SensoRein

Technische Universität Braunschweig

Fraunhofer

VDMA

Nahrungsmittelmaschinen und Verpackungsmaschinen

Gefördert durch

Bundesministerium für Ernährung und Landwirtschaft

aufgrund eines Beschlusses des Deutschen Bundestages

Projektträger

Bundesanstalt für Landwirtschaft und Ernährung

Supervised cleaning-in-place processes enabled by a fiber-optical fluorescence sensor

Vivien Behrendt, Dr. Alexander Blättermann, Dr.-Ing. Albrecht Brandenburg
Fraunhofer IPM, Freiburg

Outline

Background
- Motivation
- Measurement technique

Setup
- Sensor
- Measurements

Results
- Cleaning of various food soils
- Reference measurement
- Monitoring a real CIP

Summary

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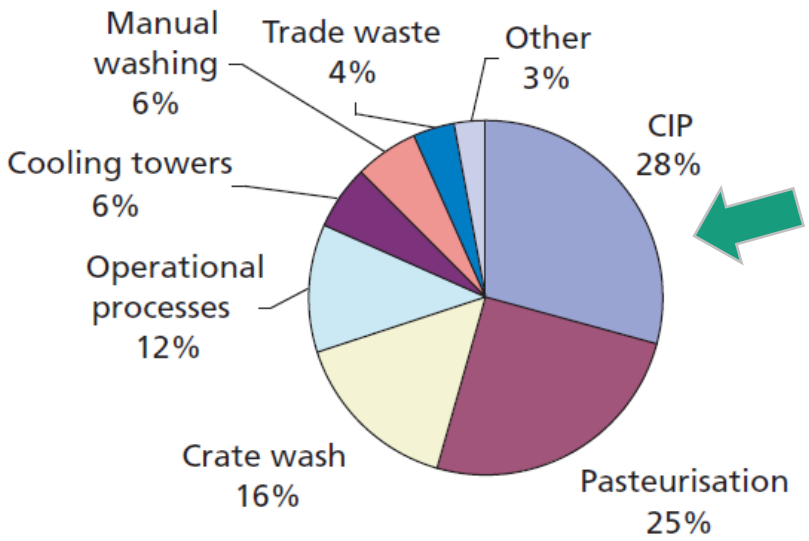
Background
Motivation



Water usage of a market milk processor [1]

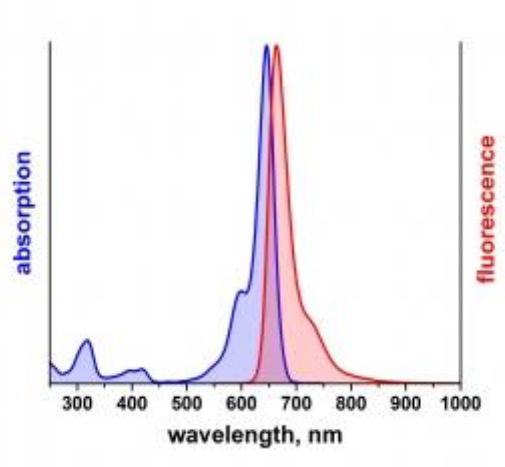
- CIP processes are often designed for **worst case scenario**
- Huge potential to **save resources**
  - Time
  - Water
  - Energy
  - Cleaning detergents
- Knowledge on the **state of cleanliness** required
- Current methods use indirect measures: pressure drop, heat flux, …

[1] Prasad, P et al. (2005): Eco-efficiency for the dairy processing industry. http://www.eleche.com.uy/media2/design/style000001/00000000030000001438.pdf, 25.02.2022.

Background

Measurement technique

Fluorescence

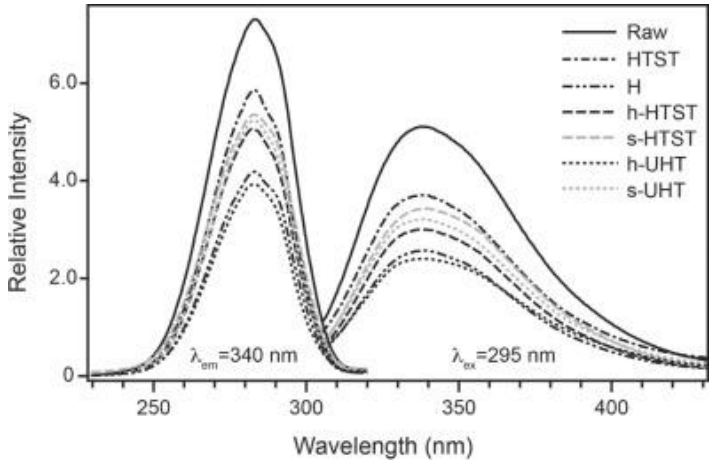


Fluorescence spectra of fluorescent dye ATTO 647[1]

- Spontaneous emission after excitation
- Short lifetime of excited states
- Many imaging systems use dyes

[1] https://www.atto-tec.com/ATTO-647N.html, visited 21.03.2022

Fluorescence in food

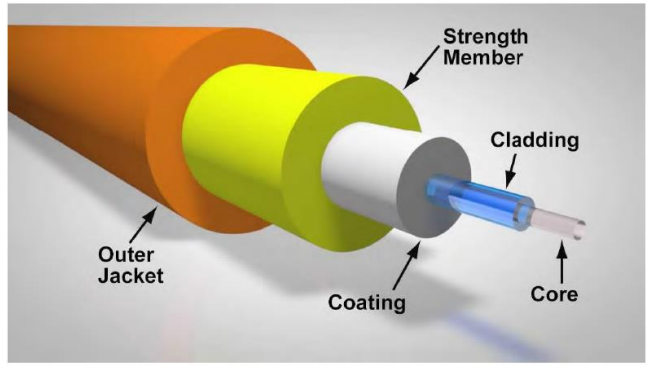


Fluorescence spectra of Trp [2] for various methods of milk pasteurization [3]

- Organic materials are typically fluorescent, in particular oils
- Foods as e.g. meat, fish and cheese are fluorescent [4]

[2] Tryptophan, most abundand fluorescent amino acid in whey protein
[3] Qi, Phoebe X. et al. (2015): Effect of homogenization and pasteurization on the structure and stability of whey protein in milk. In: Journal of dairy science 98 (5)
[4] Whitehead, Kathryn A. et al. (2008): The detection of food soils and cells on stainless steel using industrial methods: UV illumination and ATP bioluminescence. In: International journal of food microbiology 127 (1-2)

Fiber optic sensors



Scetch of an optical fiber [5]

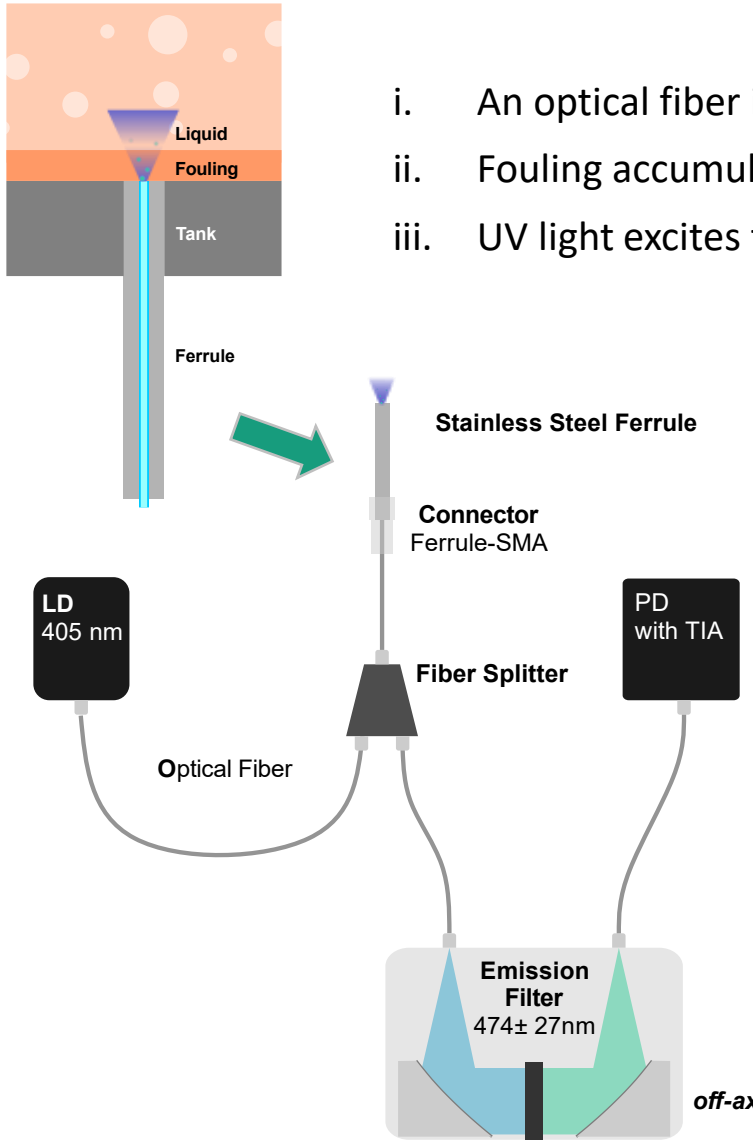
Fields of use:
- Measurement of e.g. strain, temperature, pressure
- Lightguide

Benefits:
- Easy integration
- Not conducting
- Lightweight, robust

[5] https://engineer-educators.com/topic/basic-structure-of-an-optical-fiber/

Setup

Sensor



i. An optical fiber is integrated into the tank wall

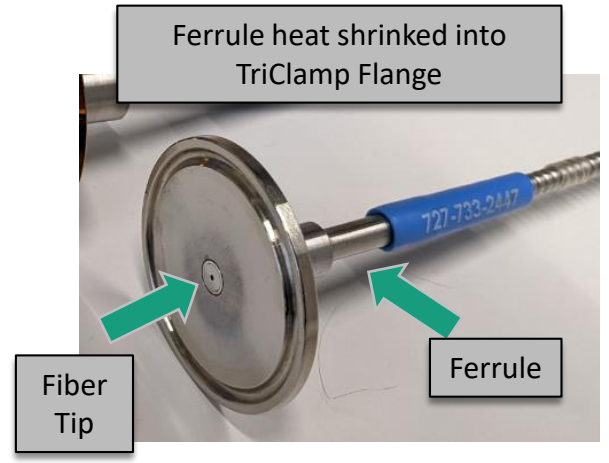
ii. Fouling accumulates on top of the sensor

iii. UV light excites the fluorescence of the fouling

iv. Fluorescence is guided to detection unit via fiber system

v. Detection after optical filtering

vi. The fluorescence signal indicates the state of cleanliness



Benefits:

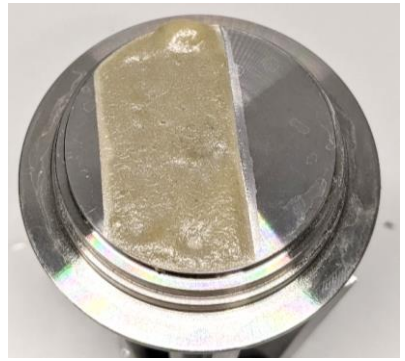
- Fluorescence principle is applicable to many food soils
- Fiber optical system makes optical alignment robust
- Tiny fiber tip (Ø 1 mm) causes no perturbation of fouling/cleaning processes and is easy to integrate
- Low price

Setup

Measurements

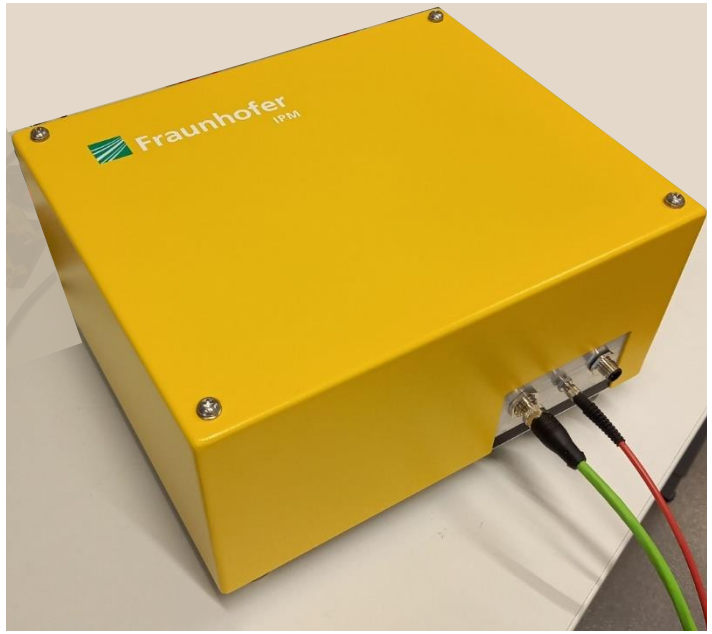
Preparation of a sample:

- Sensor head is heated
- Soil is evenly applied to sensor head
- Baked for several minutes



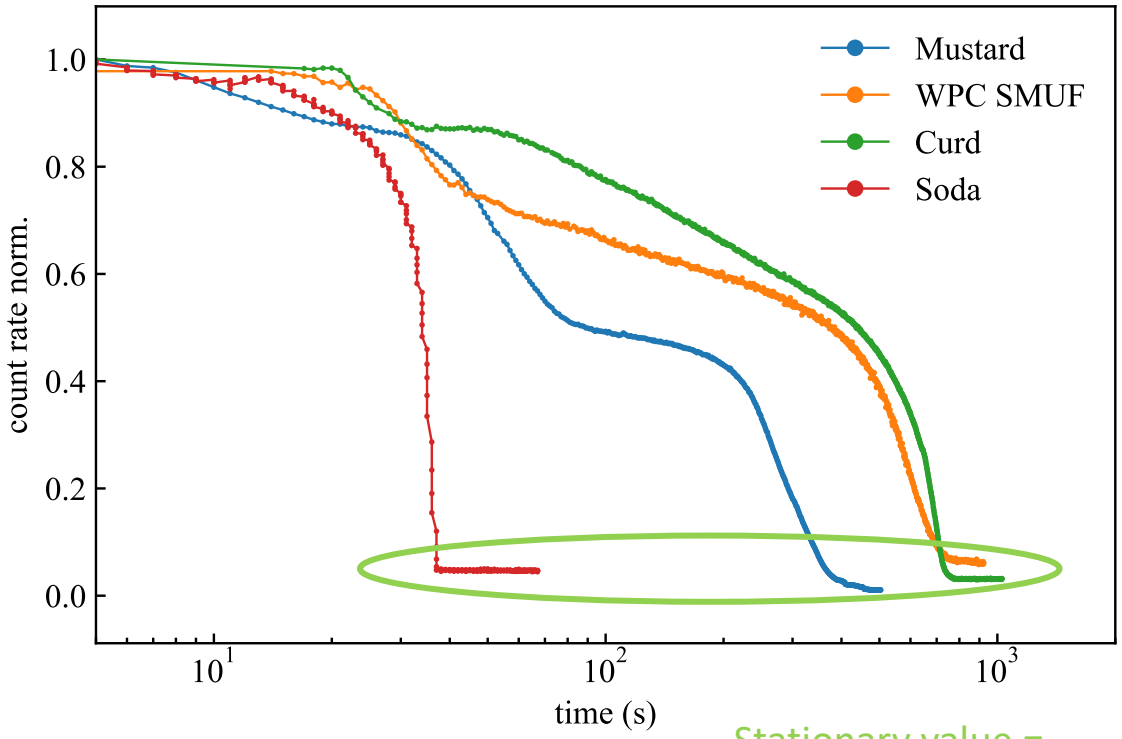
Cleaning process:

- *Either*: Sensor placed in glas of whirling water
- *Or:* CIP with alkali in a small-scale cleaning systems
- Monitoring real time: pulsed measurement

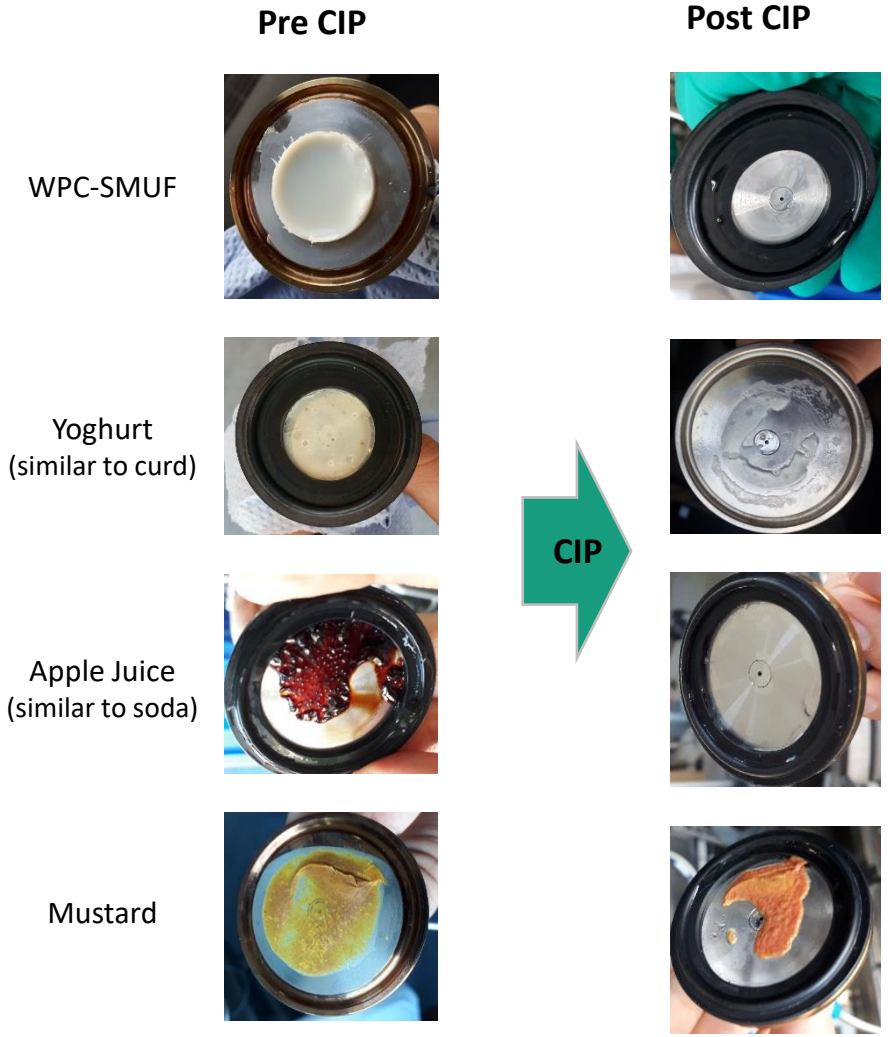


Results

Cleaning of various food soils



Stationary value = Clean sensor

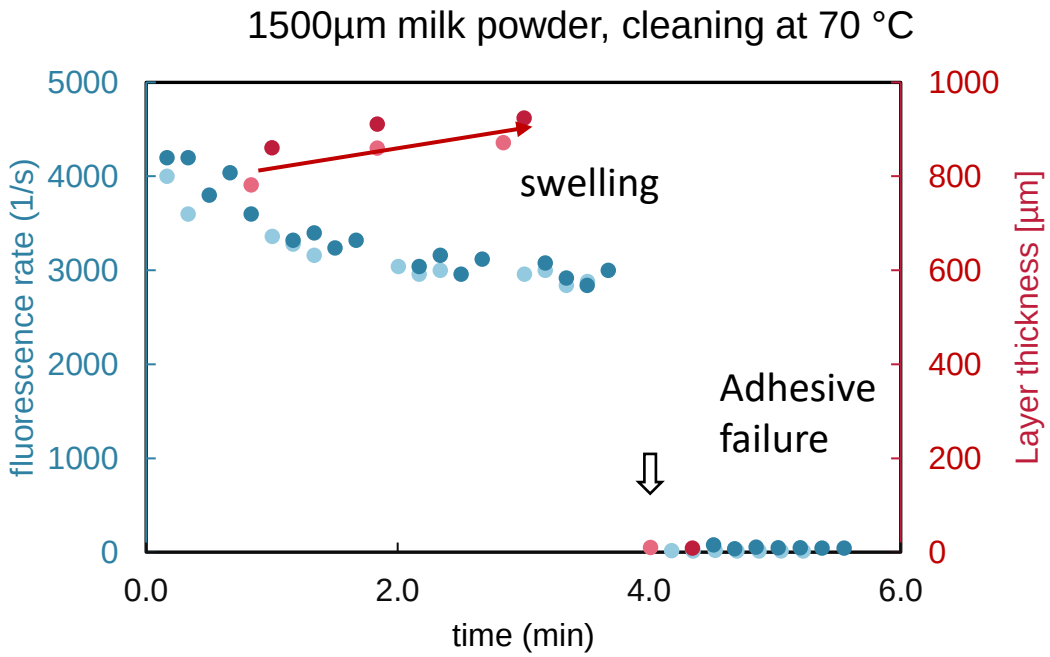


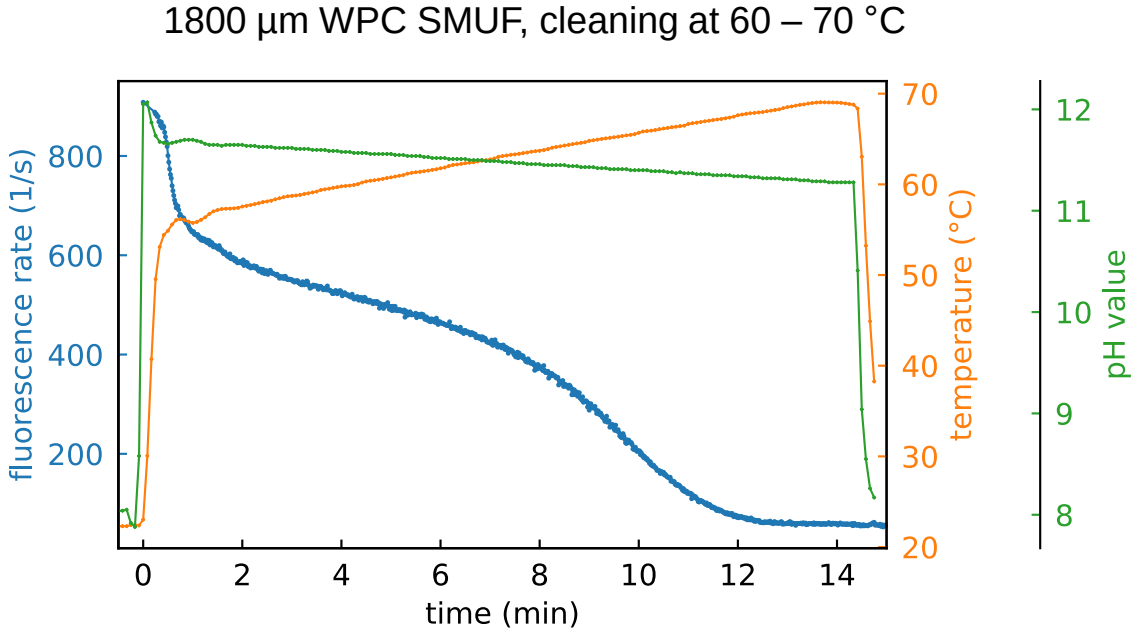
- **Reference soils**: WPC SMUF, tomato paste, starch
- **Other soils**: yoghurt, curd, milk powder, mustard, ketchup, apple juice, soda, yeast
- **Clean sensor** is detectable for **all soils**

Diversey Germany, Mannheim

Results

Reference measurements & signal dependence on CIP factors





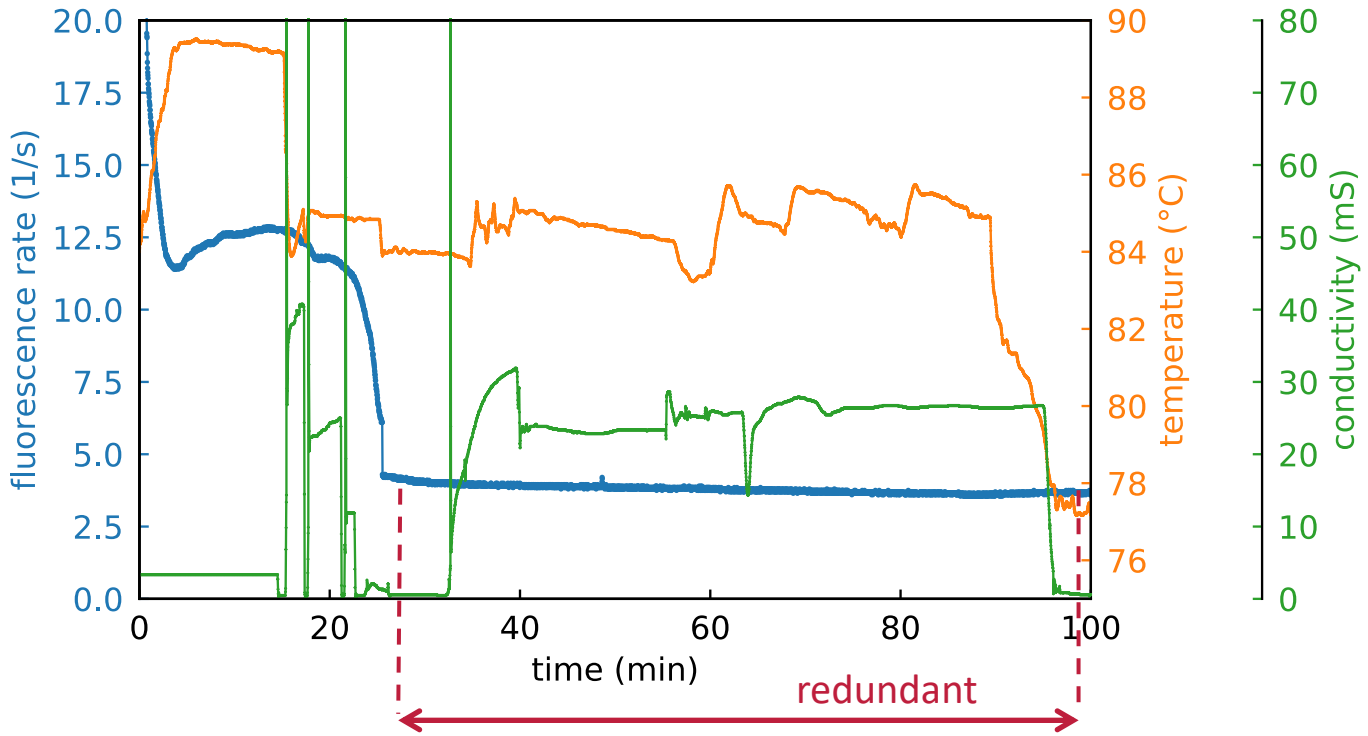
- **Reference**: simultaneous determination of layer thickness using a microscope
- **Swelling** effect increases layer thickness
- **Tear off simultaneous**

- Drop correlates with rise of temperature and pH value
- **Fluorescence** monitors **other processes** (photobleaching, temperature, pH value, chemical reactions …)

Diversey Germany, Mannheim
TU Braunschweig

Results

Monitoring a real CIP



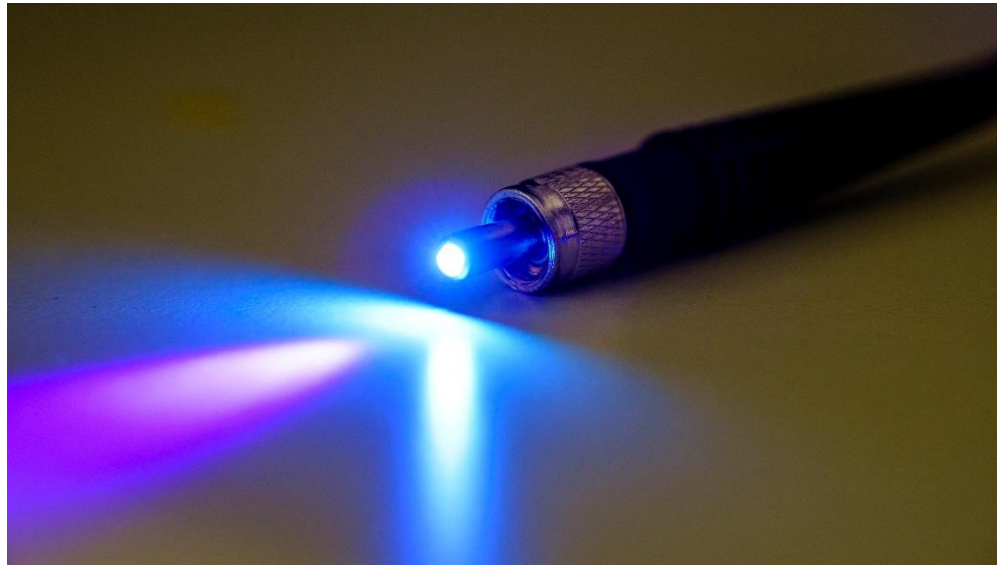
- **Soil:** baked yeast (worst case soiling)
- **CIP:** 90 min with alkali (~ 85°C, ~30 mS)
- Constant fluorescence after 30 min
- **60 min redundant CIP**
- Clean sensor signal independent of CIP

Great potential to save resources

Brewery school, Munich

Summary

- **Versatile sensor**
  - applicable to many soil types
  - Simple and small design
  - Applicable in production conditions
  - Low cost
  - Real time measurement
- Demonstrated **good performance**
  - High sensitivity
  - Reliable detection of clean state
- First impressions on the extend of possible CIP improvement



Future:

- Project finished
- Further development with partner from industry
- Publications

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Thank you very much!

Questions are welcome

vivien.behrendt@ipm.fraunhofer.de