Research performed within RealSense1 (2019-2021) and RealSense2 projects (2019-2022); Good Food Institute

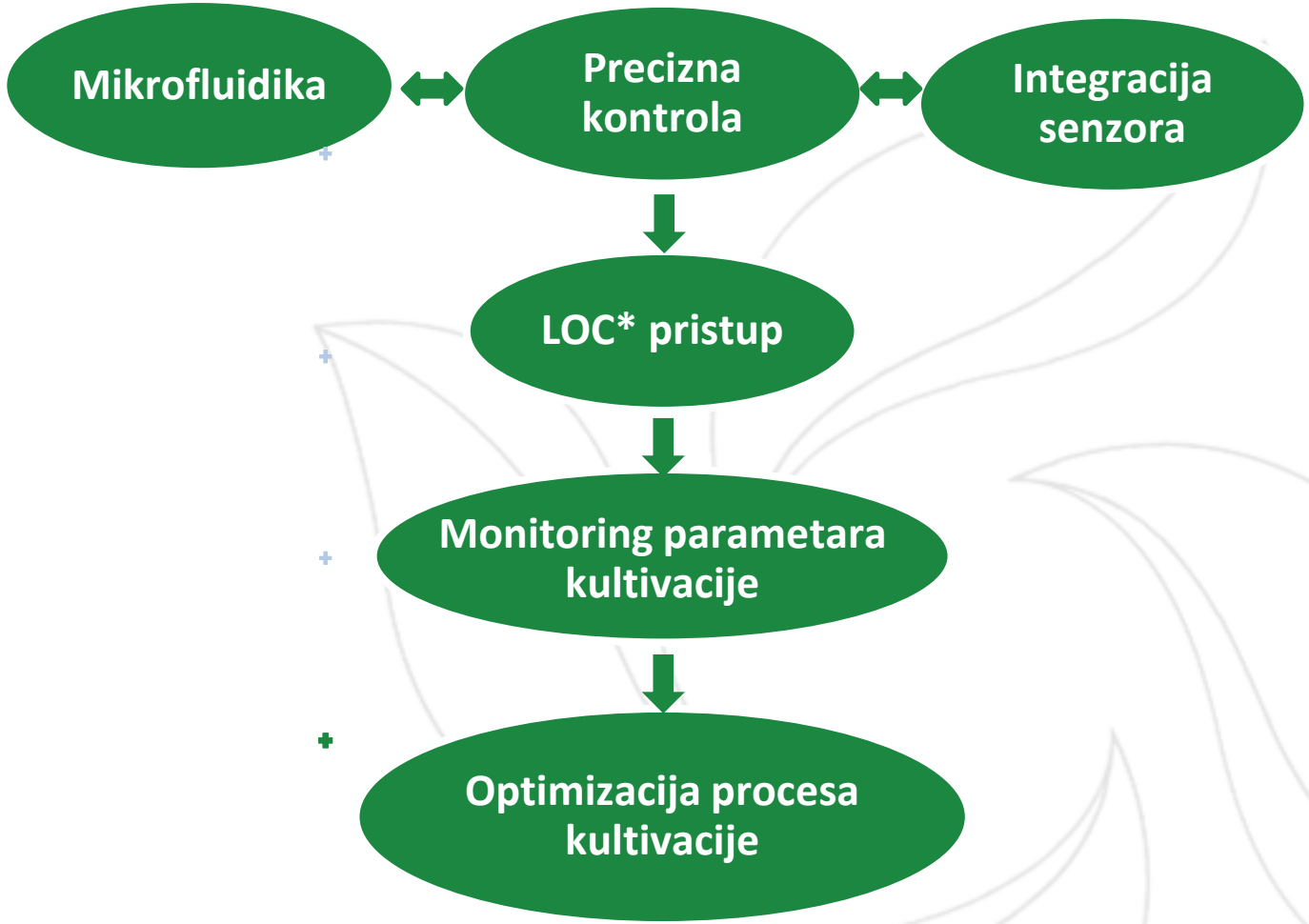
Značaj primene senzora u proizvodnji kultivisanog mesa

Ivana Podunavac

KOMUNALT
16. decembar 2022.

Motivacija

- Ujedinjene Nacije - porast populacije u narednih 30 godina do **10 milijardi ljudi**
- Porast zahteva za hranom **70%**
- Tradicionalna poljoprivreda veliki zagađivač
- Klimatske promene
- Antibiotici u proizvodnji mesa
- **Kultivisano meso - “clean meat”**
- Senzori za merenja u realnom vremenu
- **Smanjenje troškova** celog bioprocesa



*LOC - Laboratorija-na-čipu (eng. Lab-on-a-chip)

RealSense 1 & 2

REALSENSE 1

MONITORING OF CELL CULTURE PARAMETERS USING SENSORS FOR BIOMASS AND NUTRIENTS/METABOLITES IN MEDIA: LAB-ON-A-CHIP (LOC) APPROACH.

- Prototipovi senzora za in-situ merenja biomase, nutrijenata i metabolita
- Primena pristupa Laboratorija-na-čipu (LOC)
- “Scale-down” pristup

REALSENSE 2

FROM LAB-ON-A-CHIP TO CUSTOM BIOREACTOR: SCALE UP MODELING STUDY.

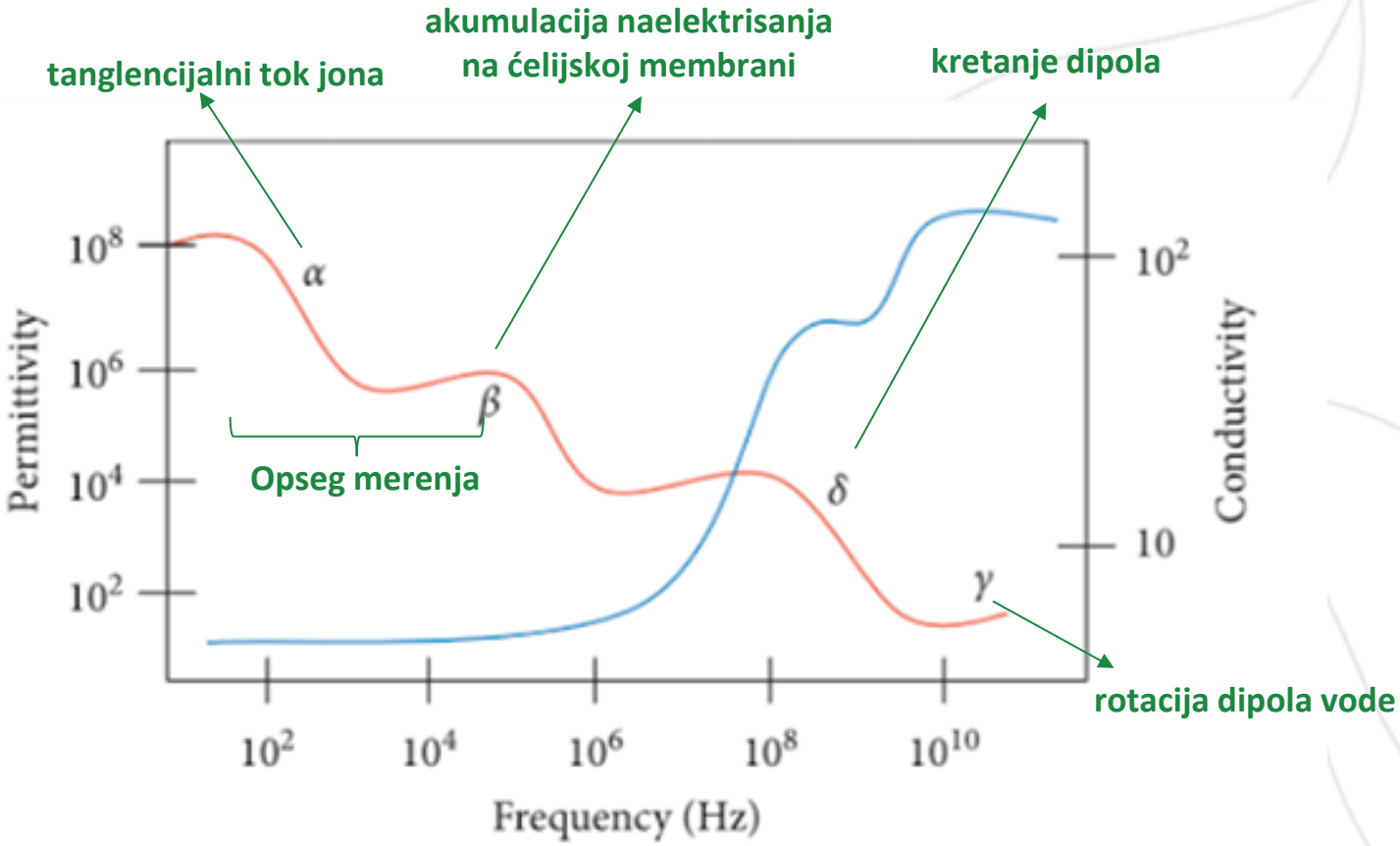
- Integracija senzora u bioreaktor
- Razvoj i optimizacija nove generacije senzora za biomasu, nutrijente i metabolite
- Modelovanje bioreaktora

Sadržaj

1. Uvod
2. Senzor za biomasu - LOC pristup
   a. Realizacija mikrobioreaktora
   b. Kultivacija MRC-5 ćelija
   c. Obrada slike
   d. Modelovanje elektronskim kolom
3. Senzor za biomasu - integracija u bioreaktor
   a. Integracija senzora u bioreaktor
   b. Razvoj elektronike za automatsko merenje impedanse
4. Detekcija glukoze - LOC pristup
   a. Realizacija LOC platforme 3D štampom
   b. Integracija senzora u LOC platformu
   c. Elektrohemijska detekcija glukoze
5. Zaključak

Monitoring biomase

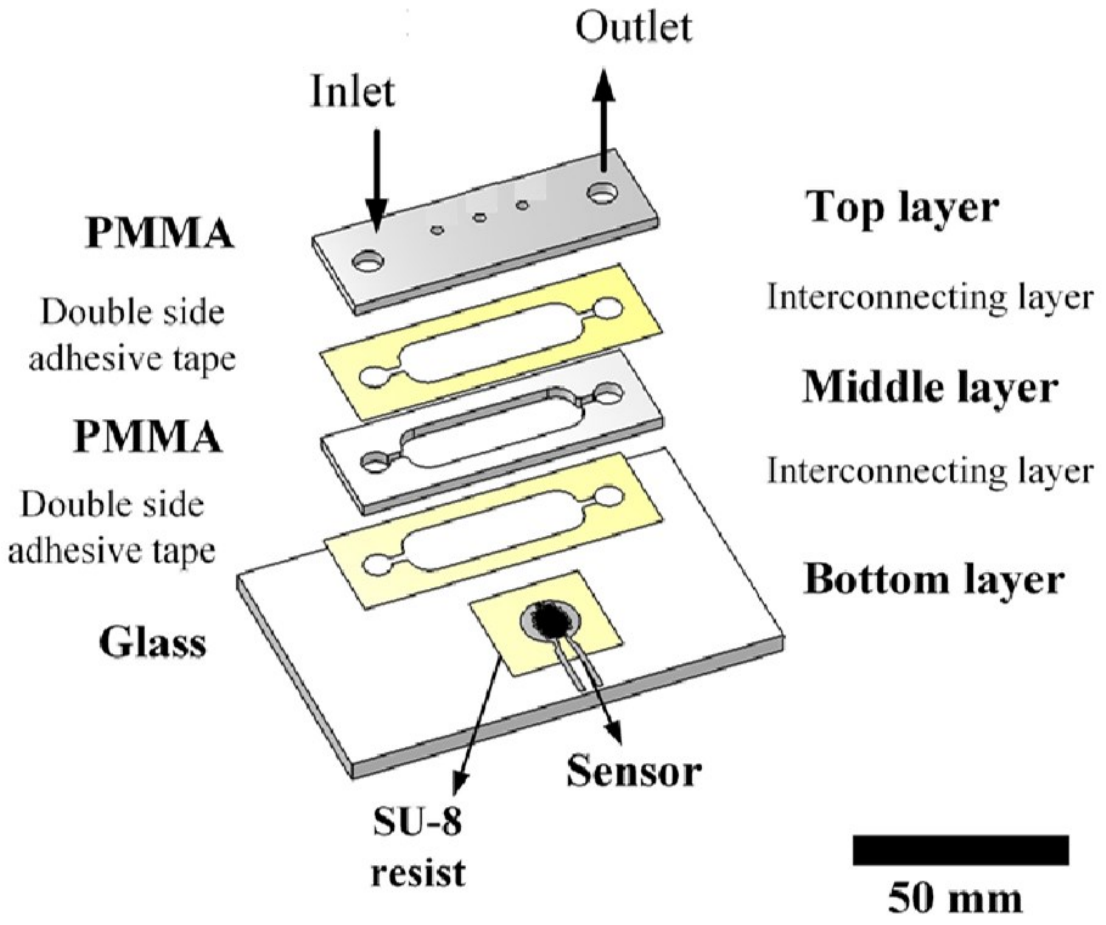
- **Interakcija ćelija i EM zračenja**
  - **Detekcija,**
  - **Karakterizacija** različitih parametara rasta
- **Radio-frekventni opseg**
  - Žive ćelije se ponašaju kao dipoli
  - **Broj ćelija ∝ dielektrična permitivnost**
  - Merenja **koncentracije ćelija** i **biomase**



Nasir N, Al Ahmad M. Cells Electrical Characterization: Dielectric Properties, Mixture, and Modeling Theories, Journal of Engineering. 2020; https://doi:10.1155/2020/9475490

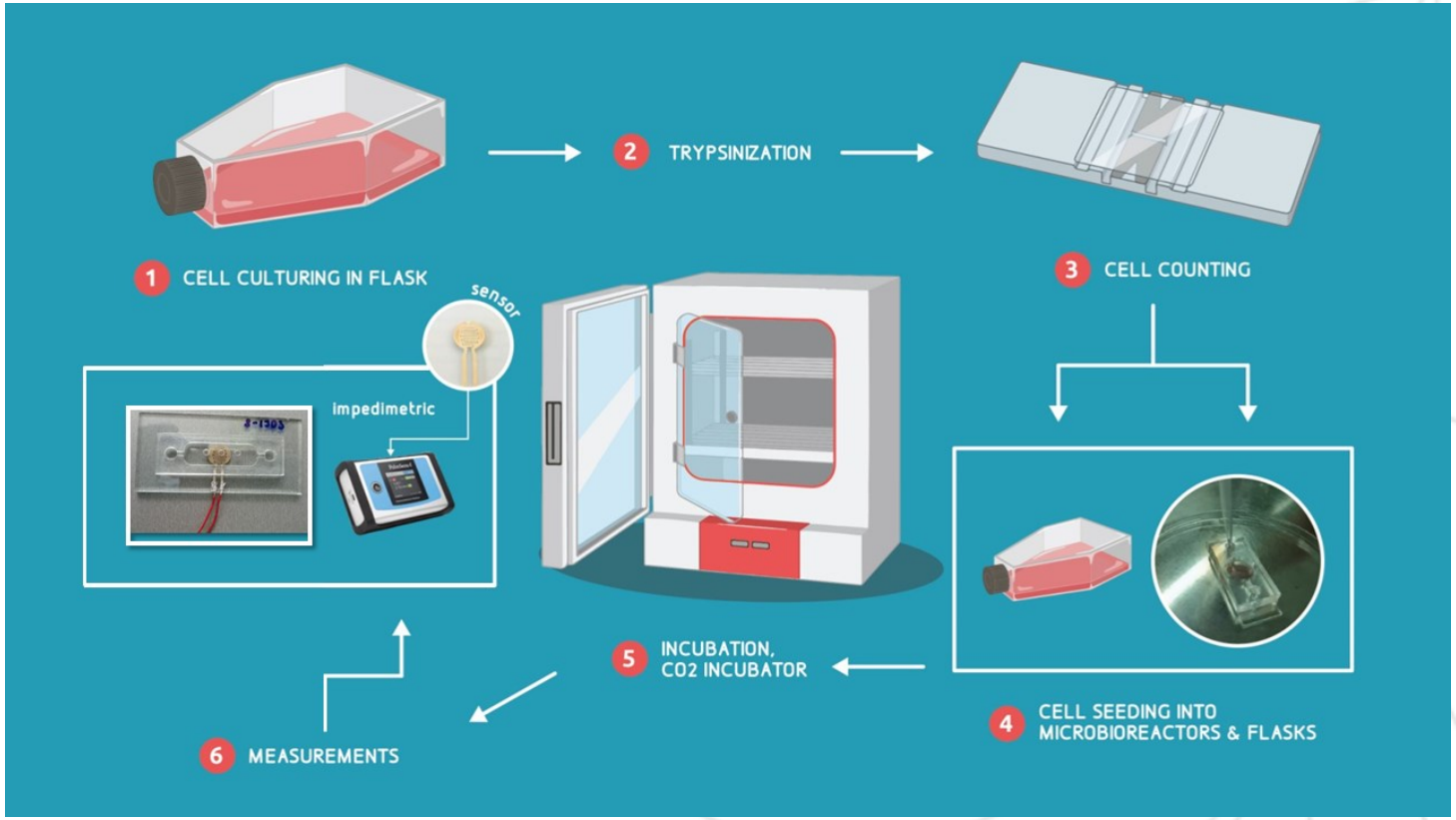
LOC platforma

- Višeslojna struktura
- Transparentni materijali
- **Inkjet** štampani senzor
- Hibridna tehnologija izrade
  - Ksirografija
  - Lasersko mikromašinstvo
  - Hladna laminacija

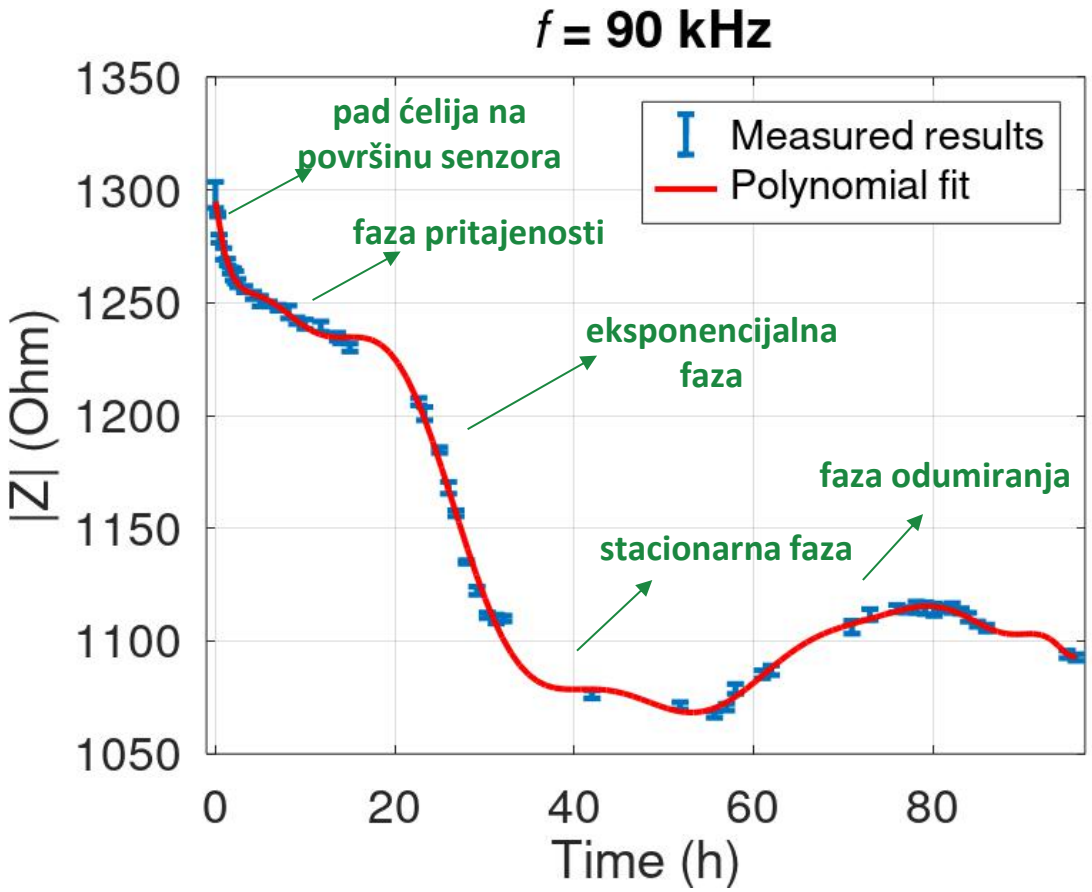


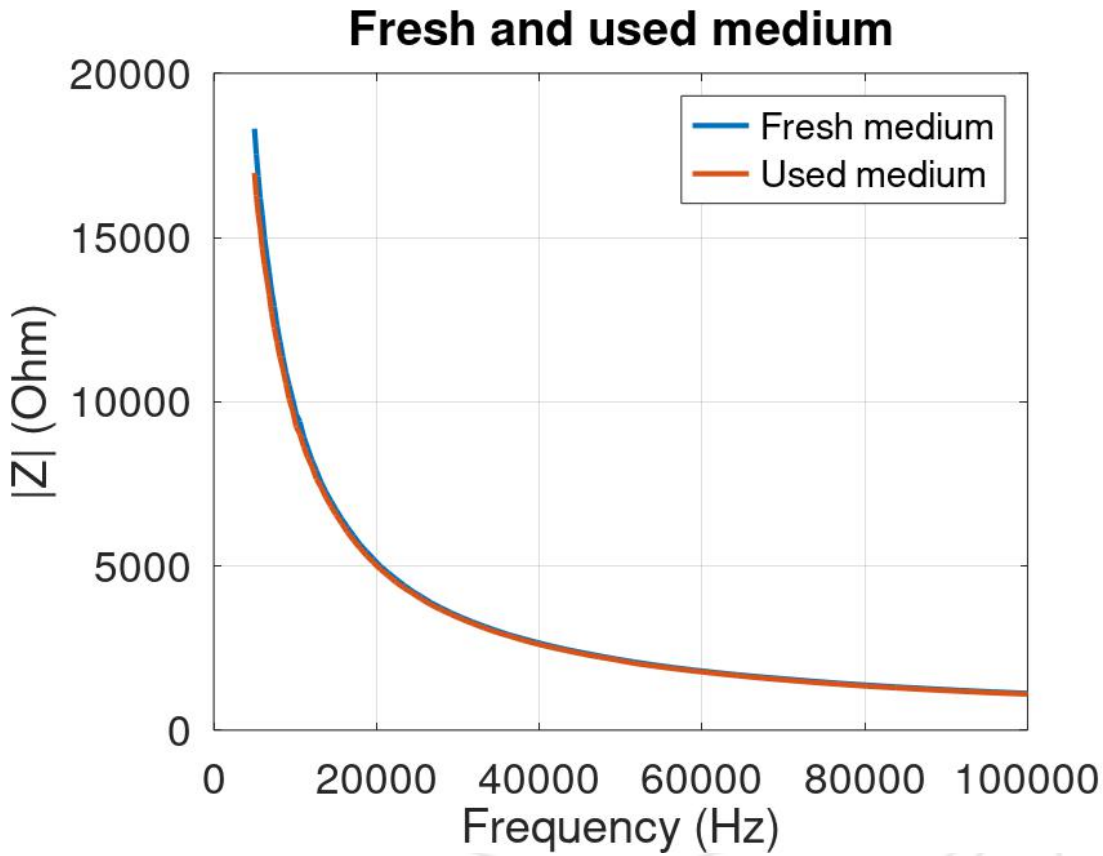
Postavka eksperimenta

- Potenciostat unutar CO_2 incubatora
- PC i PalmSense - Bluetooth konekcija
- **MRC-5 fibroblasti** model adherentnih ćelija
- Kultivacija tokom 96 h
  - Merenje impedanse
  - Mikroskopija
  - Obrada slike

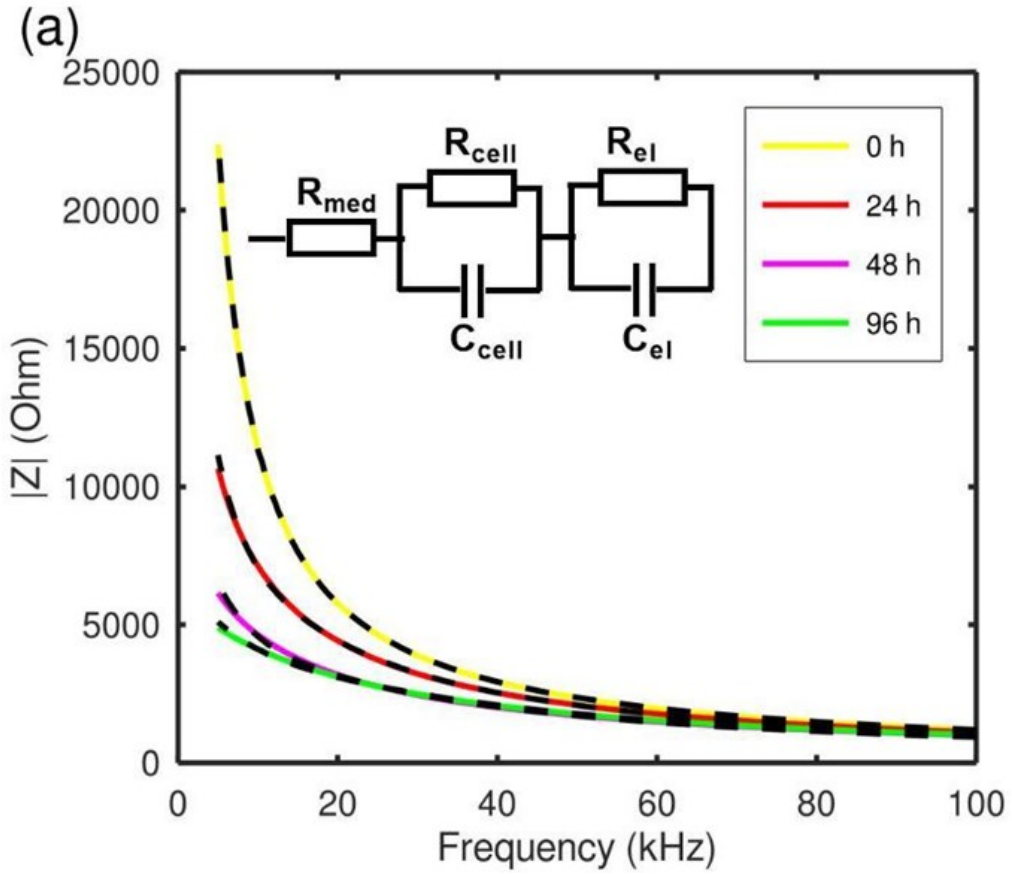


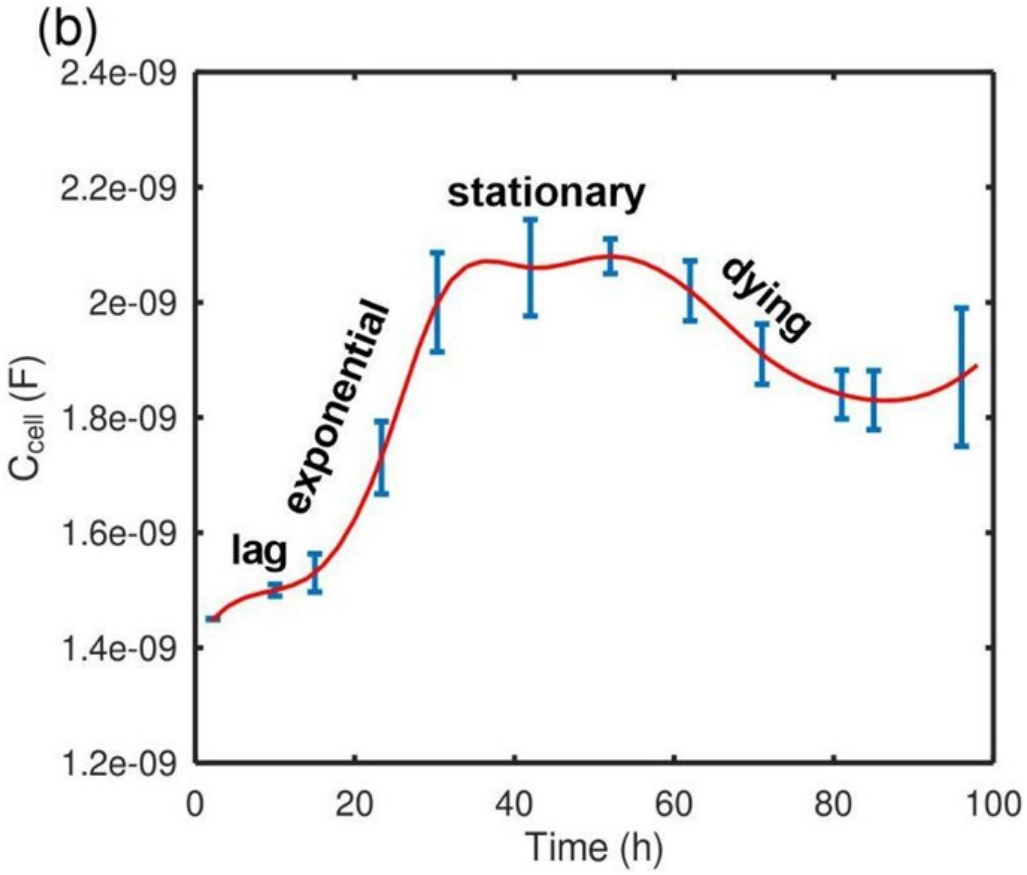
Kultivacija MRC-5 tokom 96 h u LOC





Modelovanje elektronskim kolom





Kultivacija MRC-5 tokom 96 h u LOC

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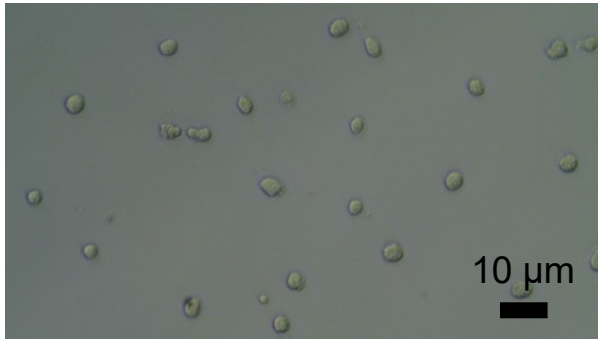

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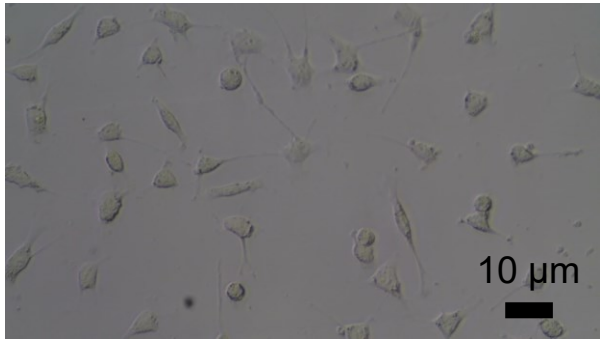

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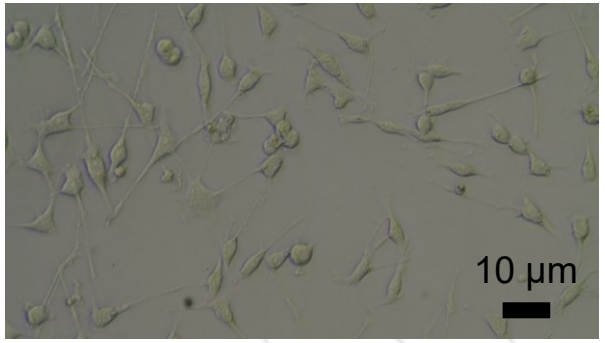

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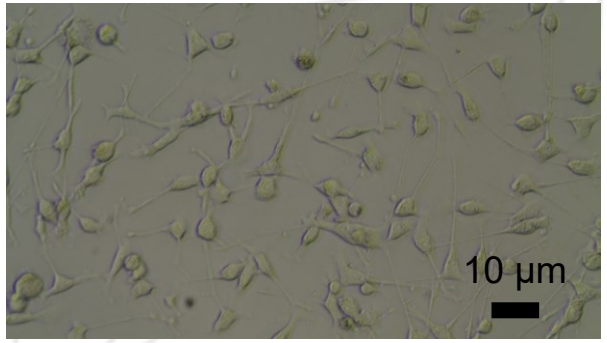

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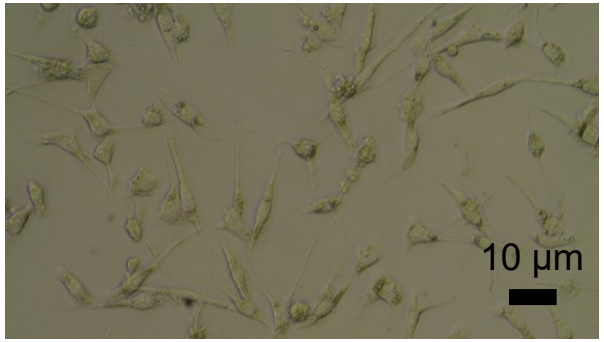

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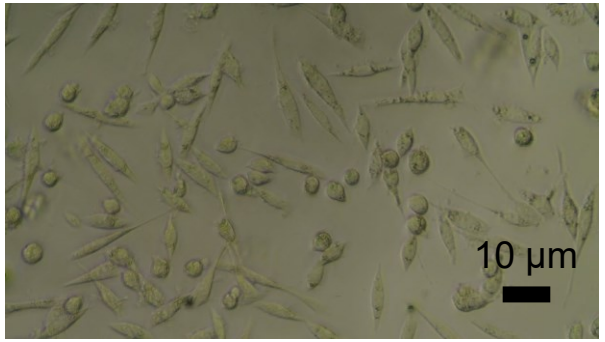

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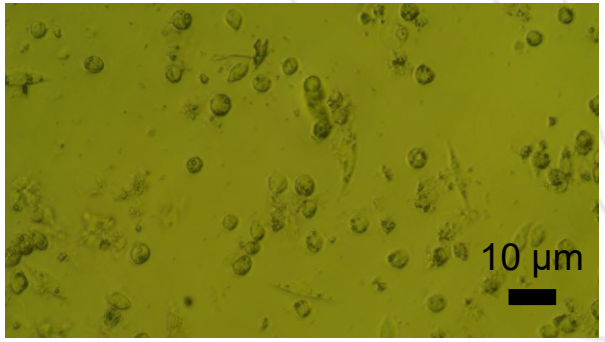
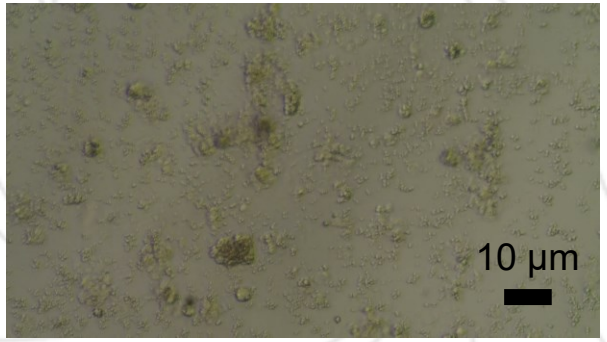


t = 96 h

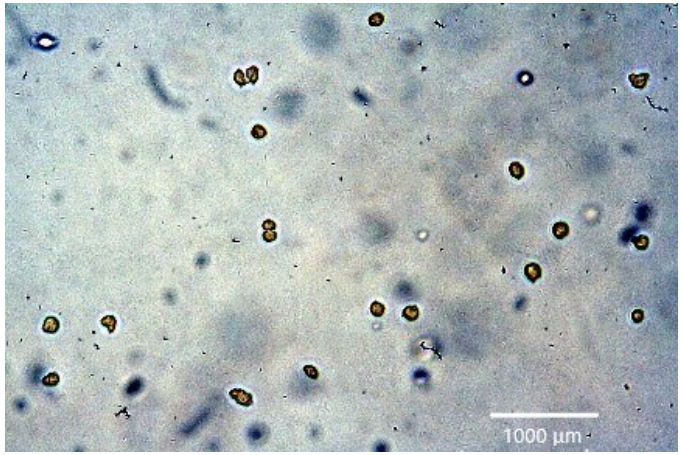


Rast ćelija

Umiranje

Procena pokrivenosti površine slike

0 h



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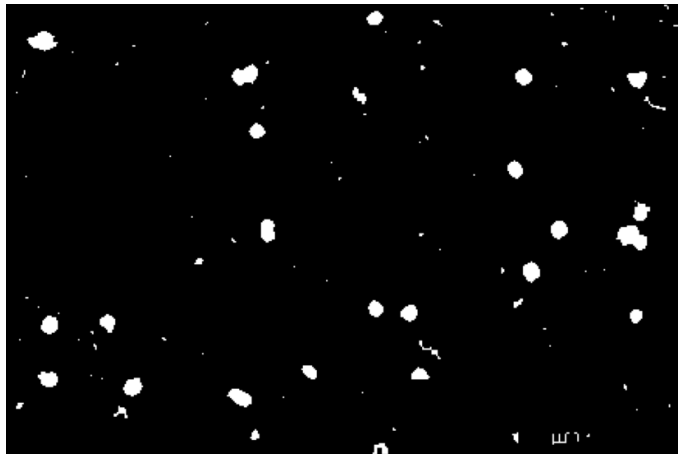
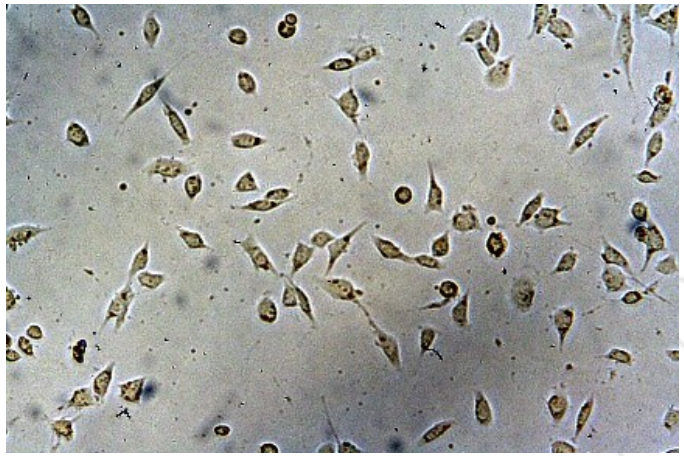


24 h



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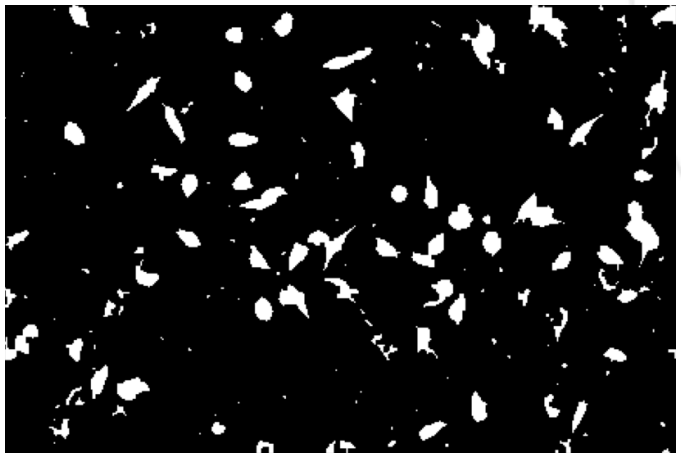
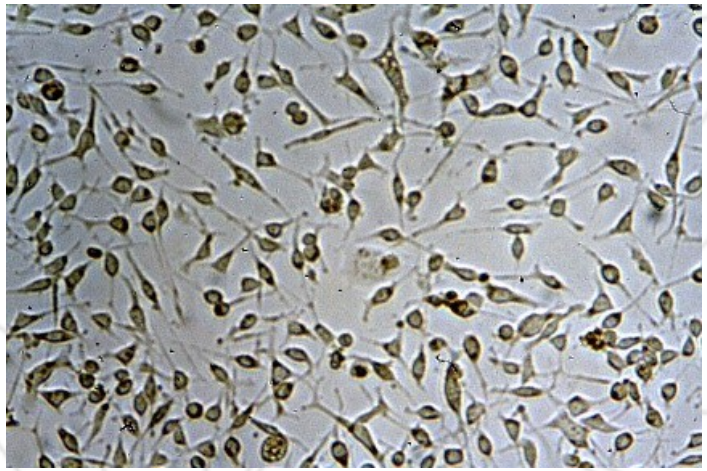


48 h



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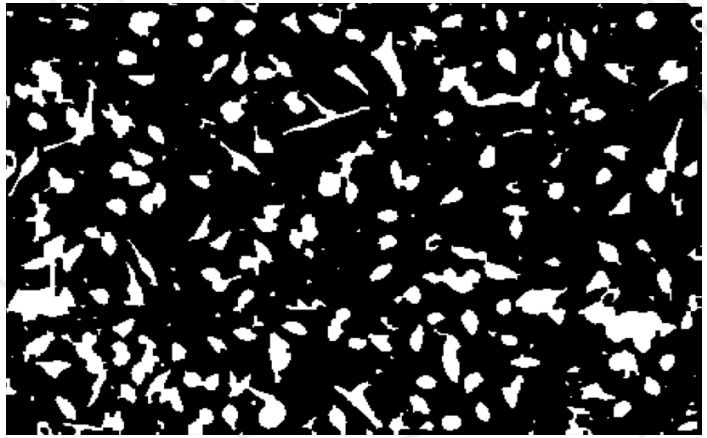
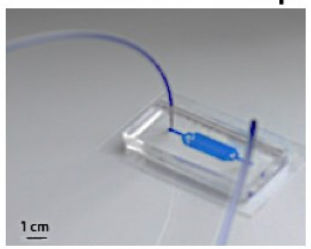
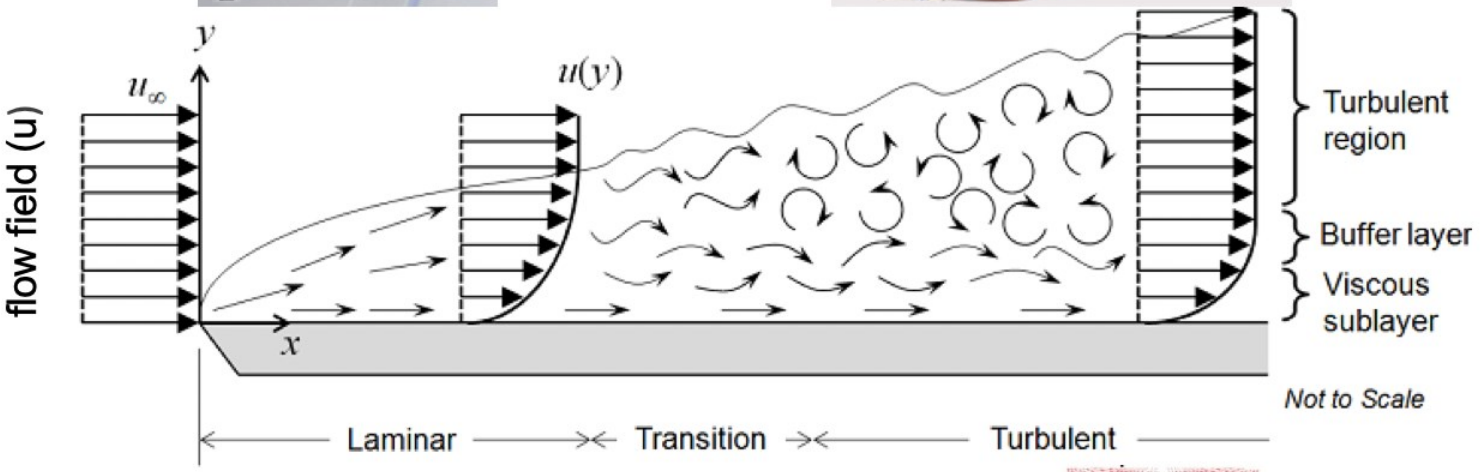


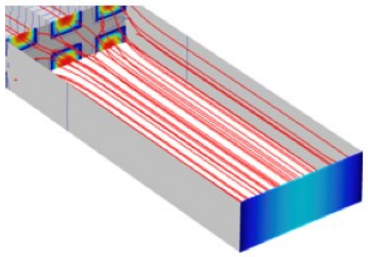
Prelazak na veće razmere

Microfluidic chip

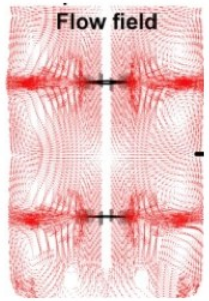


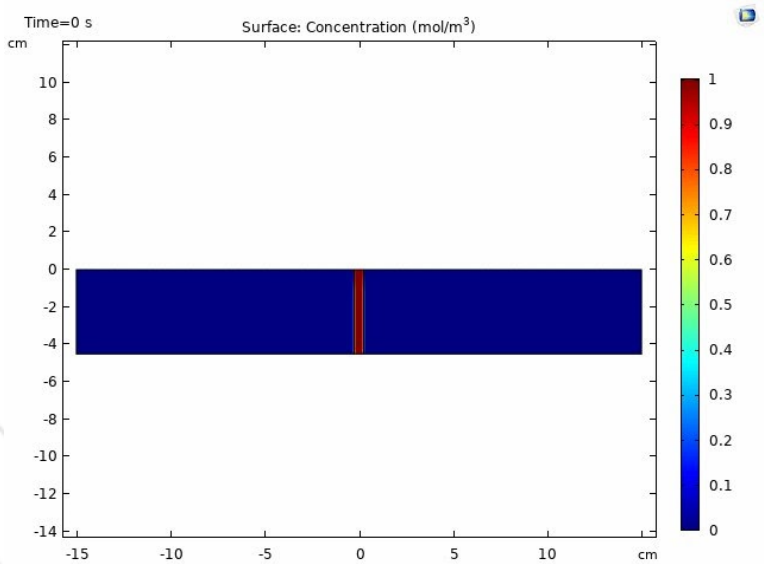
Bench-top stirred tank bioreactors

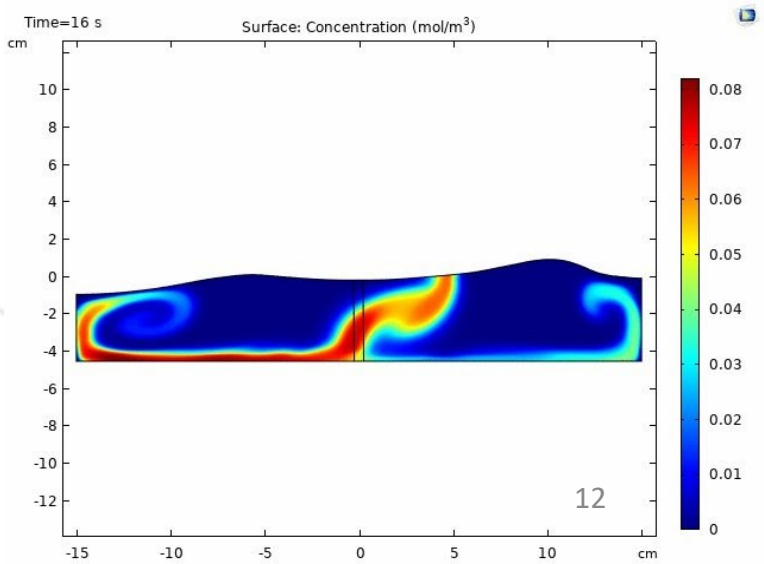




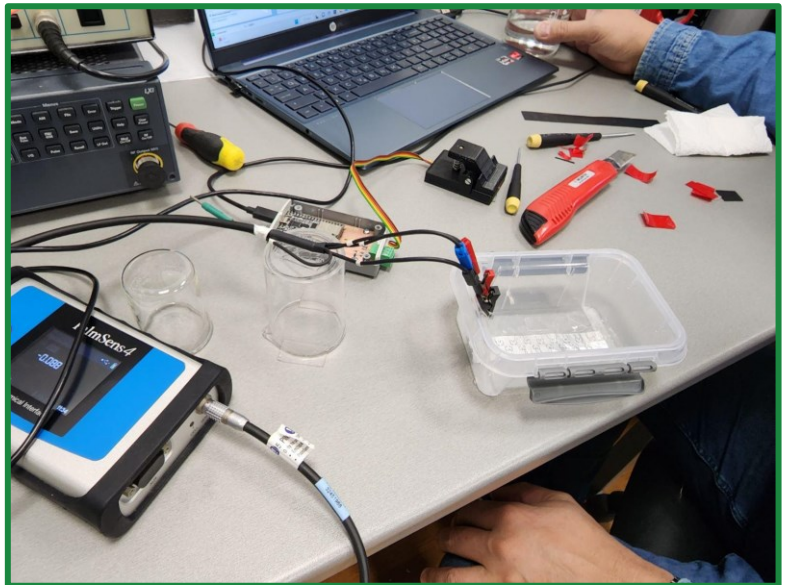
Computational Fluid Dynamics (CFD) models

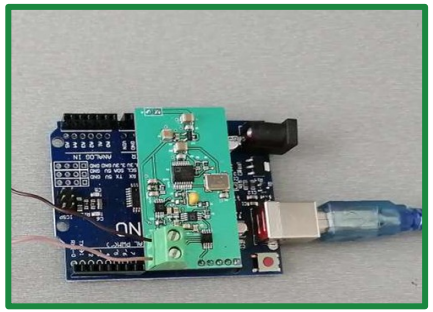


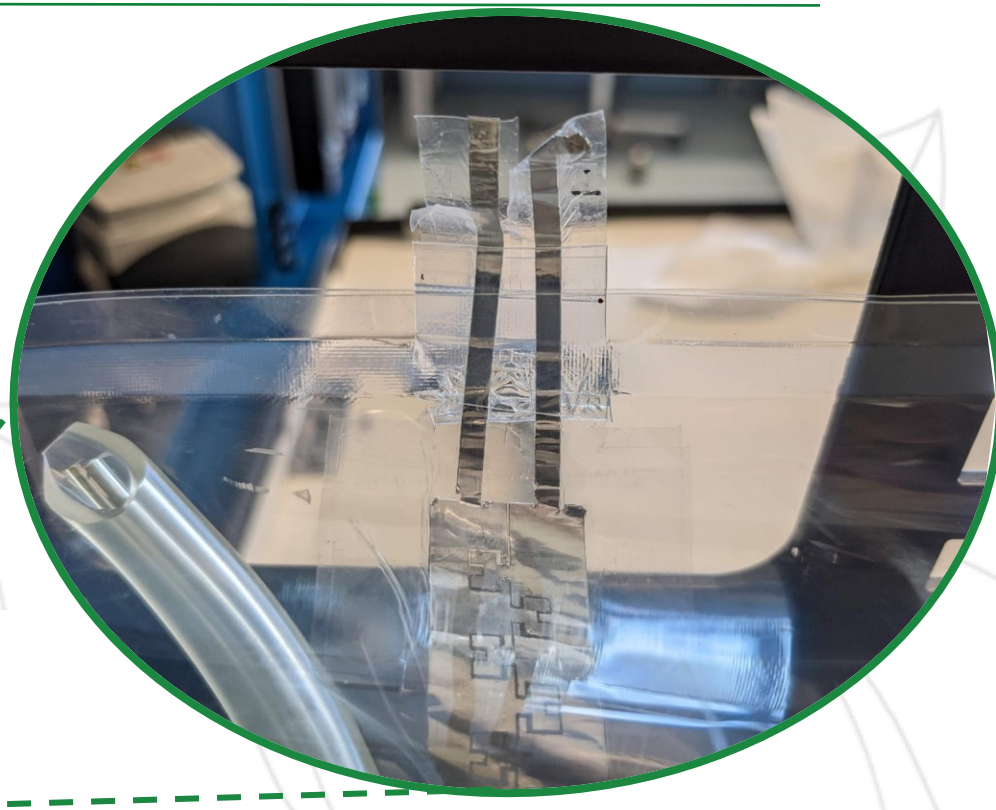




Prelazak na veće razmere







Integracija senzora u bioreaktor

Detekcija glukoze u medijumu - LOC pristup

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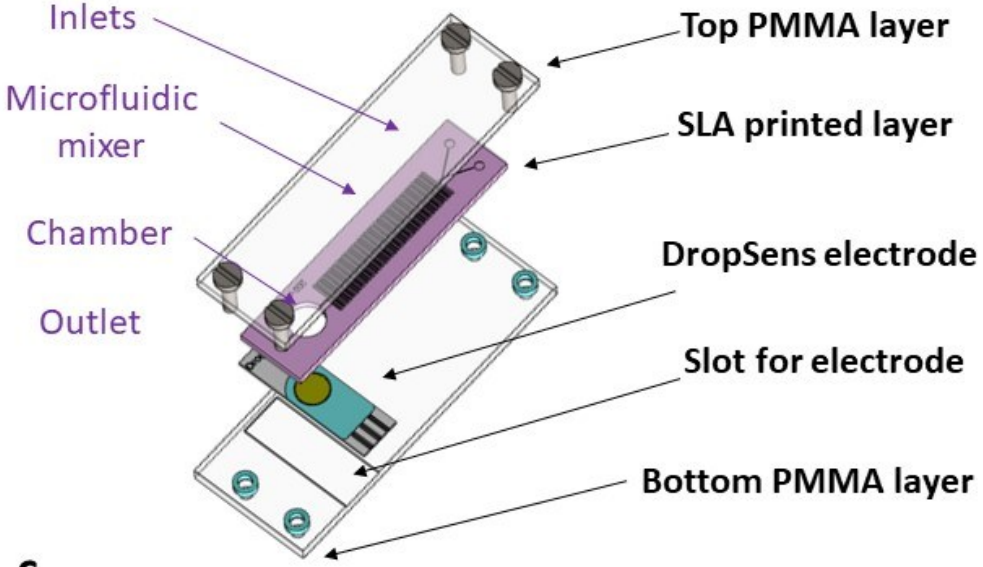

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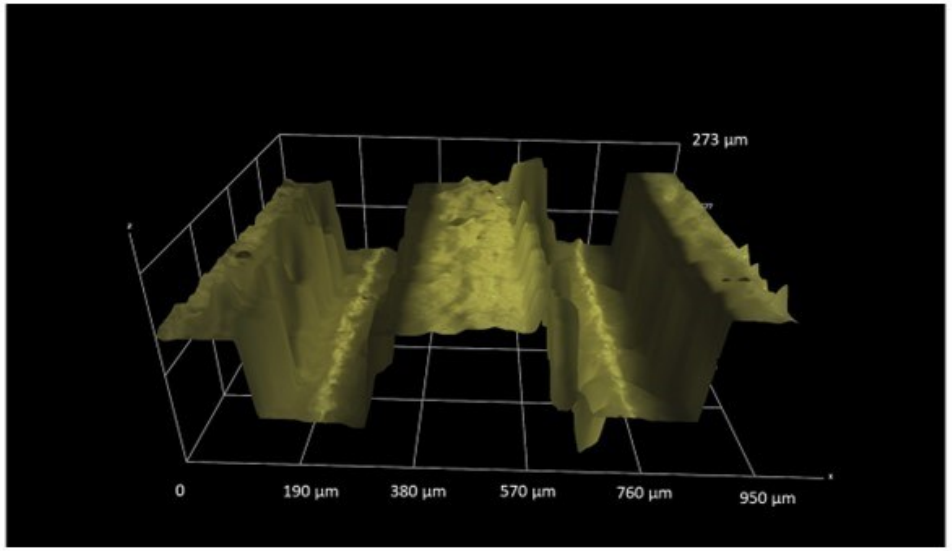

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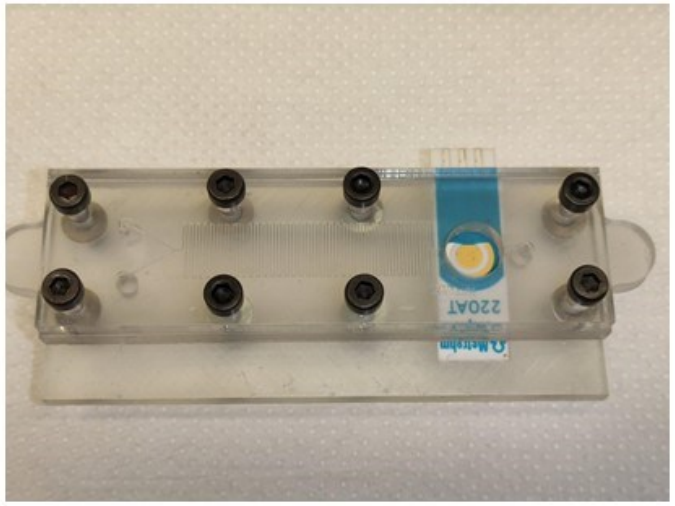

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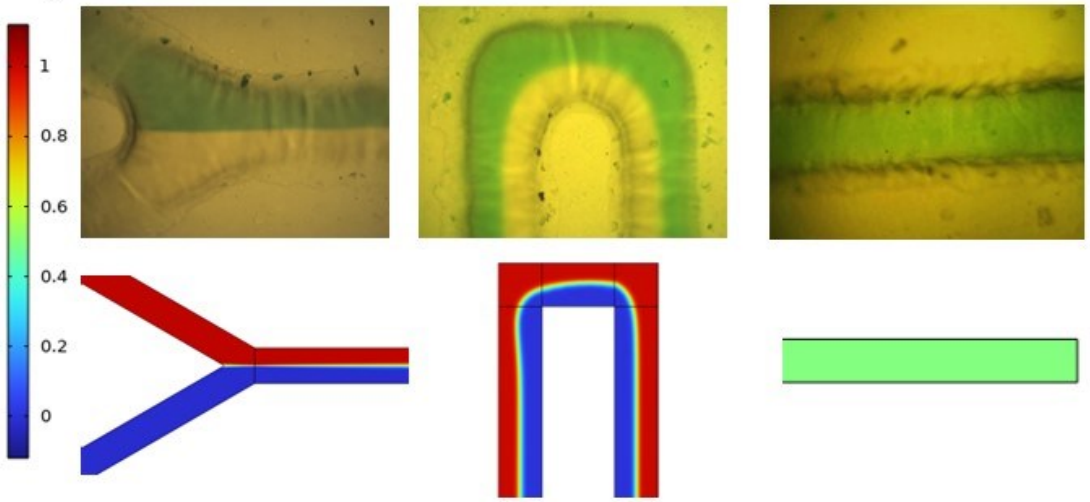
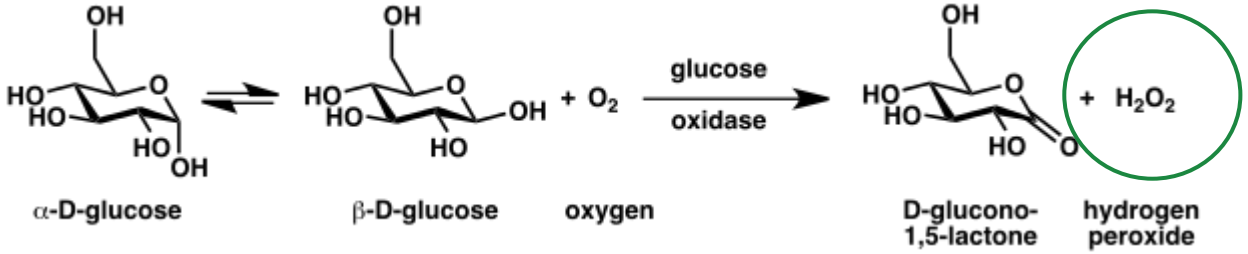
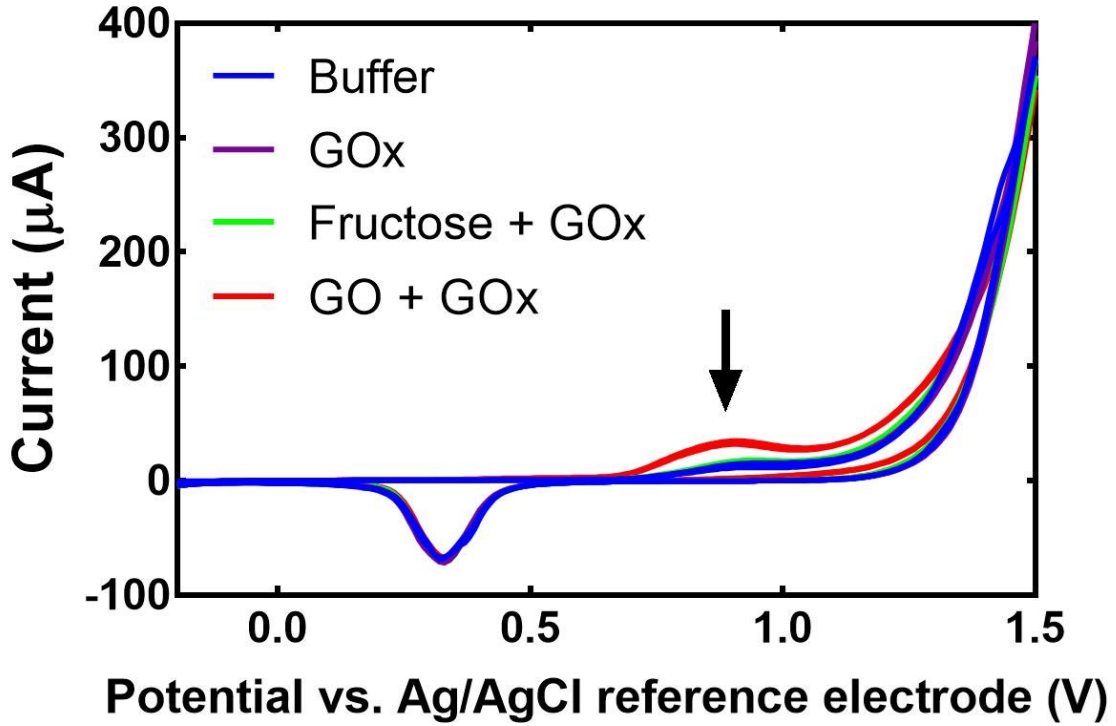
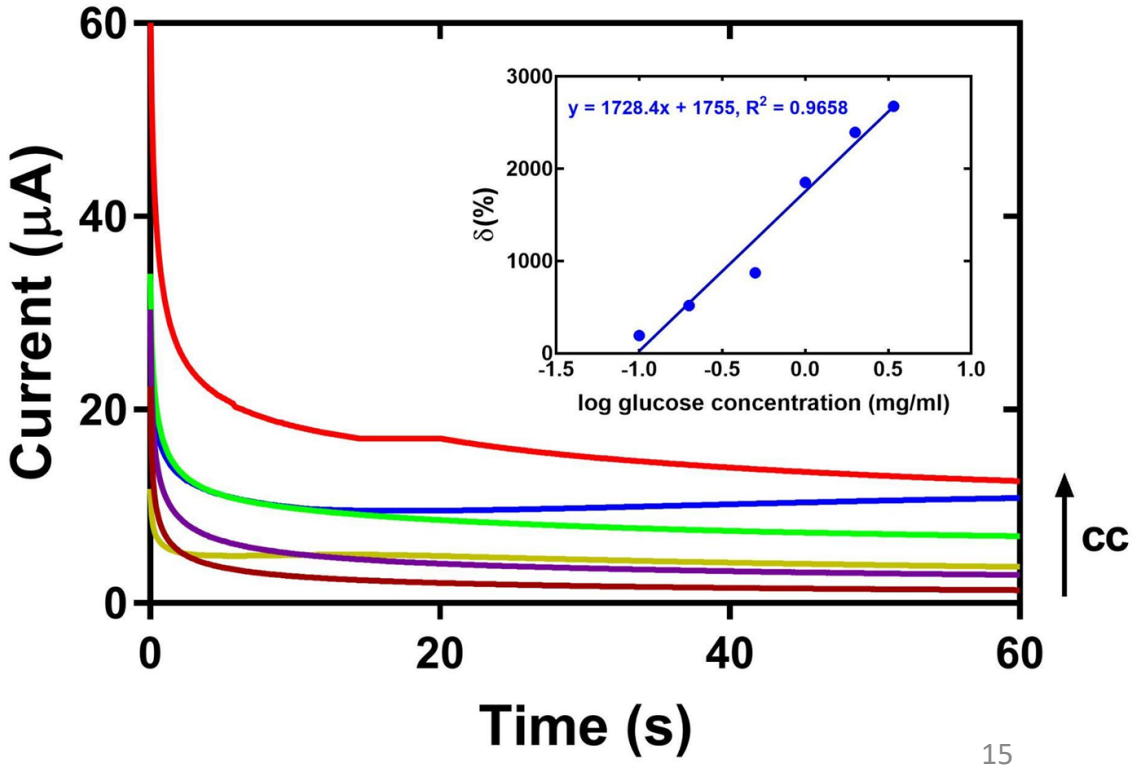


Detekcija glukoze u medijumu - LOC pristup







Zaključak

- Koncept minijaturizacije za rešavanje problema velikih razmera
- Precizna kontrola uslova i doprinosa merenju
- Predložena rešenja za LOC sisteme - praćenje različitih parametara rasta ćelija unutar mikrobioreaktora
- Jeftina i brza rešenja
- Sve faze ćelijskog ciklusa detektovane impedansnim senzorom
- Impedansni senzor uspešno proširen sa mikro na makrosistem
- Sistem za glukozu - povezivanje na bioreaktore i detekcija glukoze u realnom vremenu
- Razumevanje procesa kultivacije na velikim skalama ključno za optimizaciju procesa proizvodnje kultivisanog mesa i uštedu troškova

RealSense tim

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Dr Vasa Radonić

Dr Ljiljana Janjušević

Teodora Knežić

Mila Đisalov

Ivana Podunavac

Hvala na pažnji!

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