

Biofilm Oxygen Profiling using a Microelectrode Array on a Microfabricated Needle

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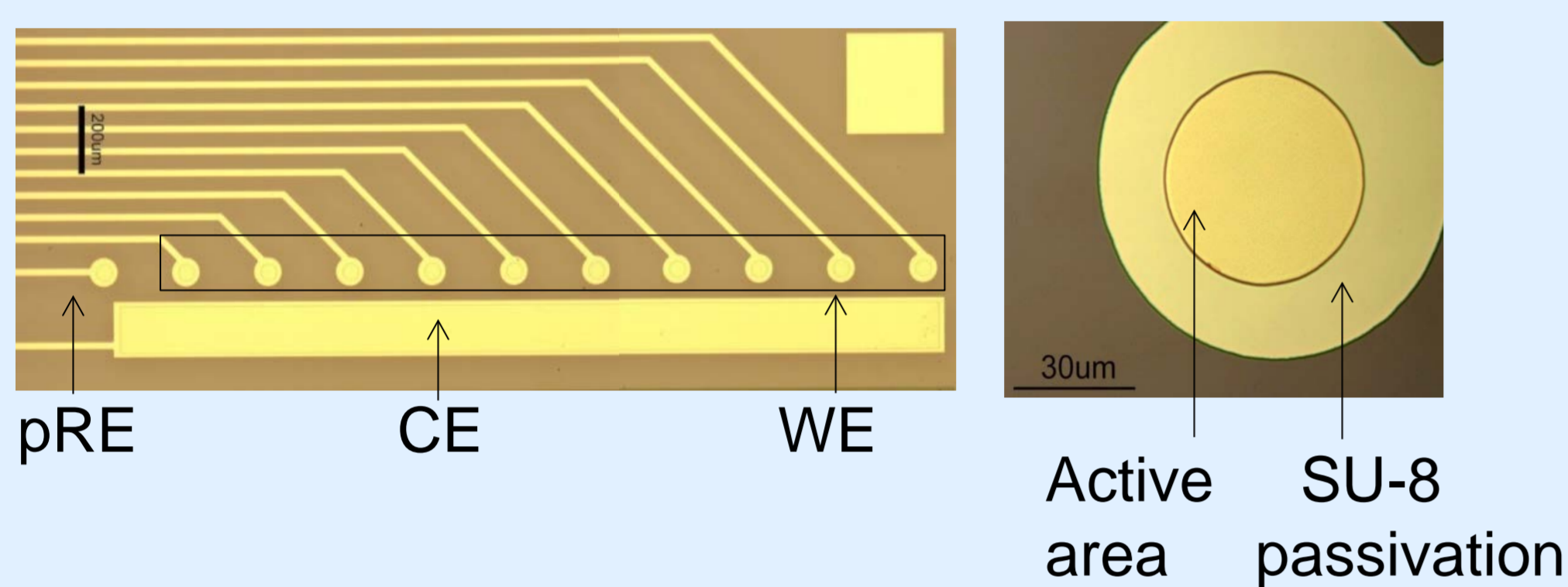
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Introduction

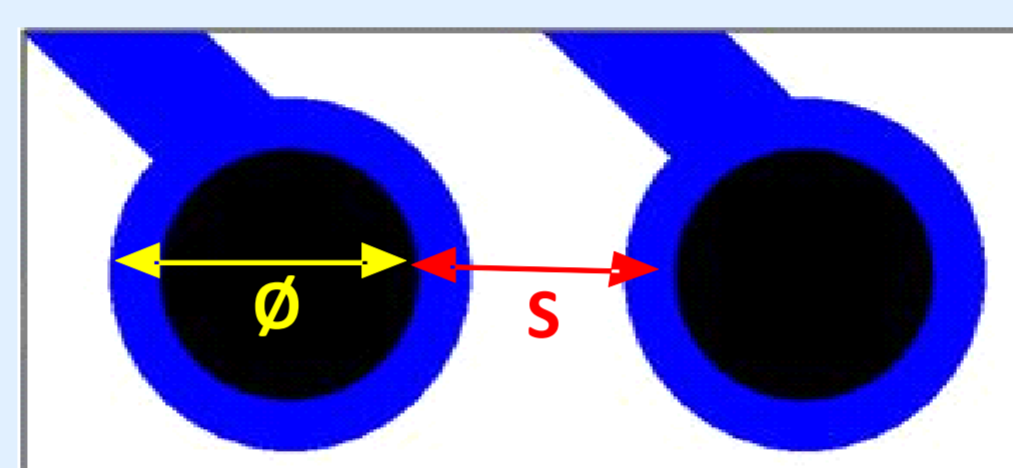
- A novel **Dissolved Oxygen MicroElectrode Array (DO-MEA)** sensor has been designed and fabricated using microelectromechanical systems technology on a needle for real time measurement of dissolved oxygen applied in a **biofilm profile** measurement.
- DO-MEA overcomes the limitations presented by Clark-type microsensors by profiling the levels of DO in an heterotrophic biofilm with **simultaneous, real-time** and **multipoint** measurements.

DO-MEA Fabrication

10 Working Electrodes (WE),
1 pseudo-reference (pRE), 1 Counter Electrode (CE)



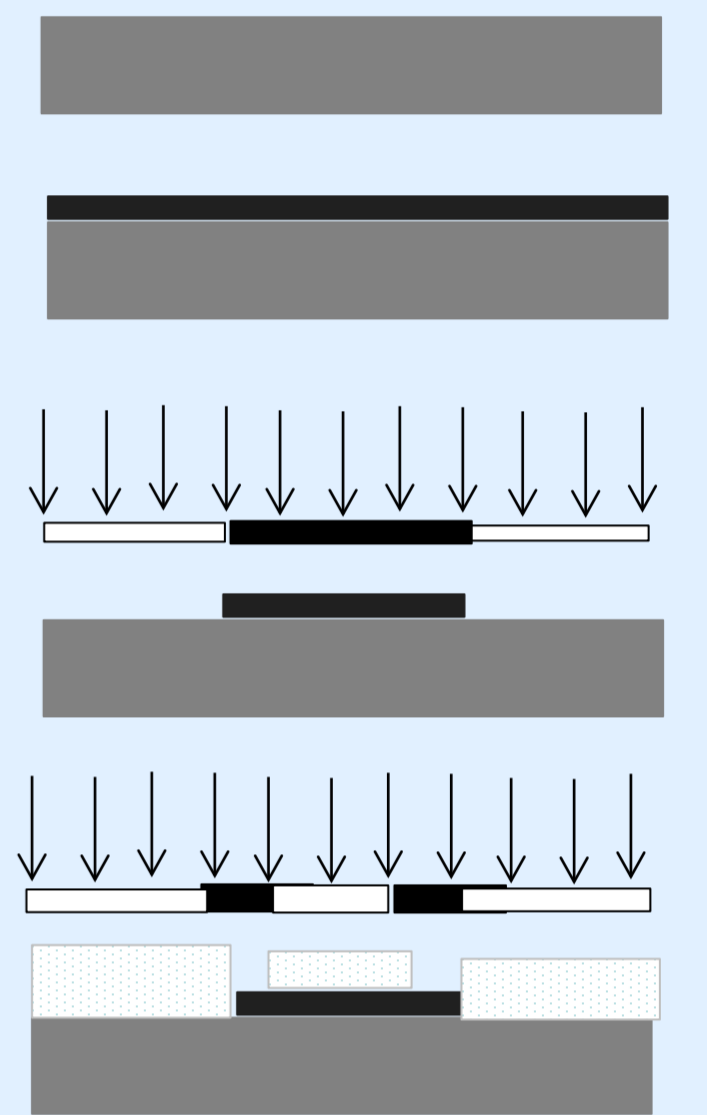
Three different designs



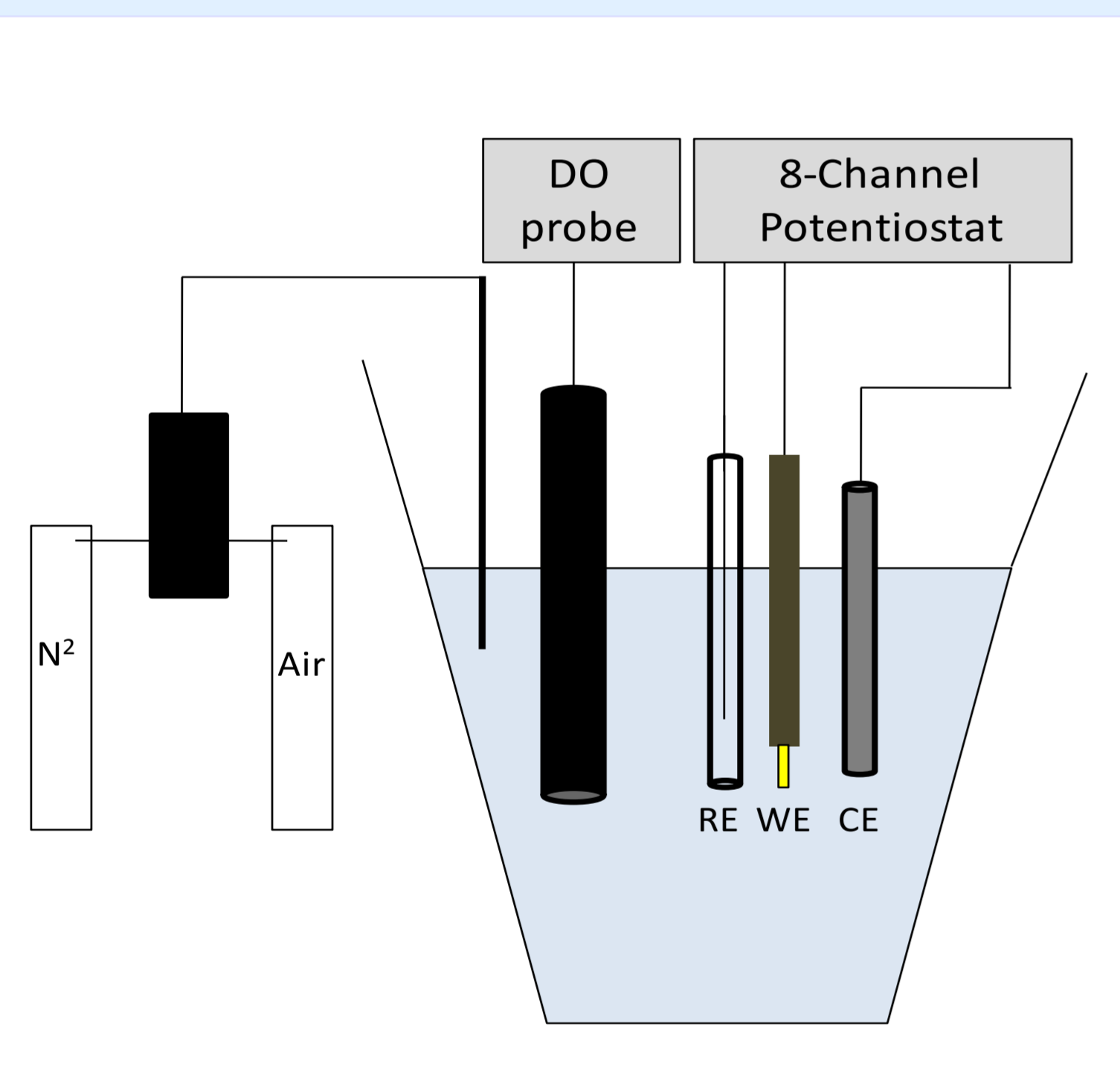
	Design 1	Design 2	Design 3
φ	50 µm	25 µm	10 µm
S	50 µm	50 µm	25 µm

Fabrication: Standard photolithography
Substrate: 500 µm thick Pyrex
Electrodes: Gold
Passivation: SU-8

Pyrex
Ti/Ni/Au
SU-8



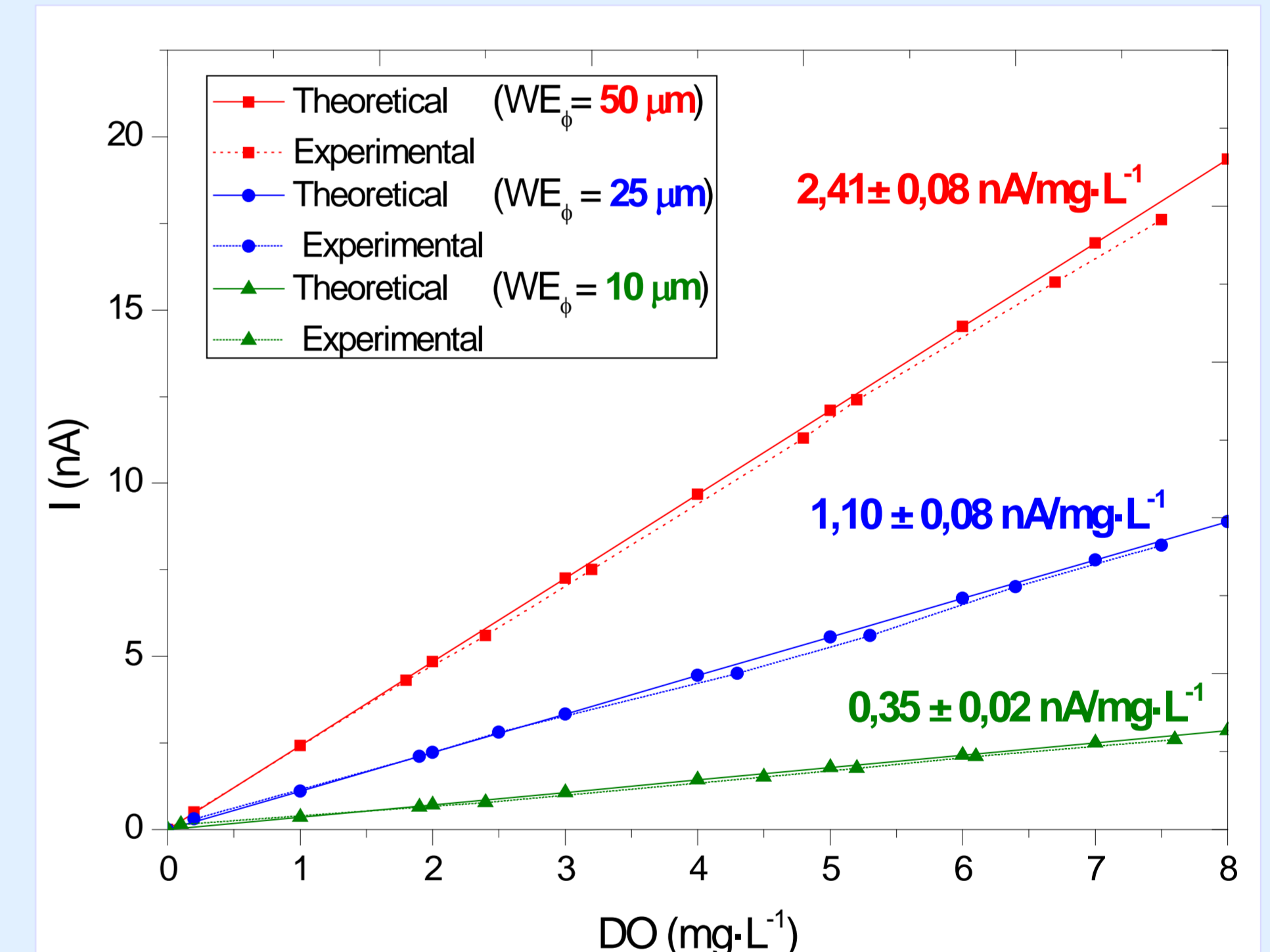
Characterization and Calibration



- Surface Activation:** Submerged in 75% v/v KOH (50 mM) + 30% v/v H₂O₂ during 30 min.
- Set-up:** Pt CE, Ag/AgCl RE
Commercial DO probe
Bubbling nitrogen/air gas
- Characterization:** Cyclic voltammetry in 0.01 M ferro/ferri cyanide and 0.1 M KNO₃ solution.
- Calibration:** 0 – 8 mg·L⁻¹ range
Polarization at - 850 mV (vs. Ag/AgCl external RE)

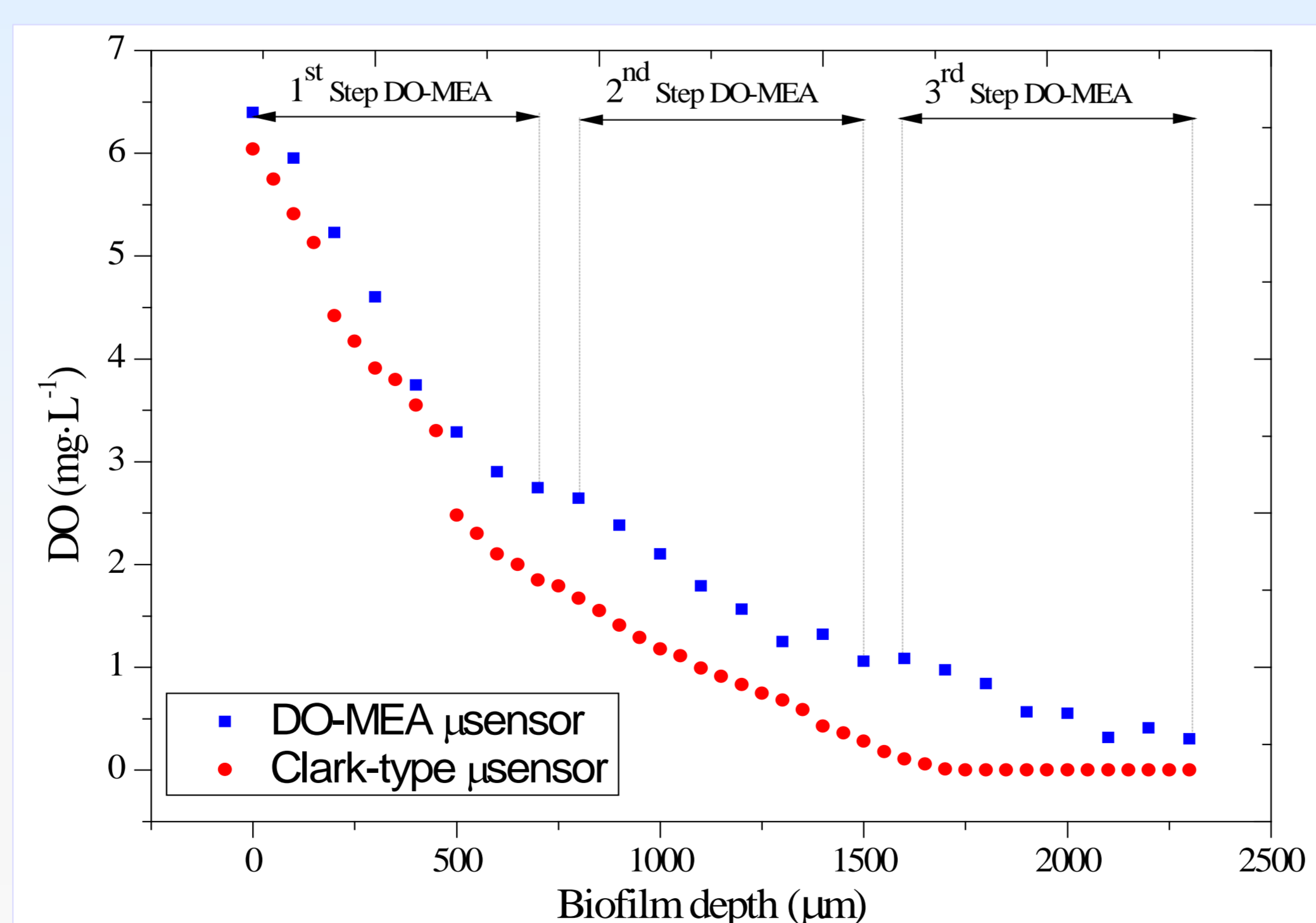
Theoretical current:
$$I_{\text{recessed}} = \frac{4nFDcr}{\frac{4L}{\pi r} + 1}$$

Theoretical vs Experimental Calibration



Biofilm DO Profile

- DO-MEA sensor vs Clark Sensor.
- Heterotrophic aerobic biofilm grown in a Flat Plate Bioreactor.
- DO-MEA sensor: 3 measurement steps (each measurement has 8 simultaneous depth points).
- Clark Sensor: 48 measurement steps (each measurement 1 depth point).



Conclusions

- DO-MEA sensor allows: Simultaneous, real-time and multipoint measurement for the measurement of a DO profile inside a biofilm.
- DO-MEA sensor exhibits an excellent linear response in the range 0-8 mg DO·L⁻¹ for the three different tested designs, with diameters of 50 µm, 25 µm and 10 µm.
- DO-MEA sensor advantages against Clark sensor are: Low cost par sensor, high versatility, High robustness and reduction of the acquisition time.
- DO-MEA sensor permits: Multiple studies of biofilm with different thickness.

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