[1]Institute of Microstructure Technology (IMT)
bastian.rapp@kit.edu
[2]Institute of Functional Interfaces (IFG)
thomas.schwartz.@kit.edu

Impedimetric sensor cell for monitoring biofilm growth

Martina Adamek[2], Kai Sachsenheimer[1], Thomas Schwartz[2], Bastian E. Rapp[1]

Objectives

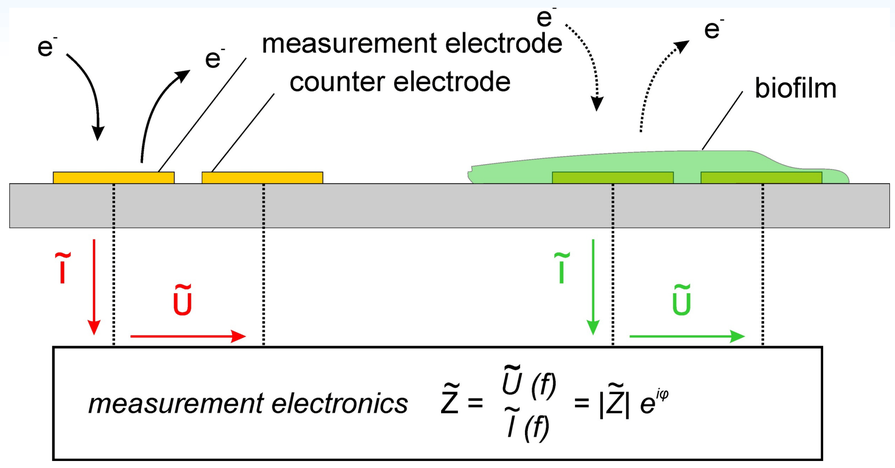
Recently electrical impedance spectroscopy (EIS) has been studied as method for monitoring biofilm growth [1]. In EIS, the change of the surface impedance is measured as a result of a biofilm deposition. We have developed an EIS based measurement cell, that consists of a polymer microfluidic flow cell with electrodes and a custom-built measurement electronics.

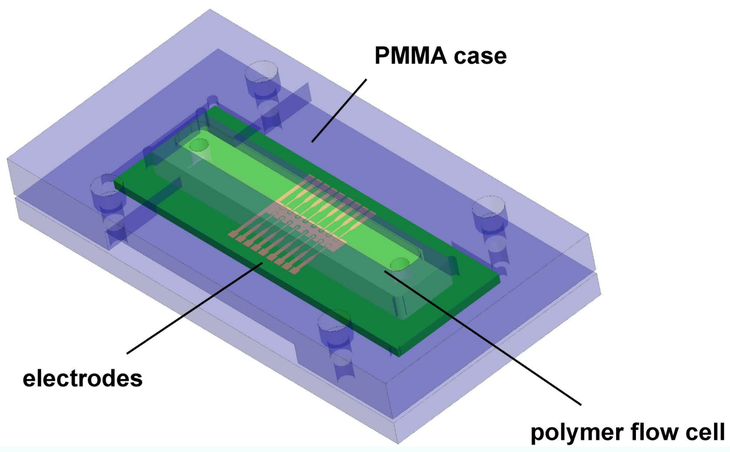
With the given setup we have been able to successfully monitor the growth of a pure culture bacterial biofilm. Future work is aiming at fast monitoring of complex matrices, such as surveillance of drinking water systems or critical points in hospital environment.

Dielectric spectroscopy / Impedance spectroscopy

Basic setup

- Measurement of the dielectric and the ohmic resistance of a surface by means of a charge transfer.
- Commonly used: 3 electrode setup (working, counter and reference electrode).



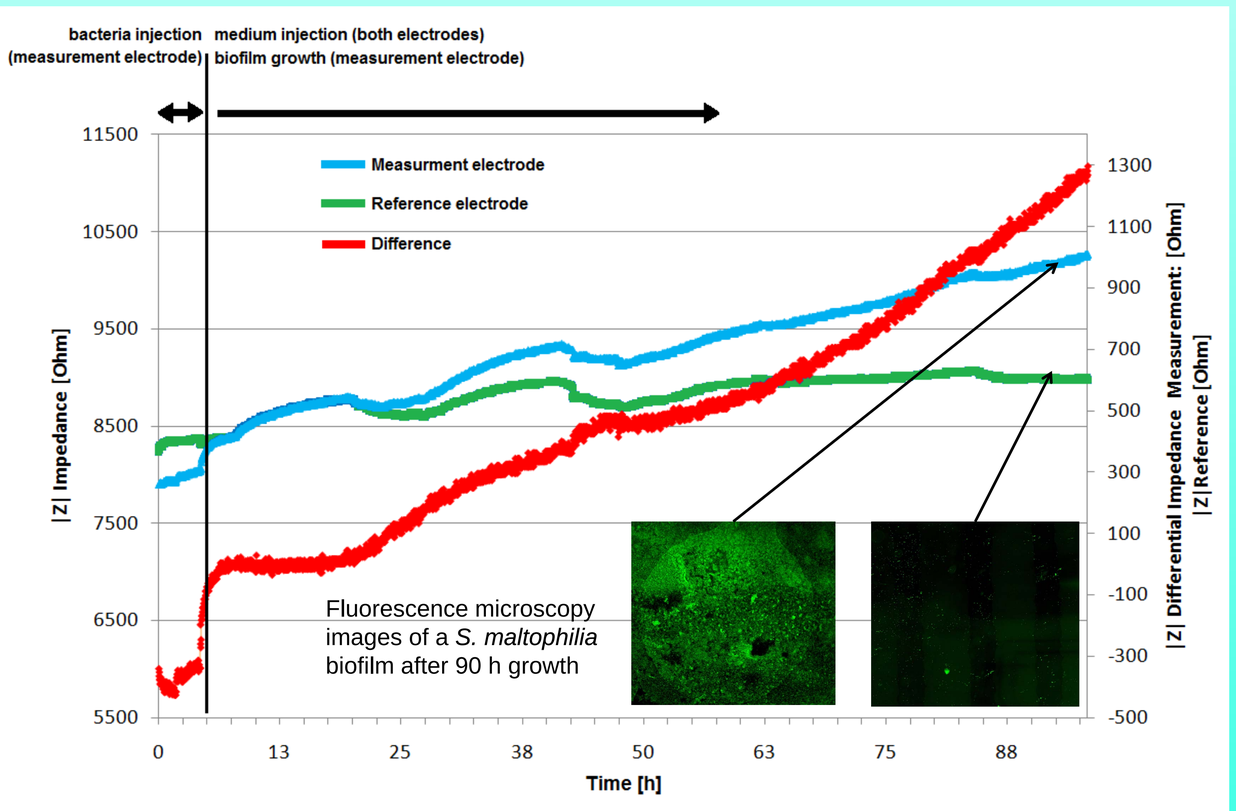


Measurement principle

- probing an electrode setup with a voltage of variable frequency (working electrode →U_0 * sin (ωt), reference electrode →earth
- measure the current as a function of time: I_0 * sin (ωt + φ)
- calculate complex impedance as |Z| * $e^{j*\varphi}$
- monitor |Z|, Re(Z) and Im(Z) as functions over time

Biofilm growth measured as impedance increase

Pseudomonas aeruignosa PA14 and *Stenotrophomonas maltophilia* NA16 were used in the biofilm experiments.
Bacterial cultures with an OD_{600} (optical density at 600 nm) of 0.5 were used as inoculi for the measurement electrode microfluidic system. In parallel, the reference electrode was rinsed with sterile broth (BHI diluted 1:4 with dH_2O). The bacterial suspension was removed from the measurement electrode system after 3 hours and both flow chambers were rinsed with growth medium. To control time dependent biofilm formation besides impedance measurements, the biofilms were stained with SYTO 9 for microscopy analysis. Similar to the measurement electrode the reference electrode was also controlled in that way.



The surface impedance increases as a result of the biofilm formation.

- Different electrode geometries will result in different sensitivities.
- Biofilm growth can be monitored already after 4 hours via impedance measurements, these findings were confirmed by imaging analysis.
- One advantage of the system is the high variability regarding the geometry and number of electrodes.

Next improvements are aiming at monitoring the very early stage of biofilm growth.

[1] J. J. Goncalves and R. Govind (2009) Rapid evaluation of biofilm attachment promoters and biofilm growth orientation using a mini-impedimetric device", *Sens. Actuators* B143,