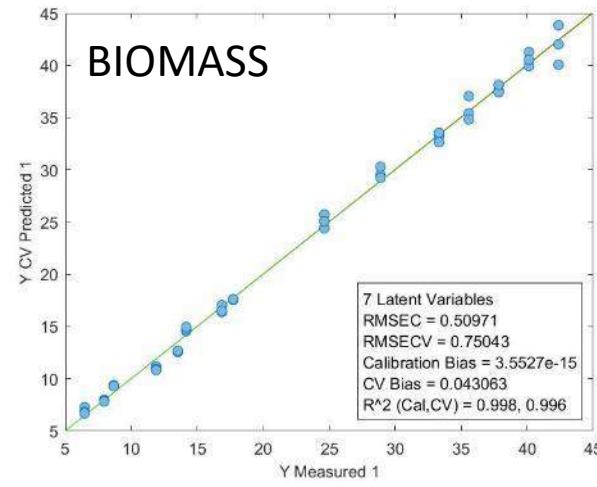


Biomass and Penicillin (PEN)

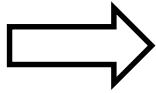
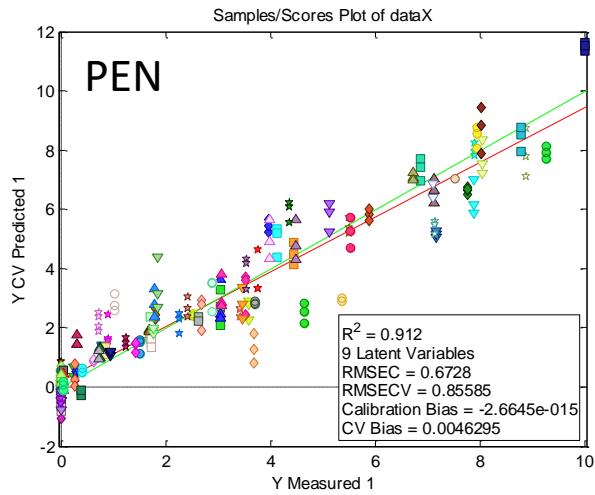
old



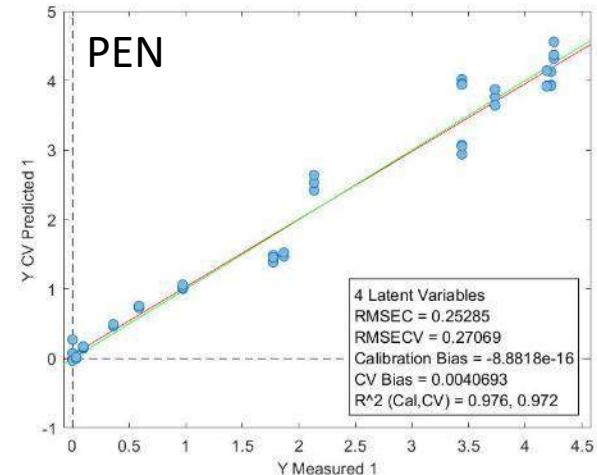
new



old



new



Latest PAT-collaboration



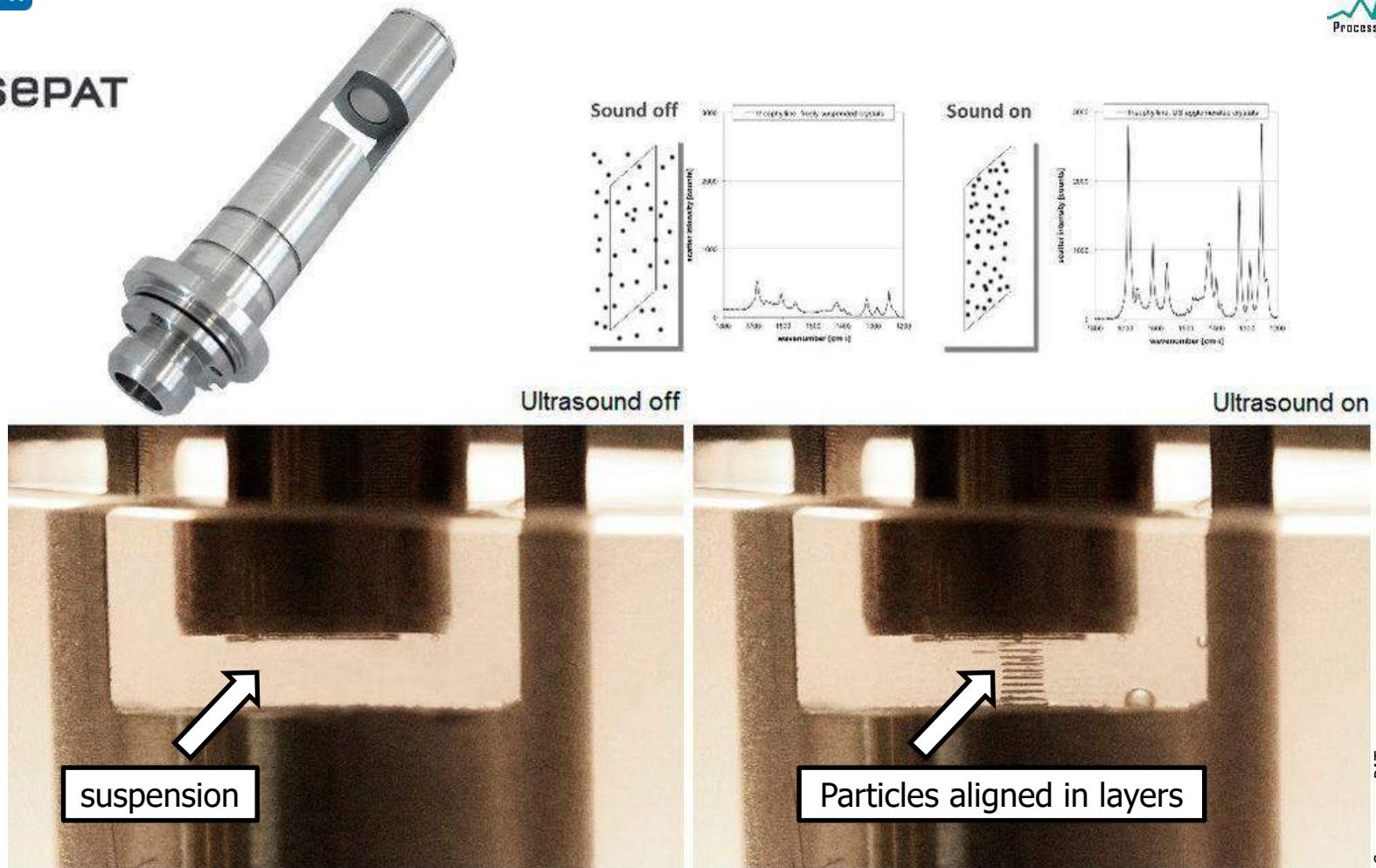
CHASE is the Austrian competence center connecting interdisciplinary domain knowledge from chemistry, (bio)process engineering, material and software sciences to transform the process industry by engineering chemical systems.

<https://chasecenter.at/>

Particle manipulation



usePAT



Publication

Probe-less non-invasive near-infrared spectroscopic bioprocess monitoring using microspectrometer technology

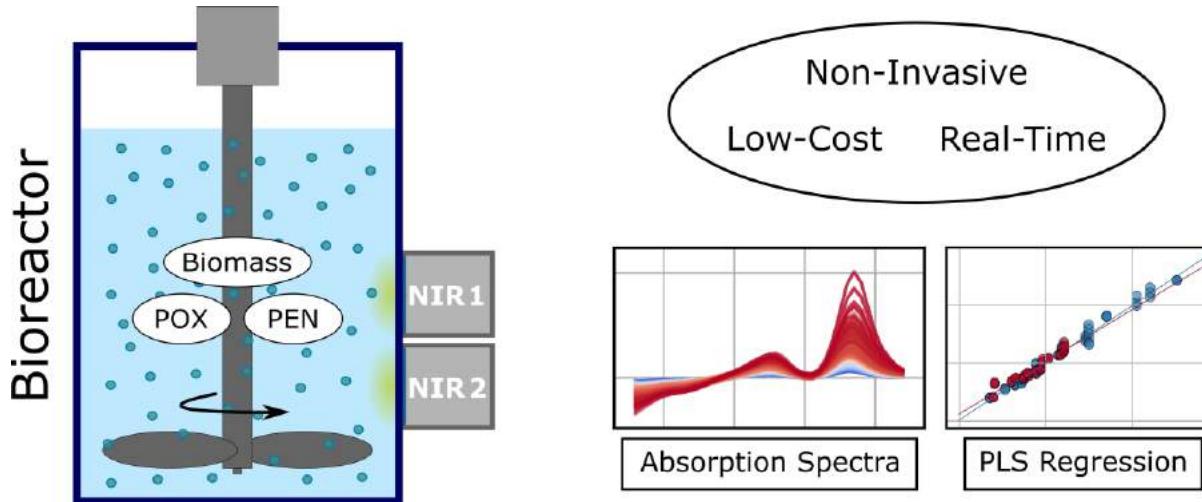
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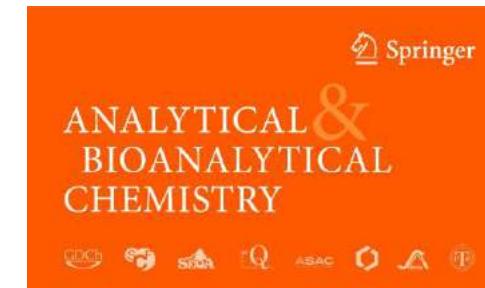
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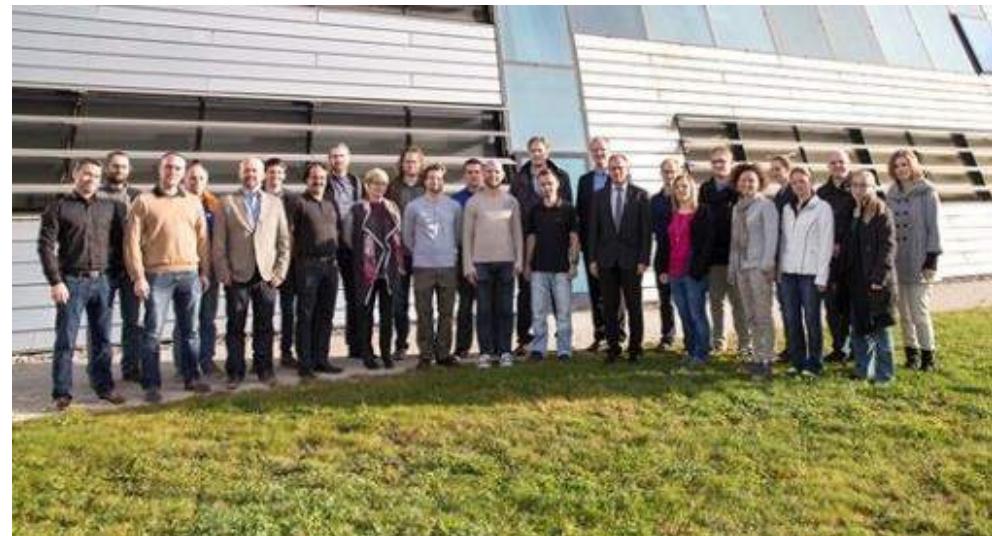
<https://doi.org/10.1007/s00216-019-02227-w>



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RESEARCH CENTER NON DESTRUCTIVE TESTING

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