3D-PRINTING MICRO-OPTOFLUIDIC SYSTEMS: *TECHNOLOGIES AND PROCESSES*

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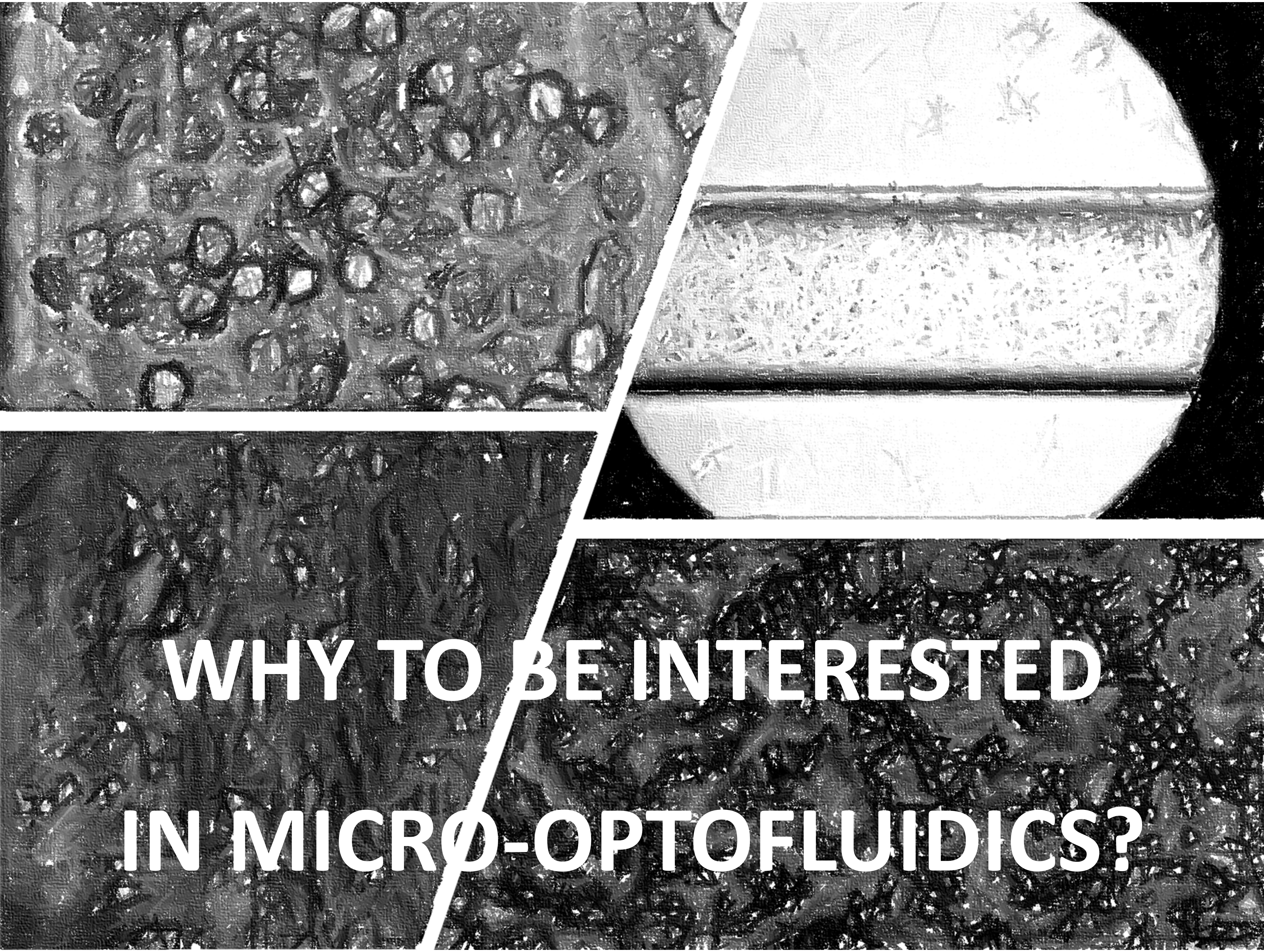
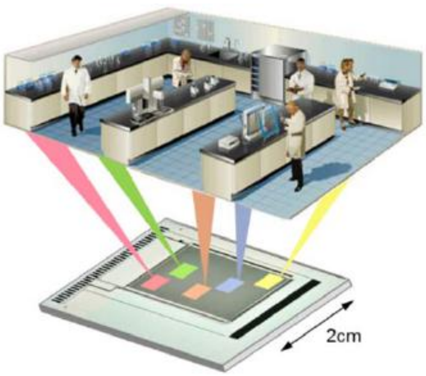
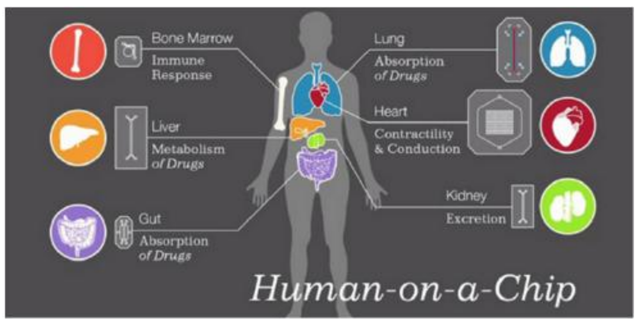

WHY TO BE INTERESTED
IN MICRO-OPTOFLUIDICS?

Microfluidics & Optic Detection

MICROFLUIDICS SYSTEMS ARE THE CORE OF THE "*LAB ON A CHIP*" USED TO TEST BIOLOGICAL SAMPLES, FOOD QUALITY AND POLLUTION (AIR, SOIL, WATER..)





(1) LOW SPACE

(2) LESS REAGENTS

(3) FASTER TEST

(4) LOW COST

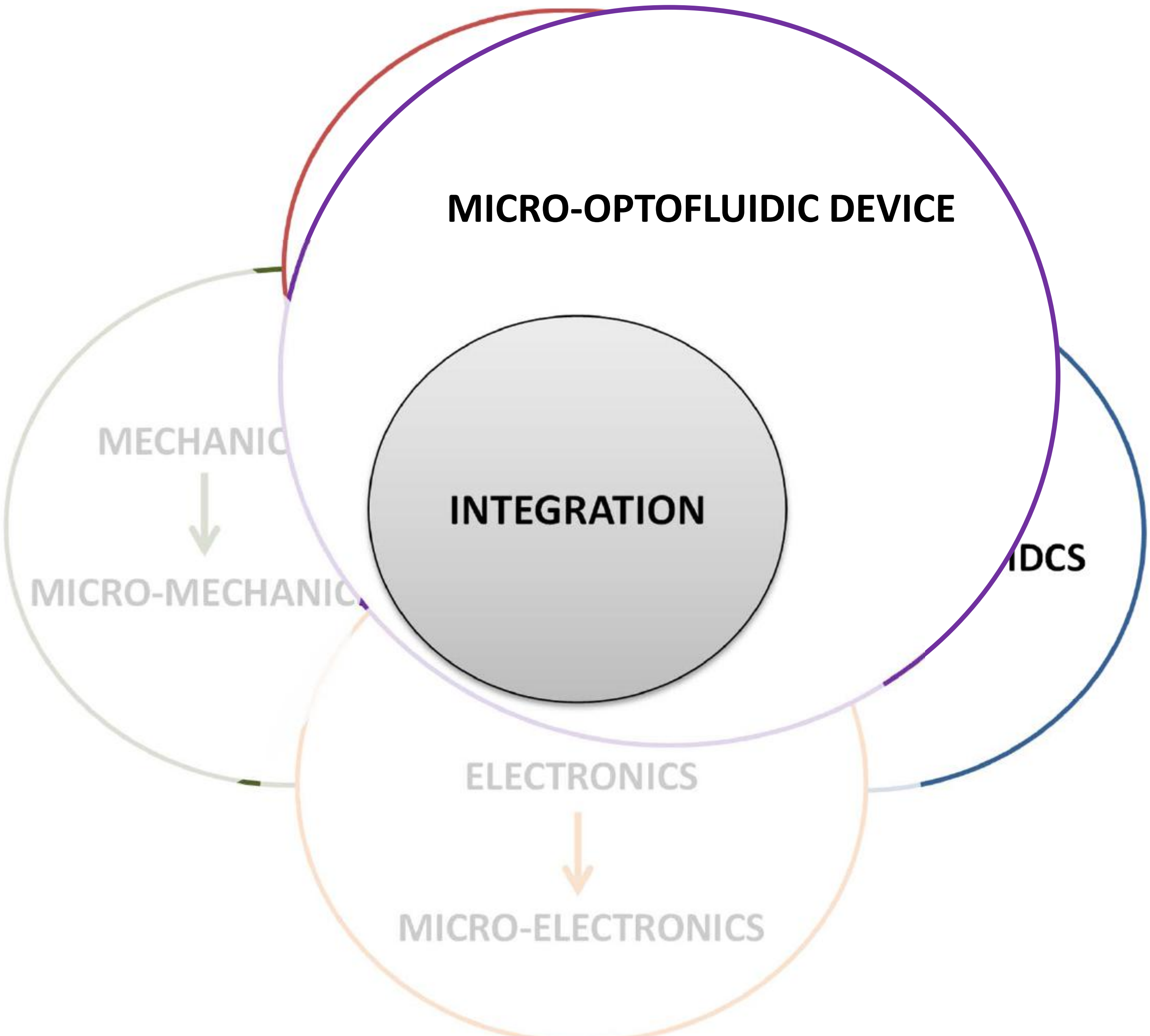
OPTICAL DETECTION IS THE STANDARD

(1) GIVING A DIRECT ACCESS TO THE SAMPLE

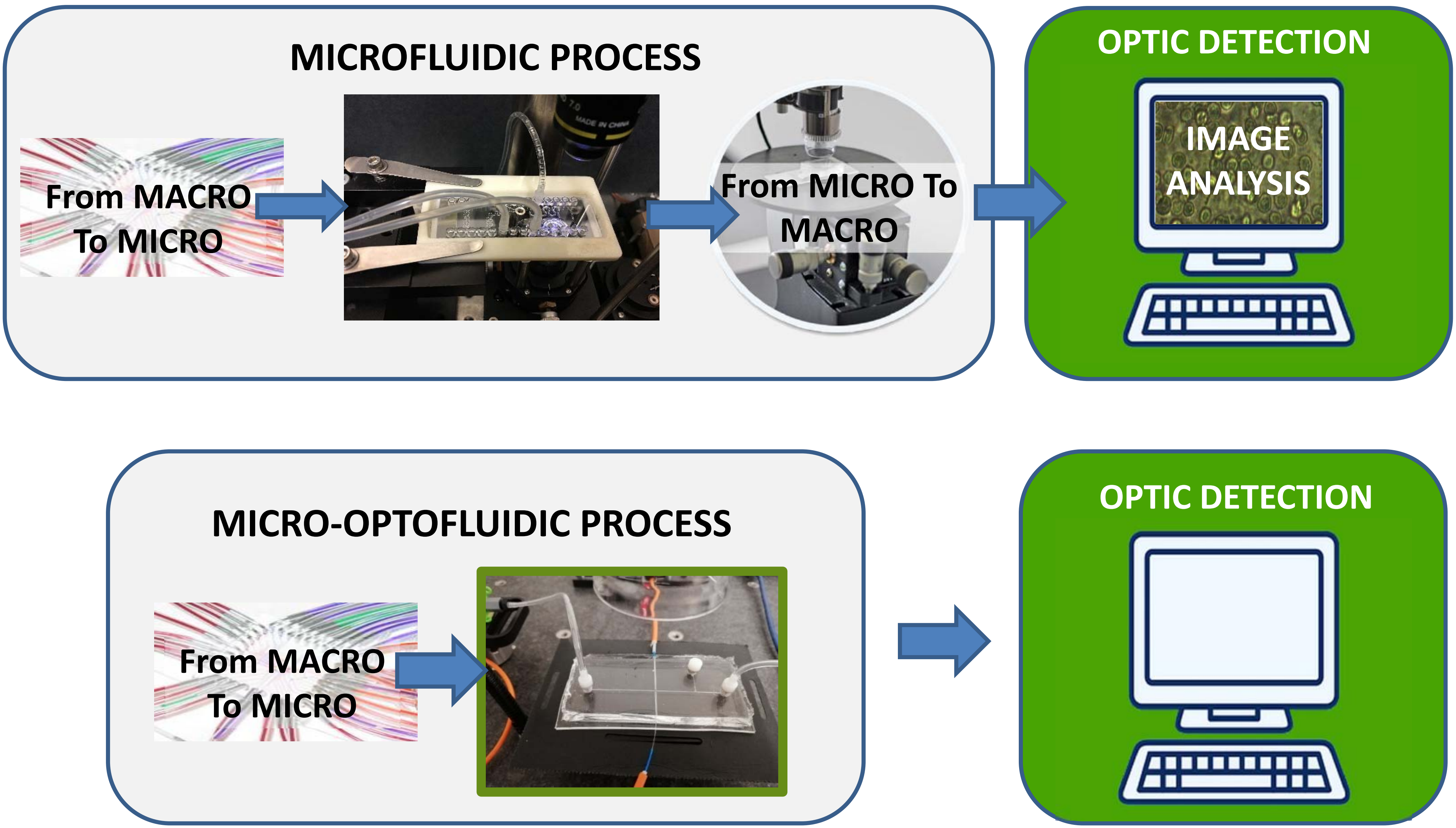
(2) EXTRACT MULTIPLE INFORMATION

(3) LESS INVASIVE (LABEL FREE)

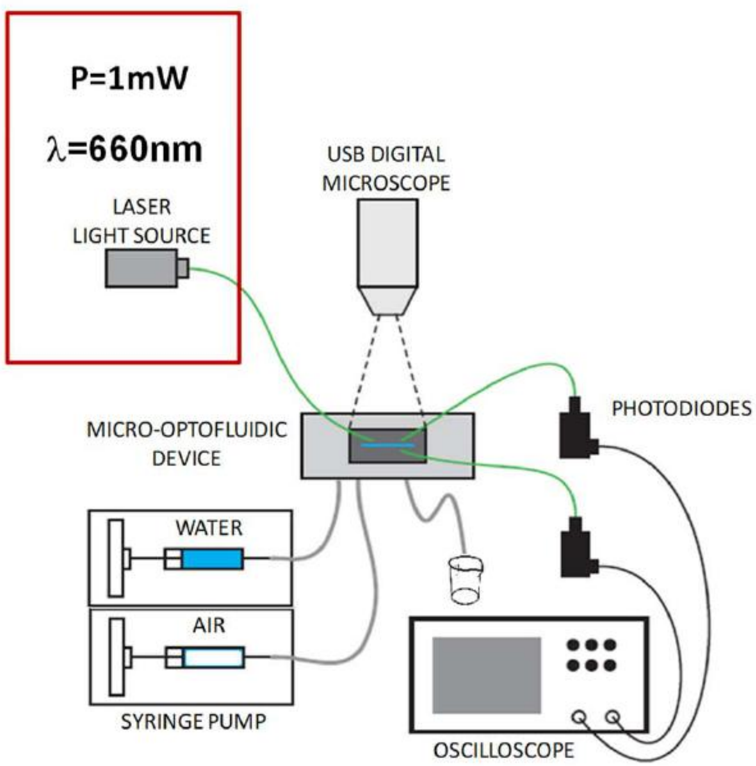
Microfluidics & Optic Detection

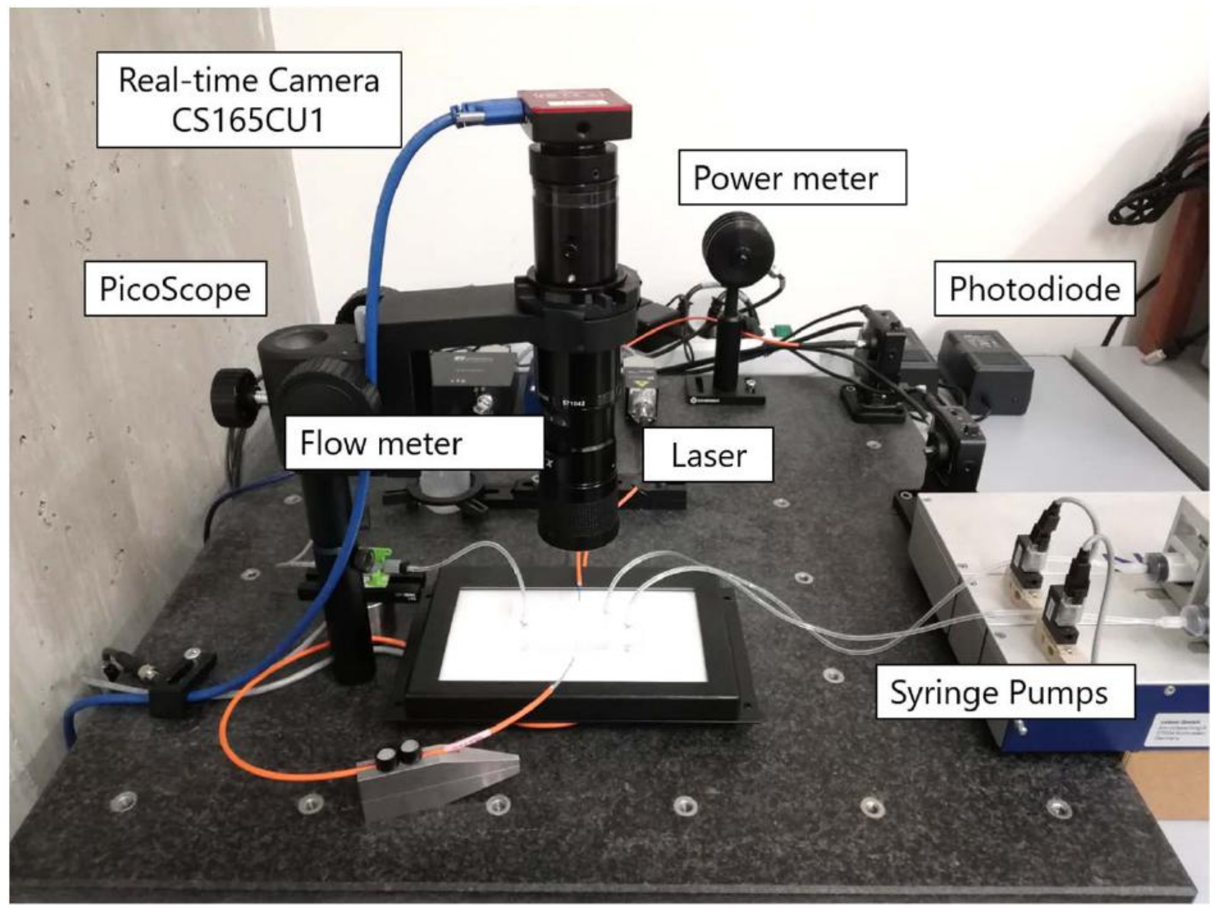


MICRO-OPTOFLUIDICS: DATA ANALYSIS

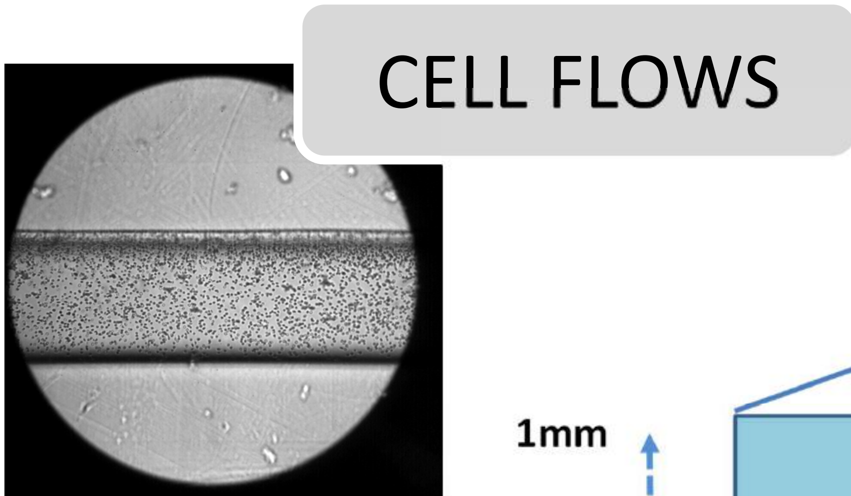


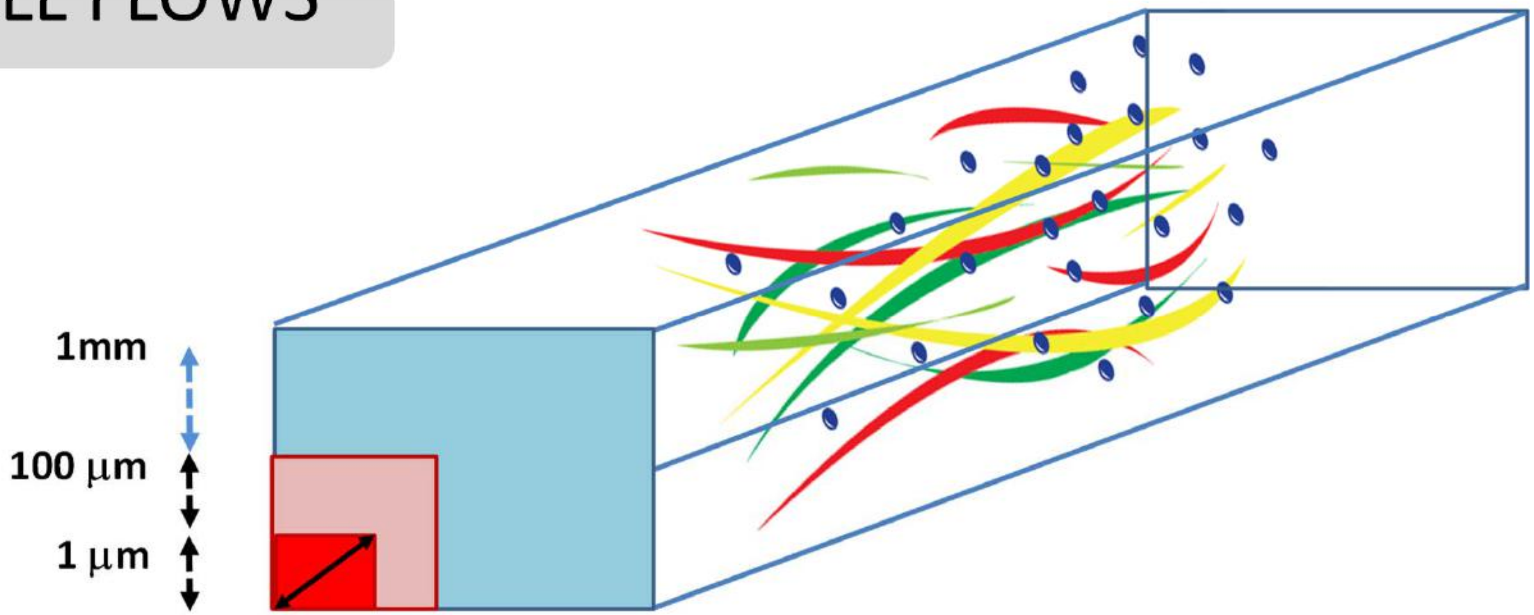
MICRO-OPTOFLUIDIC SYSTEM SET-UP

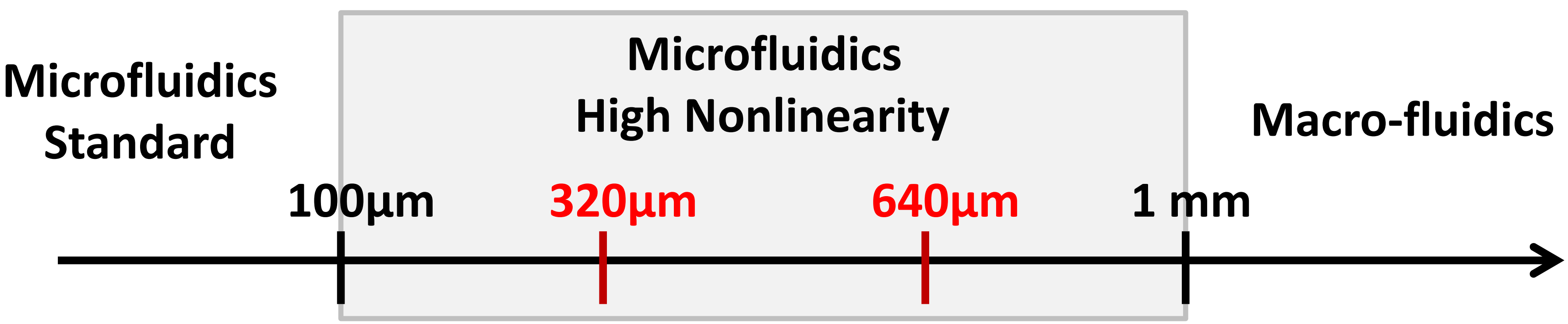




Microfluidics
Two-Phase Flows

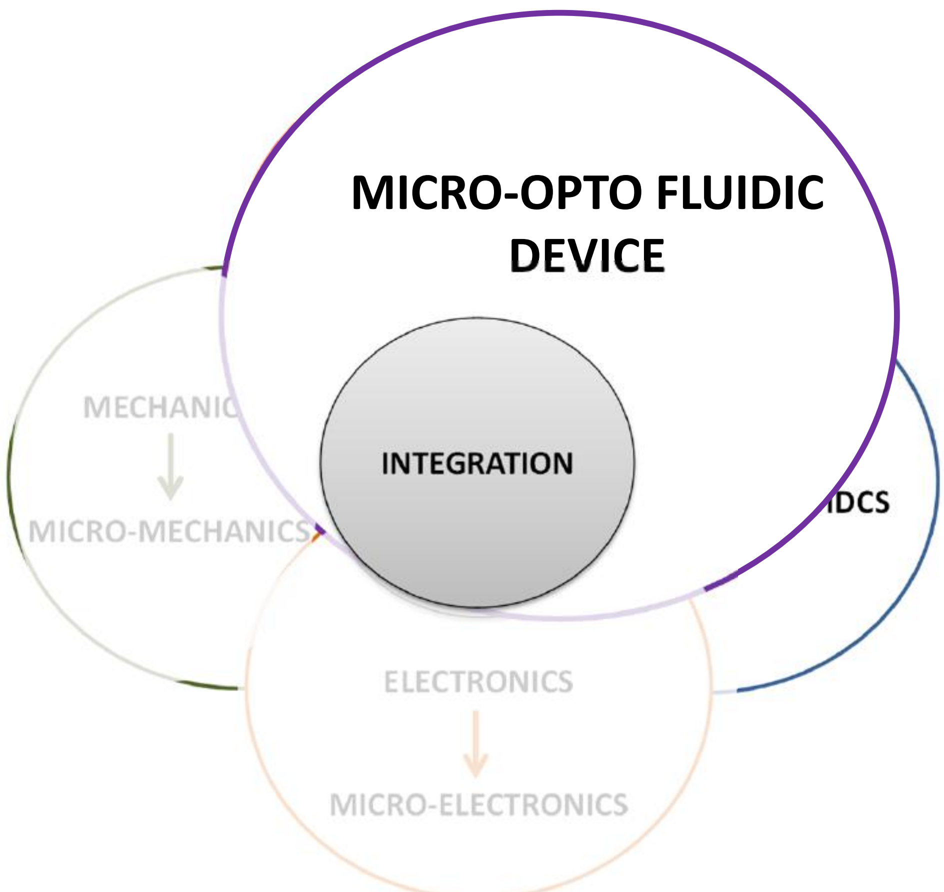






MICRO-OPTOFLUIDICS: DEVICES FABRICATION

3D-PRINTING MASTER-SLAVE PDMS-based Protocol

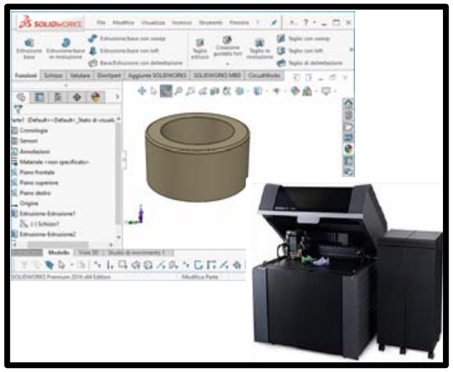


PDMS

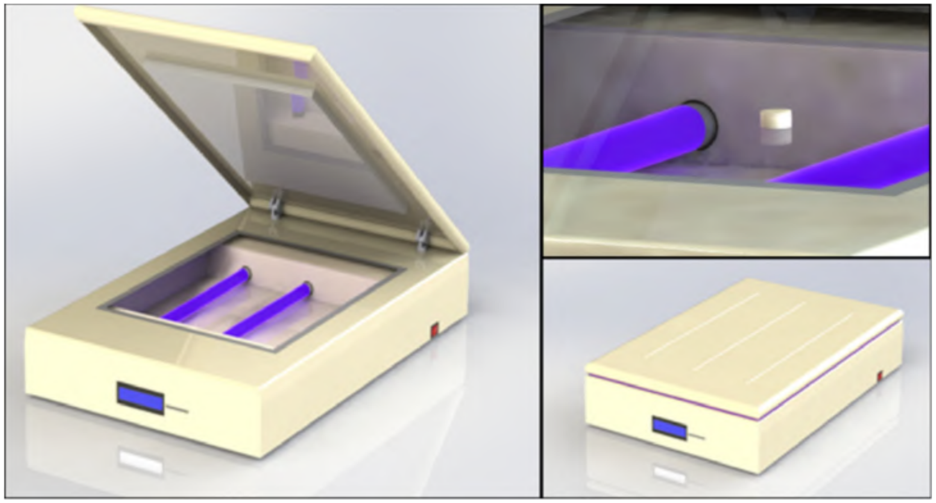
- **TRANSPARANCE**
- **BIOCOMPATIBILITY**
- **OPTICAL PROPERTY**
- **CHEMICAL PROPERTY**
- **CMOS COMPATIBLE**
- **RAPID PROTOTYPE**

MICRO-OPTOFLUIDICS: DEVICES FABRICATION

PDMS MASTER-SLAVE PROTOCOL



Design of the project
and realization by 3D printer



Exposition of master's surfaces to UV-light
for 1 hour at 35°C

Inject liquid PDMS in
the beaker

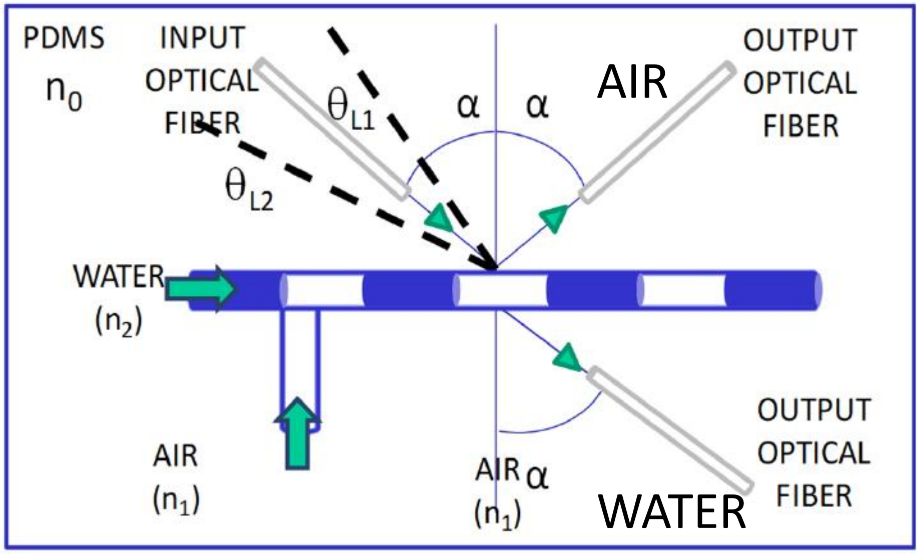
Put the beaker in the
oven for 36 hours

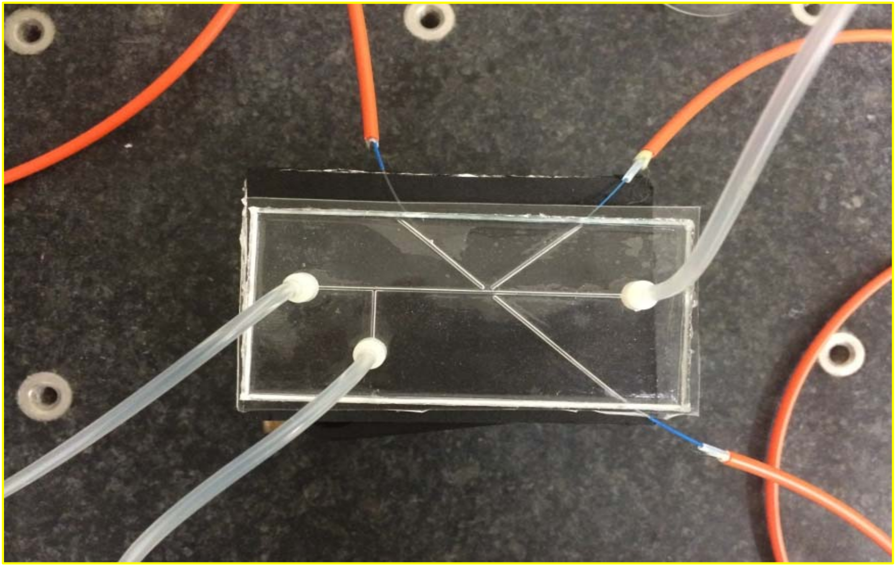
Extraction of the device

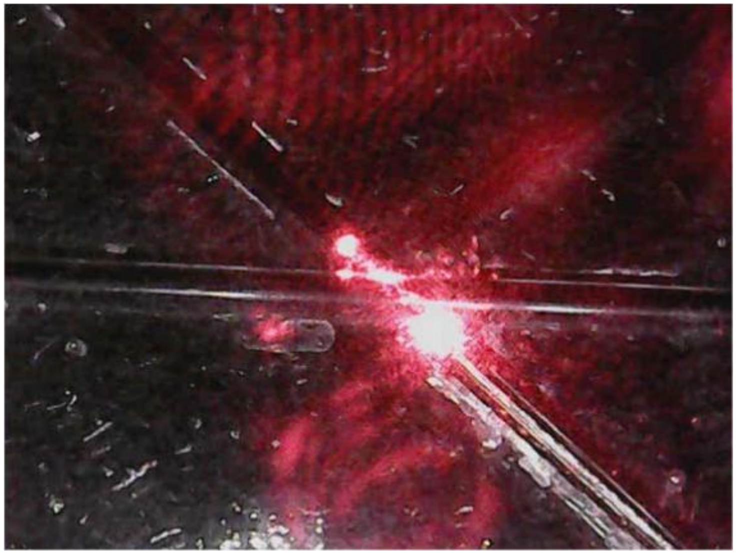
F. Cairone et al, **3D-Printed micro-optofluidic device for chemical fluids and cells detection,** *Biomedical Microdevices, 2020*

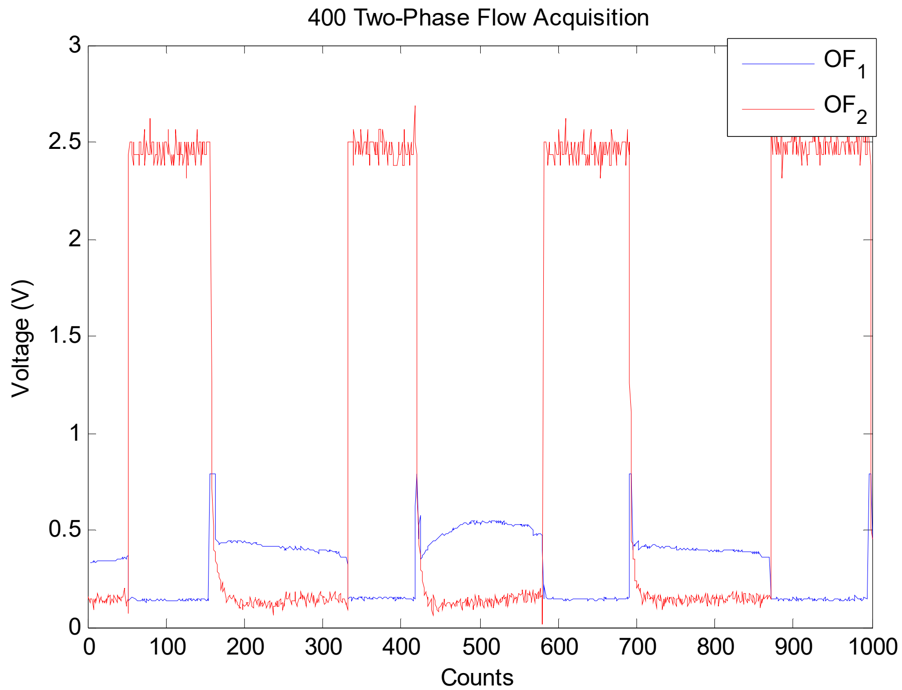
MICRO-OPTOFLUIDC FLOW DETECTOR-1

Chip size 10 cm





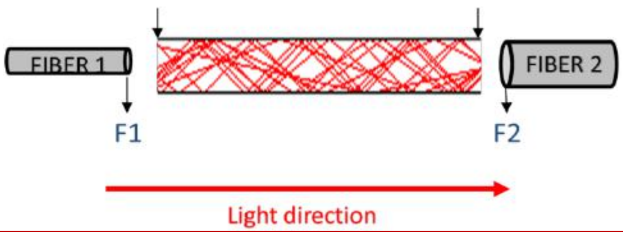


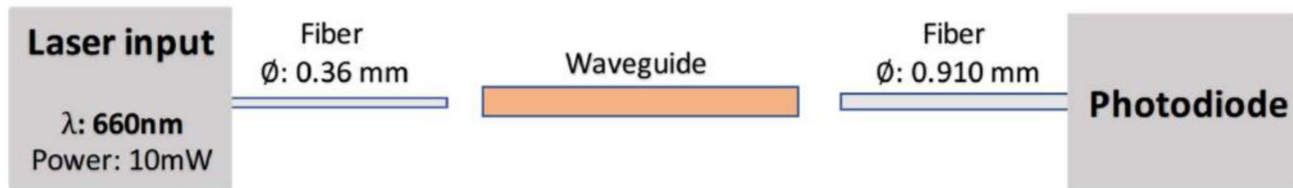


F. Cairone et al, **3D Printed Embedded PDMS Micro-Optofluidics Switch,** *Microfluidics and Nanofluidics ,2016*

MICRO-OPTICAL COMPONENTS

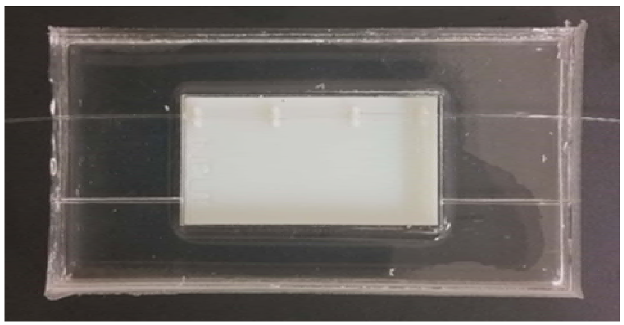
WAVEGUIDE

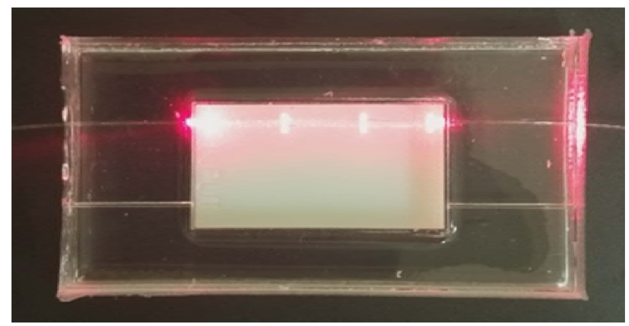




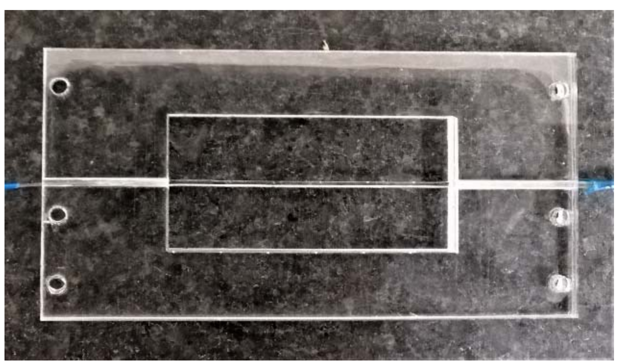
SYSTEM OFF | **SYSTEM ON**

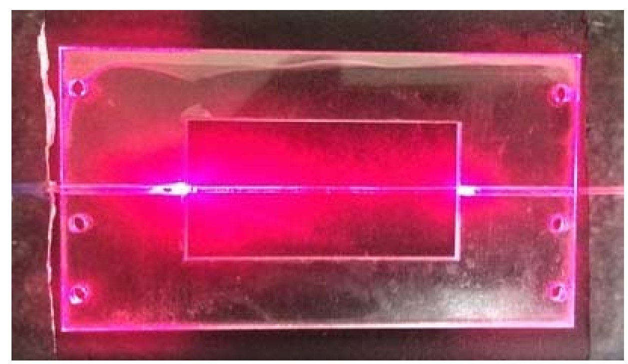
PDMS
3D-PRINTING





PMMA
LASER CUTTING

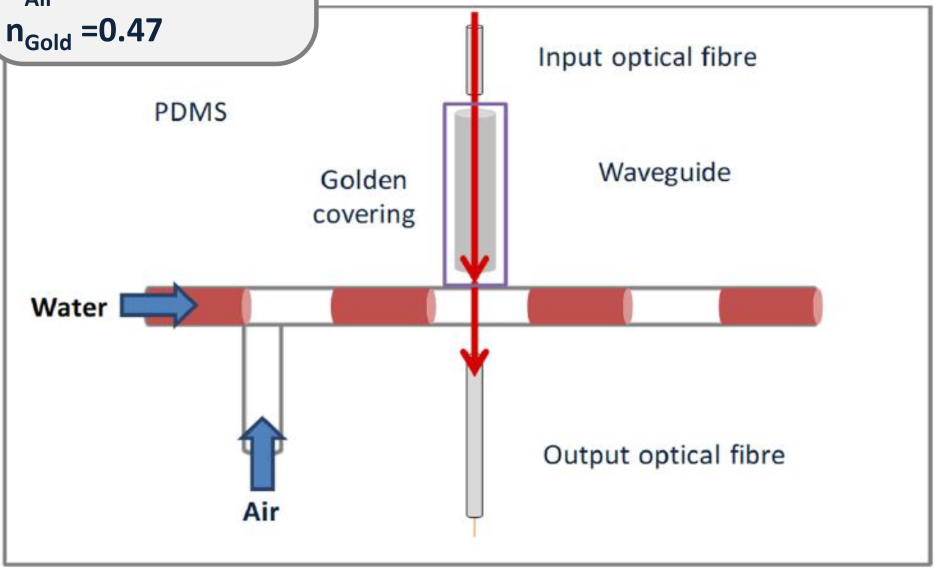


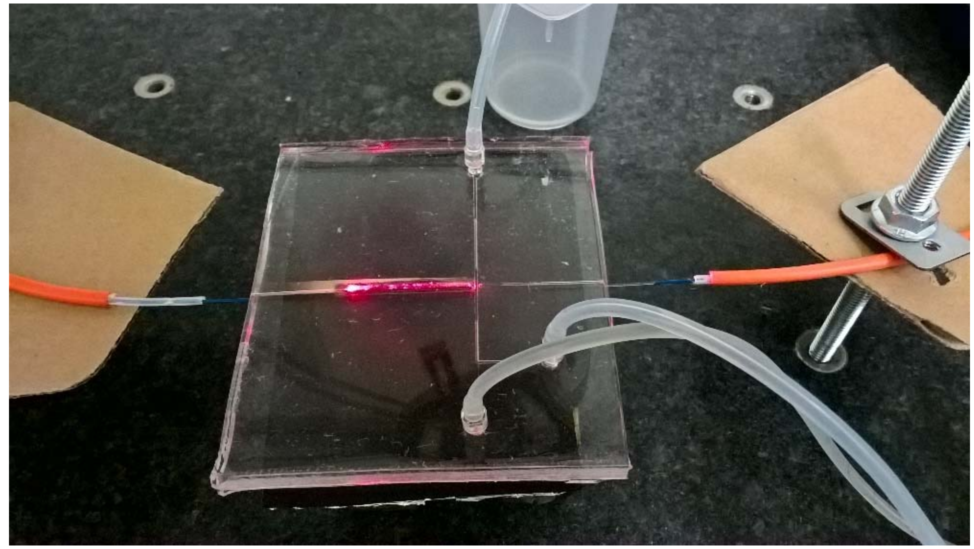


F. Cairone et al, **Micro-Optical Waveguides Realization by Low-Cost Technologies,** *Micro, 2022*

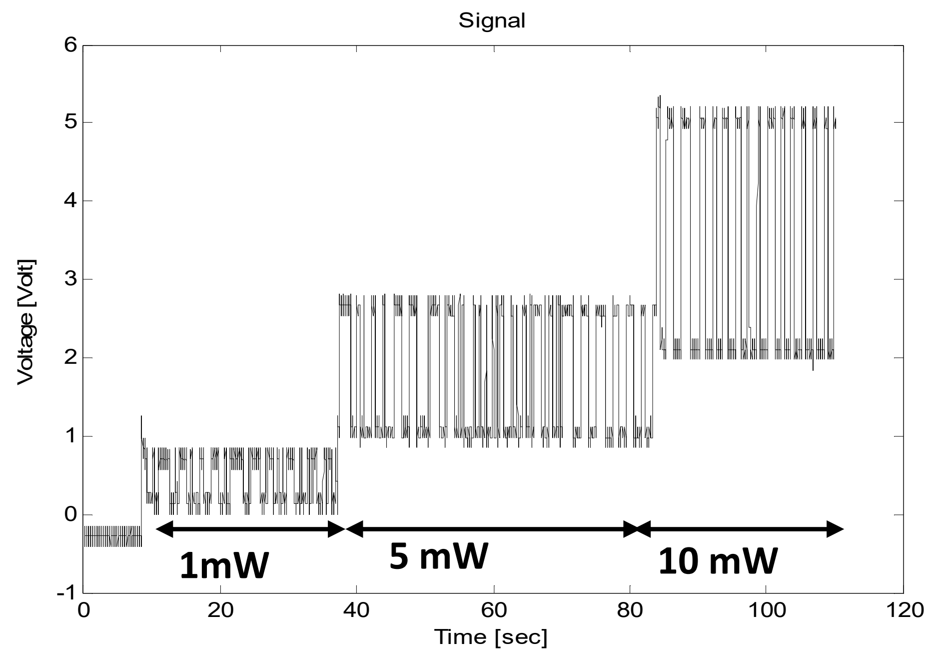
MICRO-OPTOFLUIDC FLOW DETECTORS-2

Refractive index
n_{PDMS} =1.41
n_{Water} = 1.33
n_{Air} =1
n_{Gold} =0.47





Water 0,15 ml/mm –Air 0,3 ml/mm



F. Cairone et al, **3D-Printed micro-optofluidic device for chemical fluids and cells detection,** *Biomedical Microdevices, 2020*

MICRO-OPTOFLUIDC FLOW DETECTORS-2

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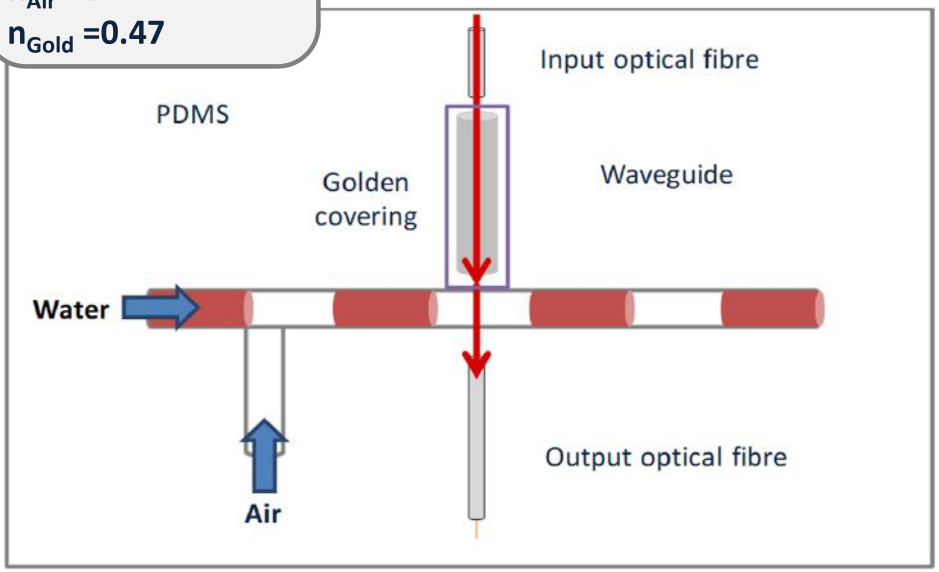
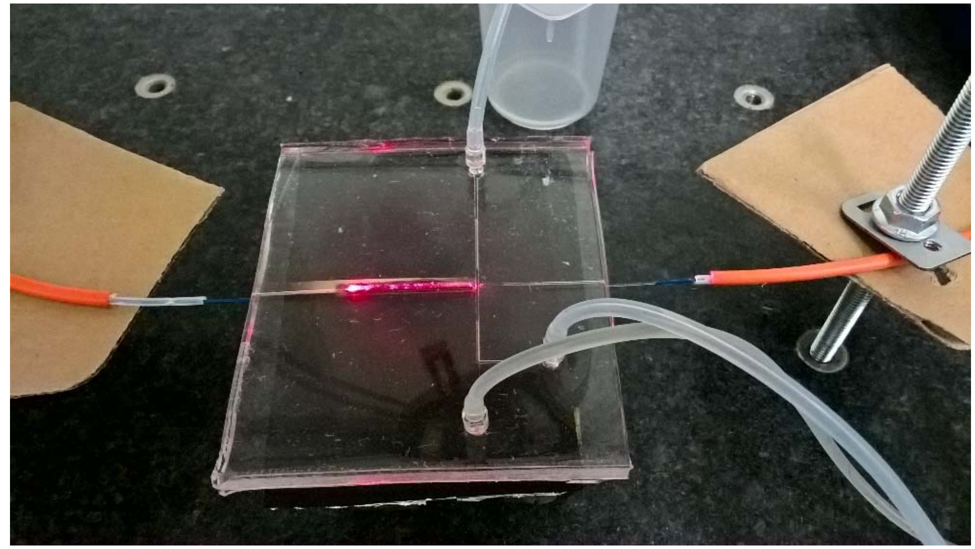
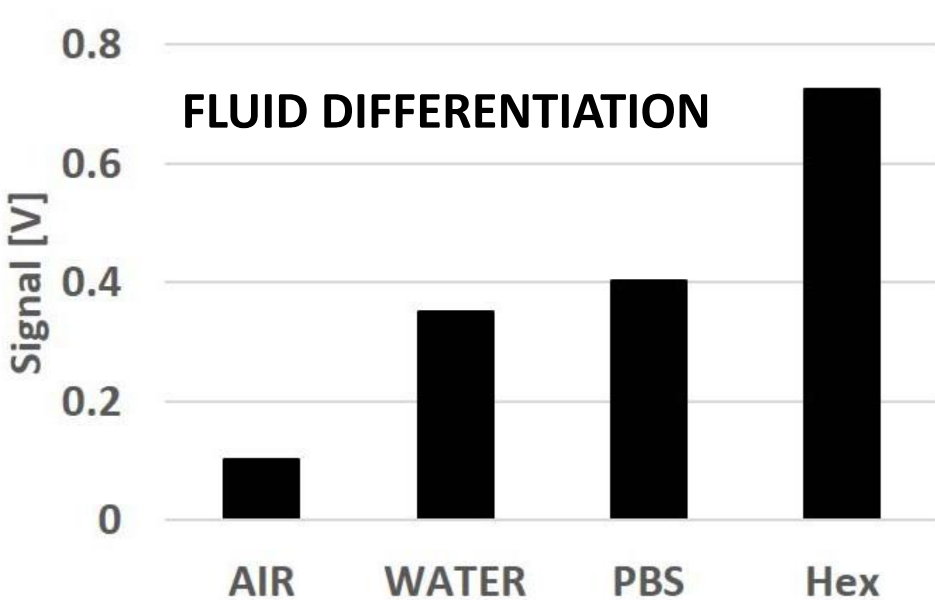
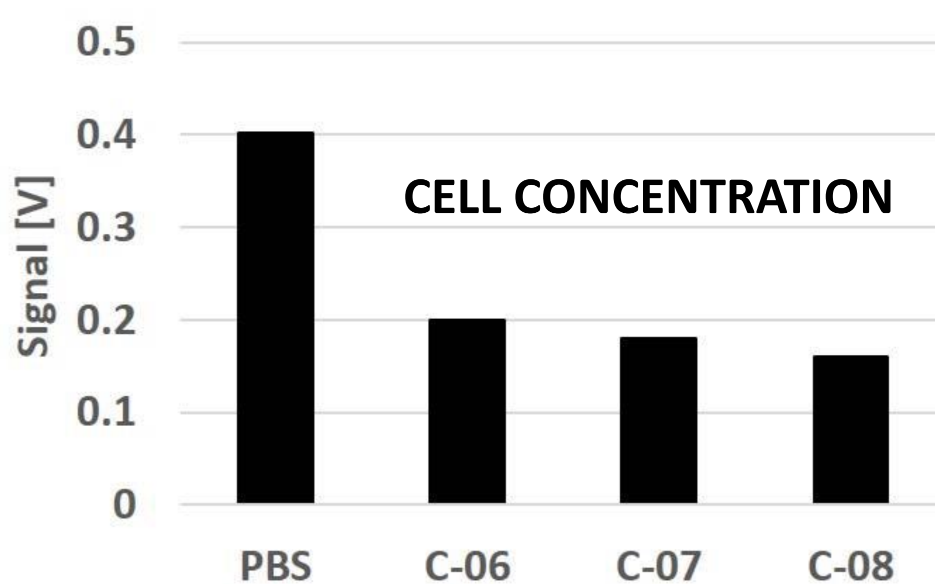




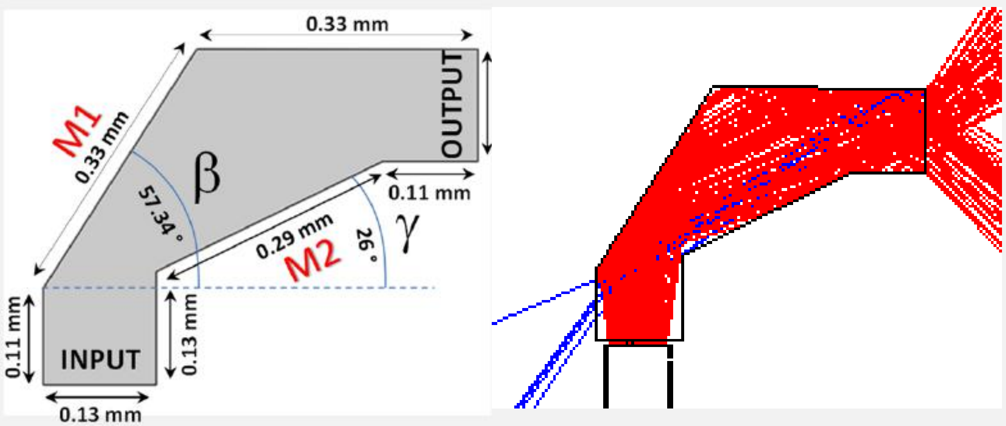




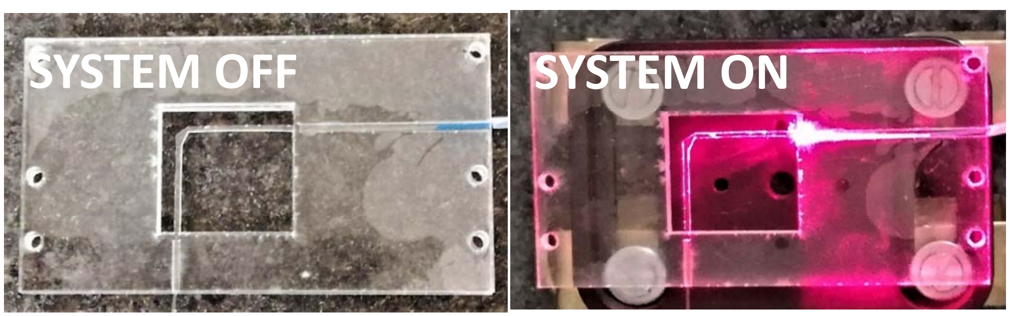
F. Cairone et al, **3D-Printed micro-optofluidic device for chemical fluids and cells detection,** *Biomedical Microdevices, 2020*

MICRO-OPTICAL COMPONENTS

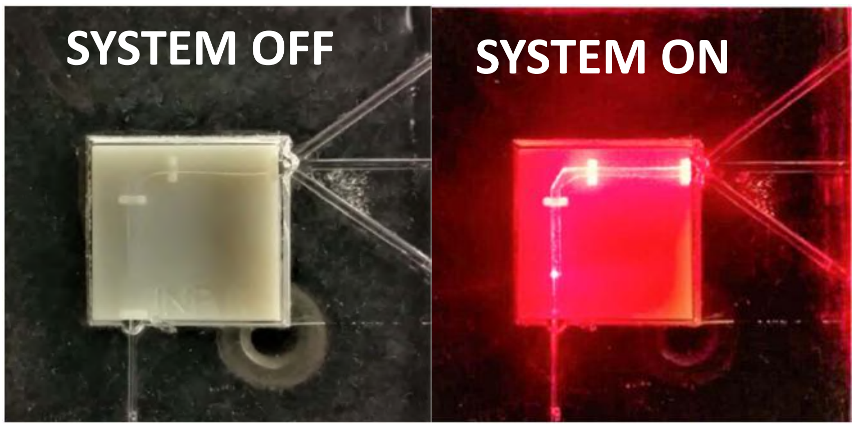
OPTICAL SPLITTER



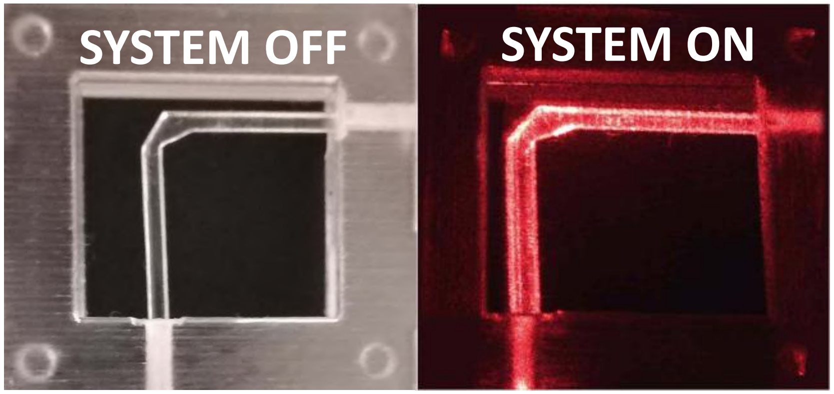
PMMA –LASER CUTTING



PDMS MASTER-SLAVE

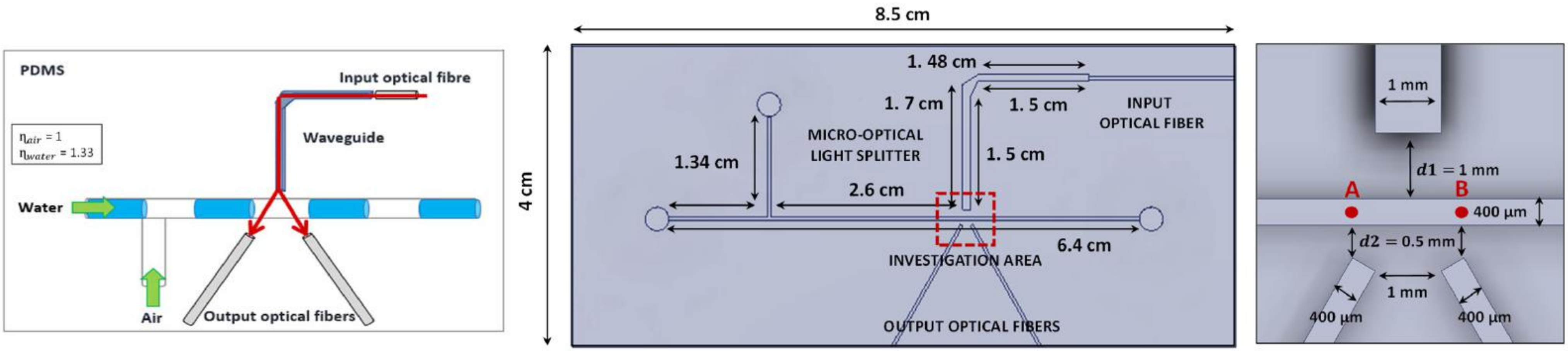


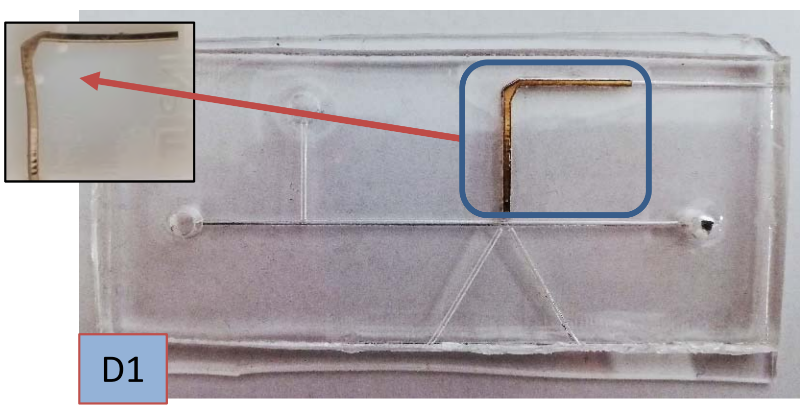
VERO-CLEAR DIRECT PRINTING



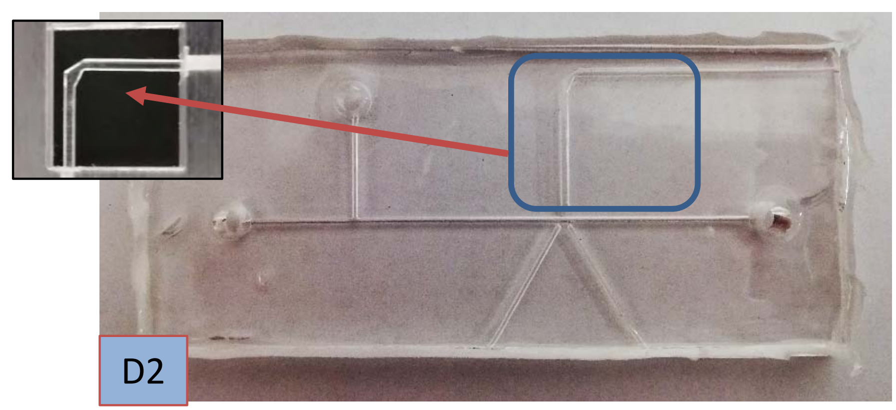
G. Stella et al, **Advanced technologies in the fabrication of a micro-optical light splitter,**. *Micro , 2023*

MICRO-OPTOFLUIDC VELOCITY DETECTOR





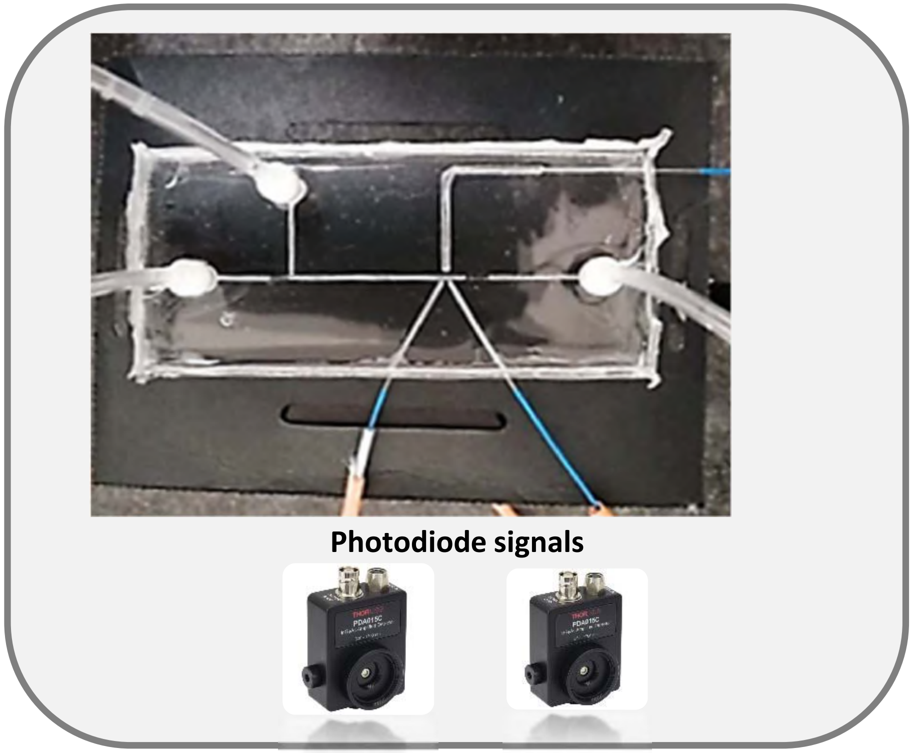
PDMS micro-optofluidic velocity detector with gold-PDMS micro-splitter.

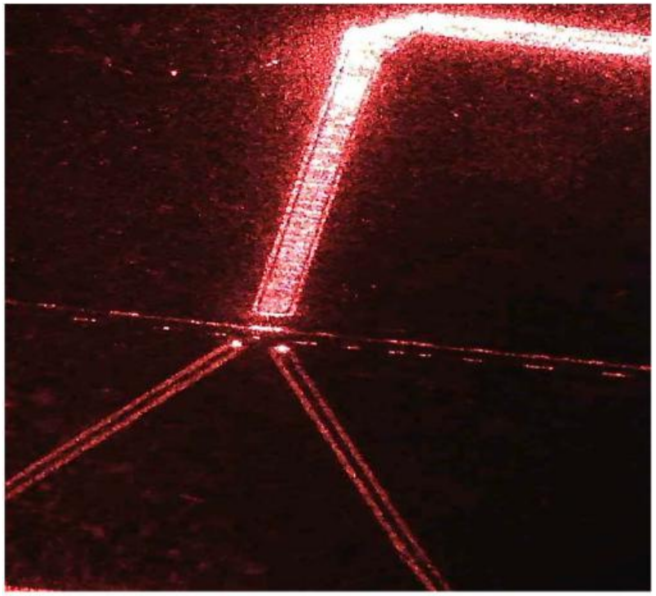


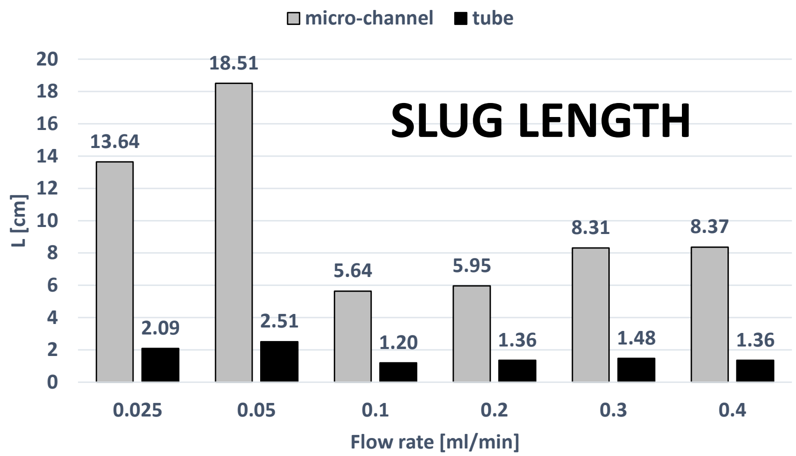
PDMS micro-optofluidic velocity detector with 3D printed micro-splitter.

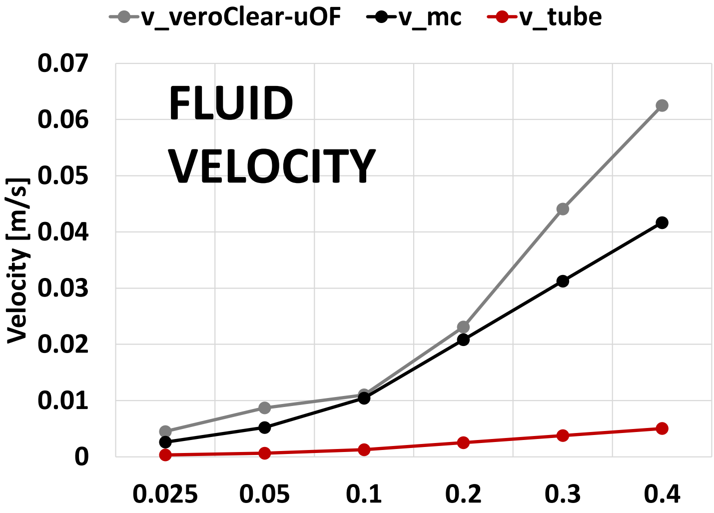
G. Stella et al, **3D-Printed Micro-Optofluidic Slug Flow Detector,** *IEEE SENSOR JORNAL, 2024*

MICRO-OPTOFLUIDC VELOCITY DETECTOR

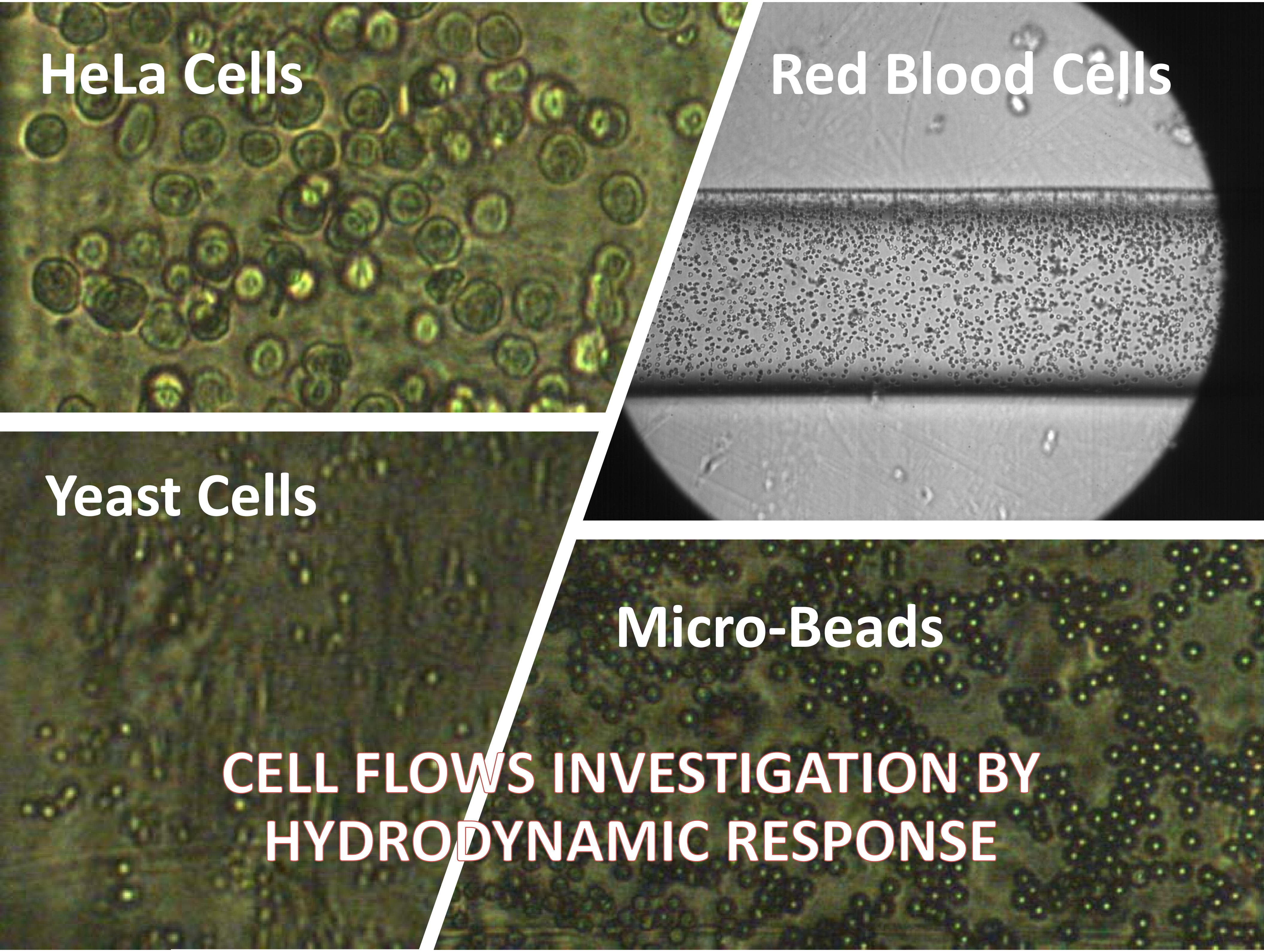




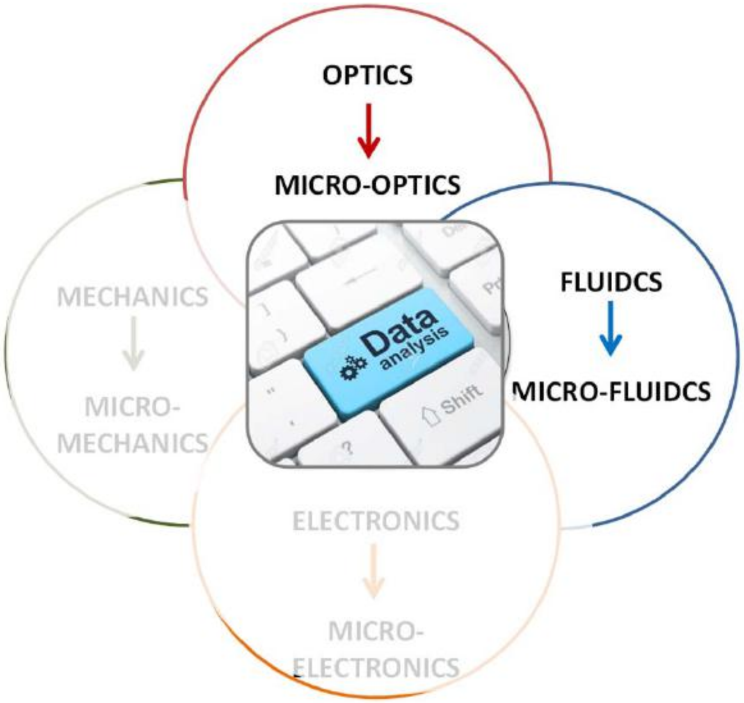




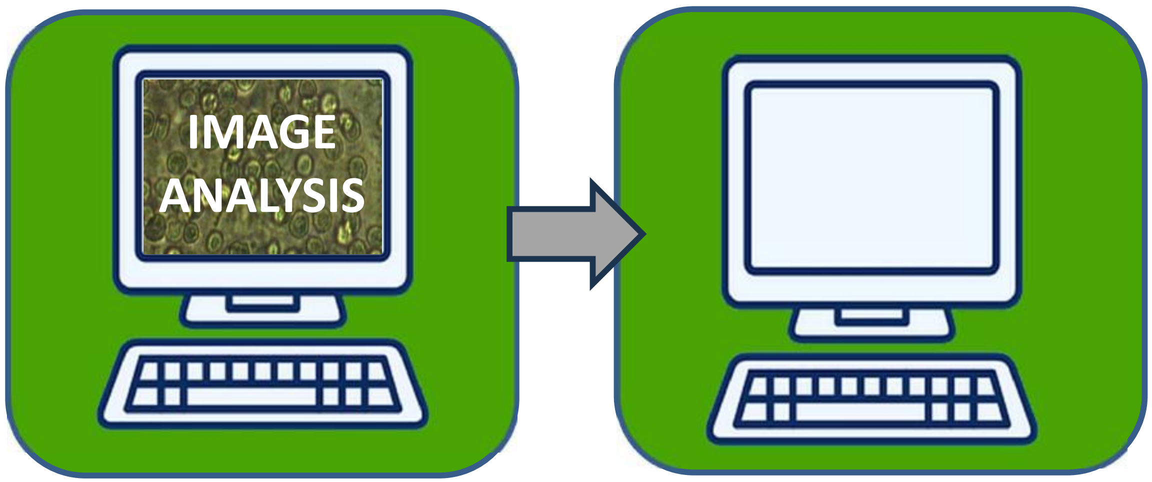
G. Stella et al, **3D-Printed Micro-Optofluidic Slug Flow Detector,** *IEEE SENSOR JORNAL, 2024*


HeLa Cells
Red Blood Cells
Yeast Cells
Micro-Beads
CELL FLOWS INVESTIGATION BY
HYDRODYNAMIC RESPONSE

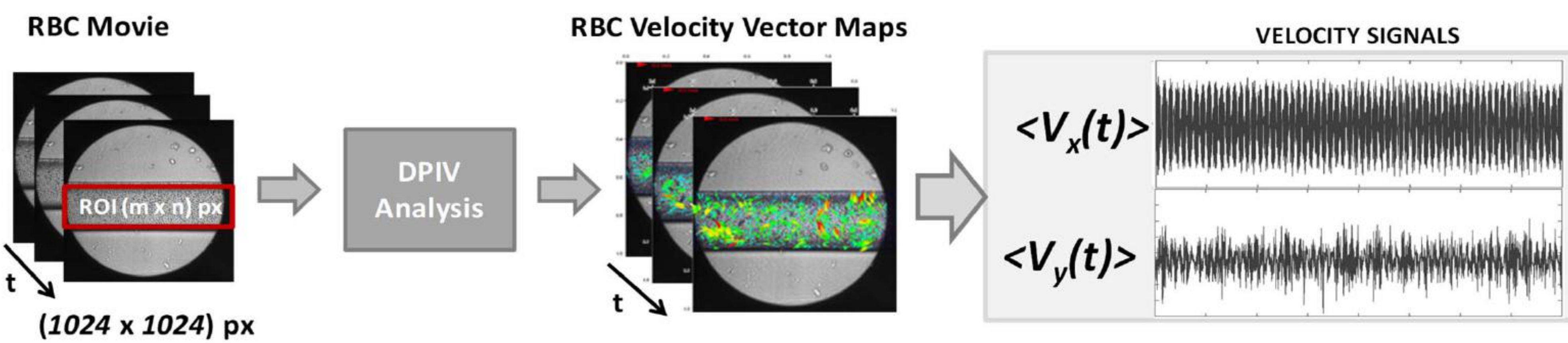
WHAT WE NEED ....



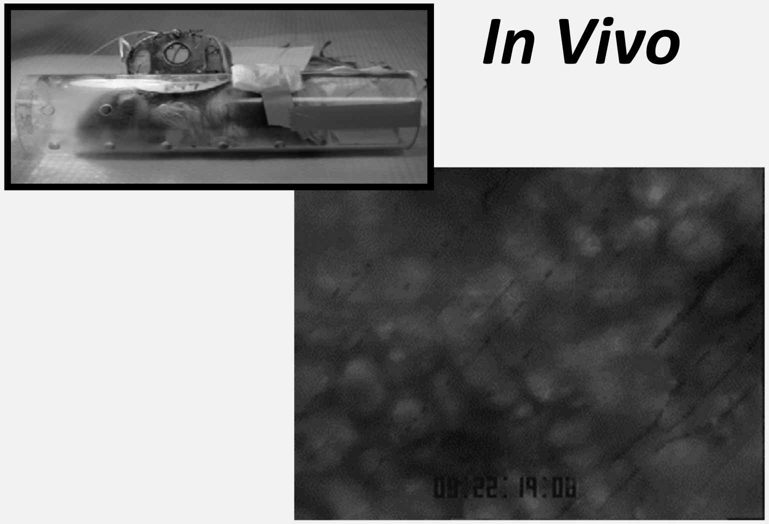
DETECTION



Ad-hoc Digital Particle Image Velocimetry (DPIV) Algorithm



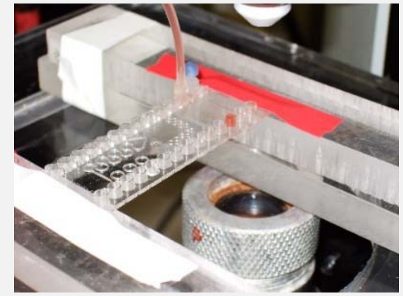
DETECTION OF **RBCs FLOWS**

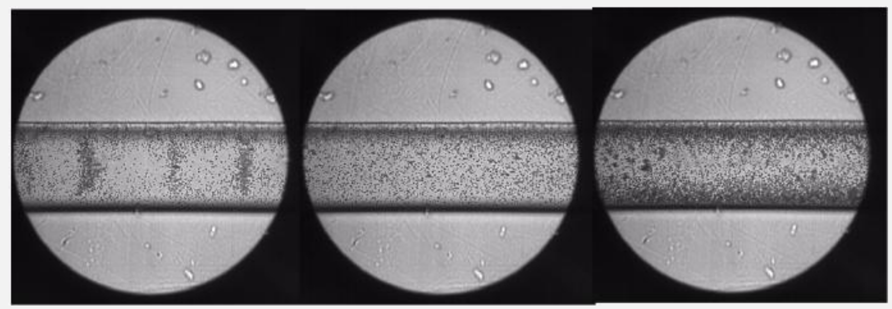


In Vivo

TRACKING RBCs VELOCITY IN MICROVESSELS NETWORKS

In Vitro





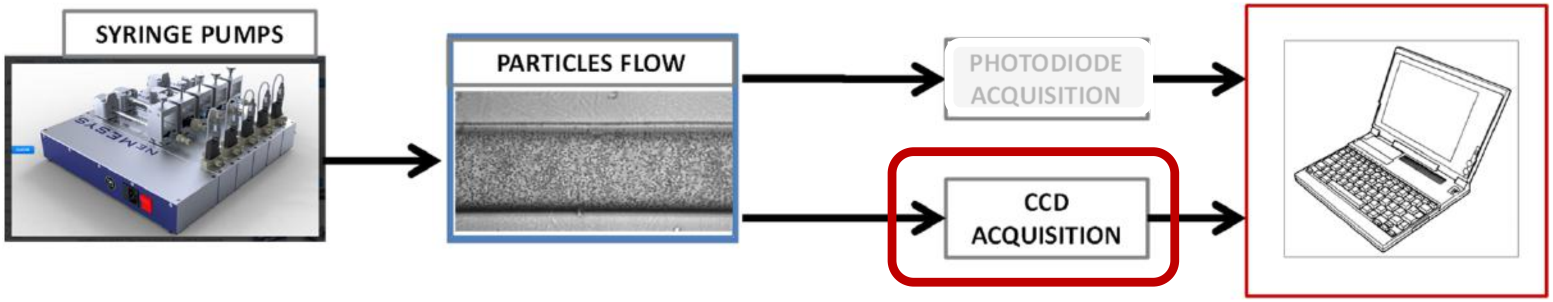
BEHAVIOURAL INVESTIGATION OF RBCs IN LOW CONCETRATION

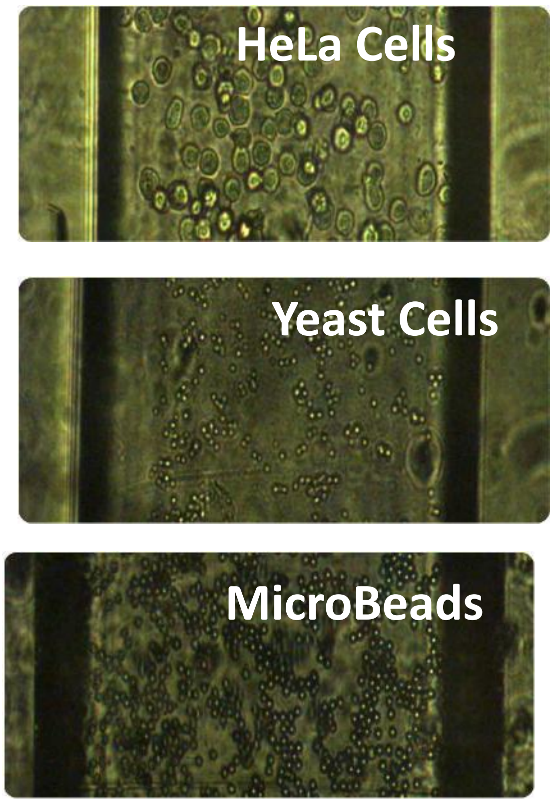
F. Cairone et al., **Quantitative Analysis of Spatial Irregularities in RBCs Flows**, Chaos Solitons and Fractals (2018)

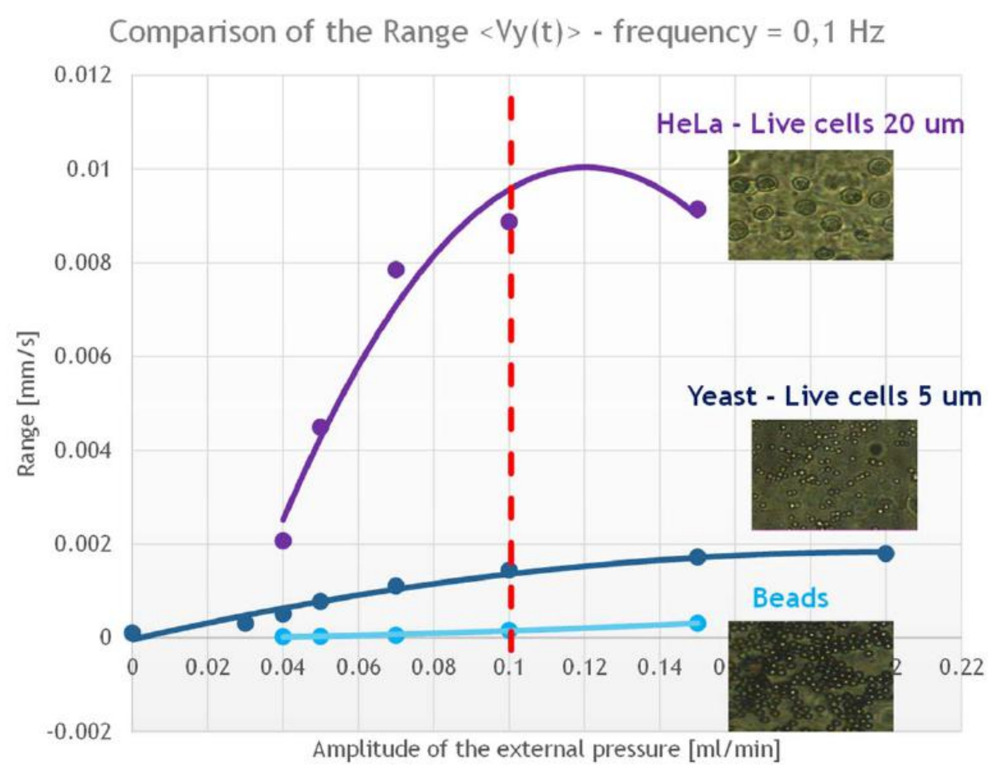
F. Cairone et al., **Emergent Behaviors in RBCs Flows in Micro-Channels using Digital Particle Image Velocimetry**, Microvascular Research, 2017

F. Sapuppo et al. , **Microfluidics real-time monitoring using CNN technology**' IEEE Trans. on Biom. Circuits and Systems 2008

CLASSIFICATION OF **CELL FLOWS**

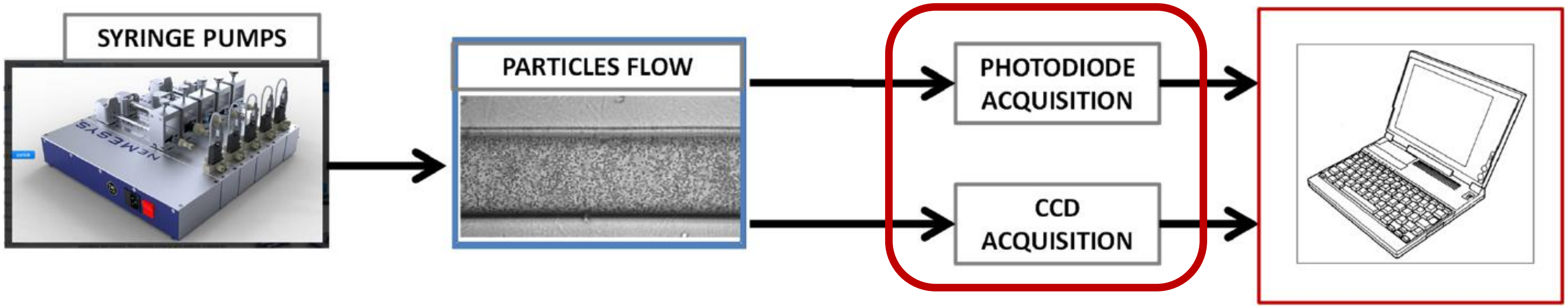


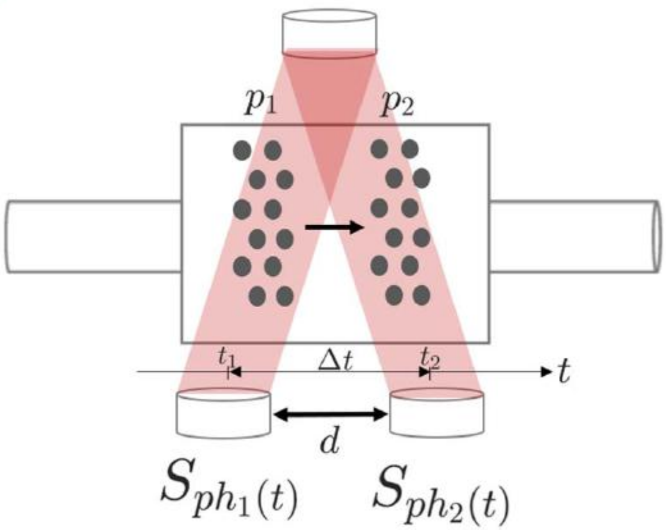


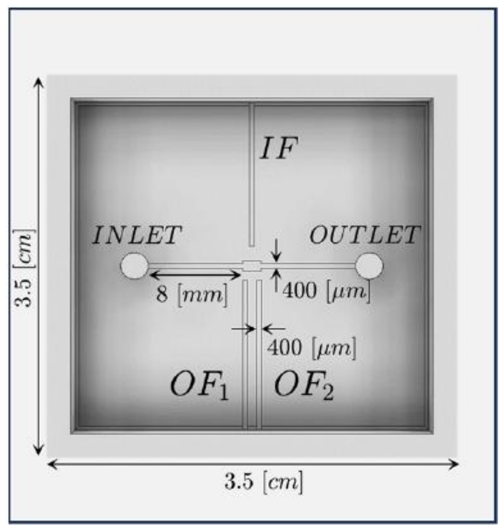


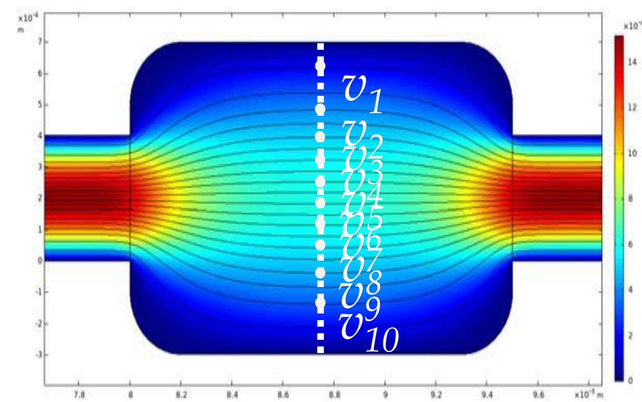
G. Stella et al., **Cell counting and velocity algorithms for hydrodynamic study of unsteady biological flows in micro-channels**, Biomicrofluidics, 2022

MICRO-OPTOFLUIDC CHAMBER



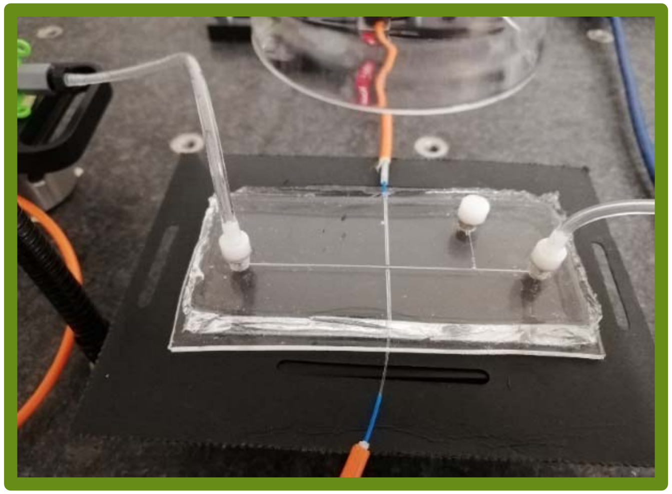


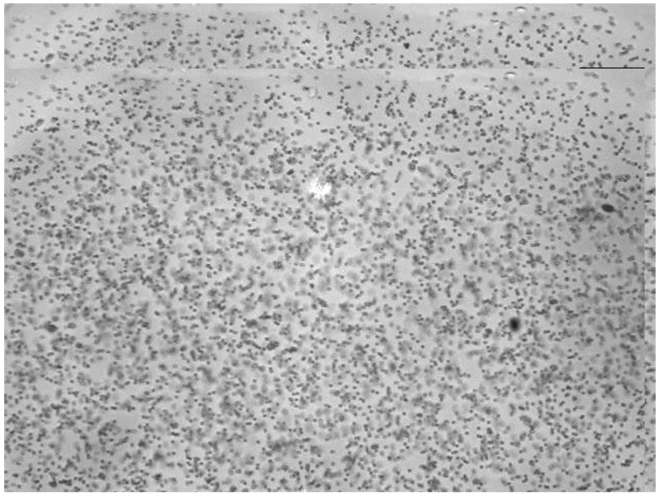


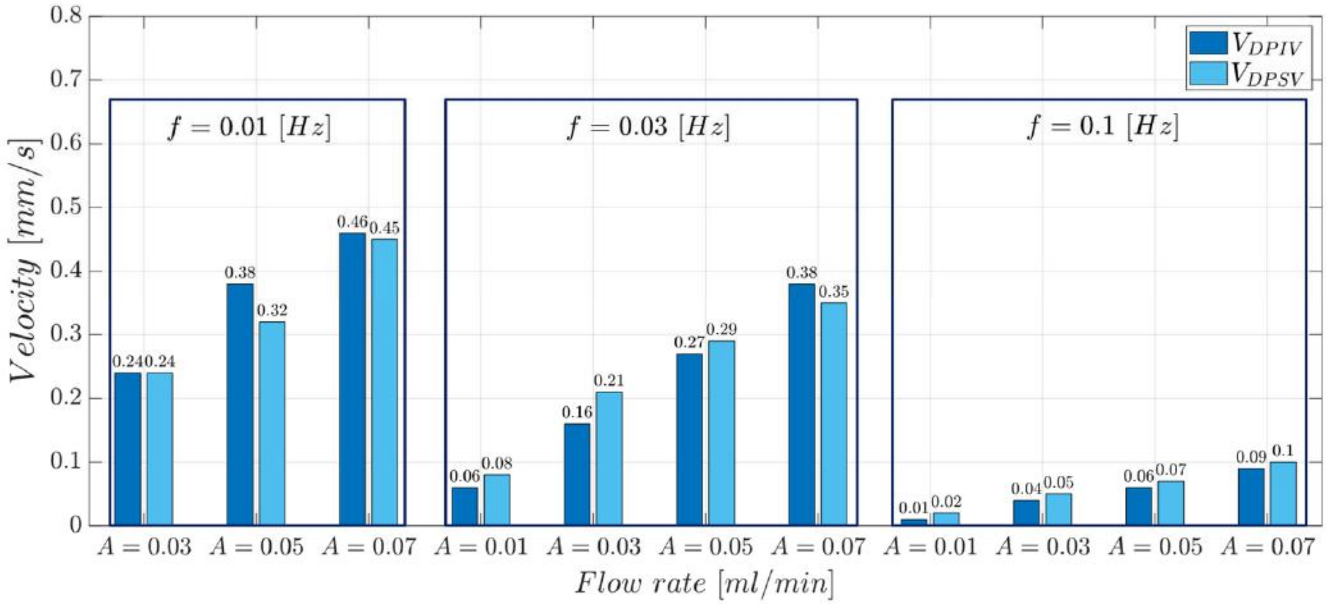


E. Cutuli et al., **A 3D-Printed Micro-Optofluidic Chamber for Fluid Characterization and Microparticle Velocity Detection**, Micromachine, 2023

MICRO-OPTOFLUIDC CHAMBER







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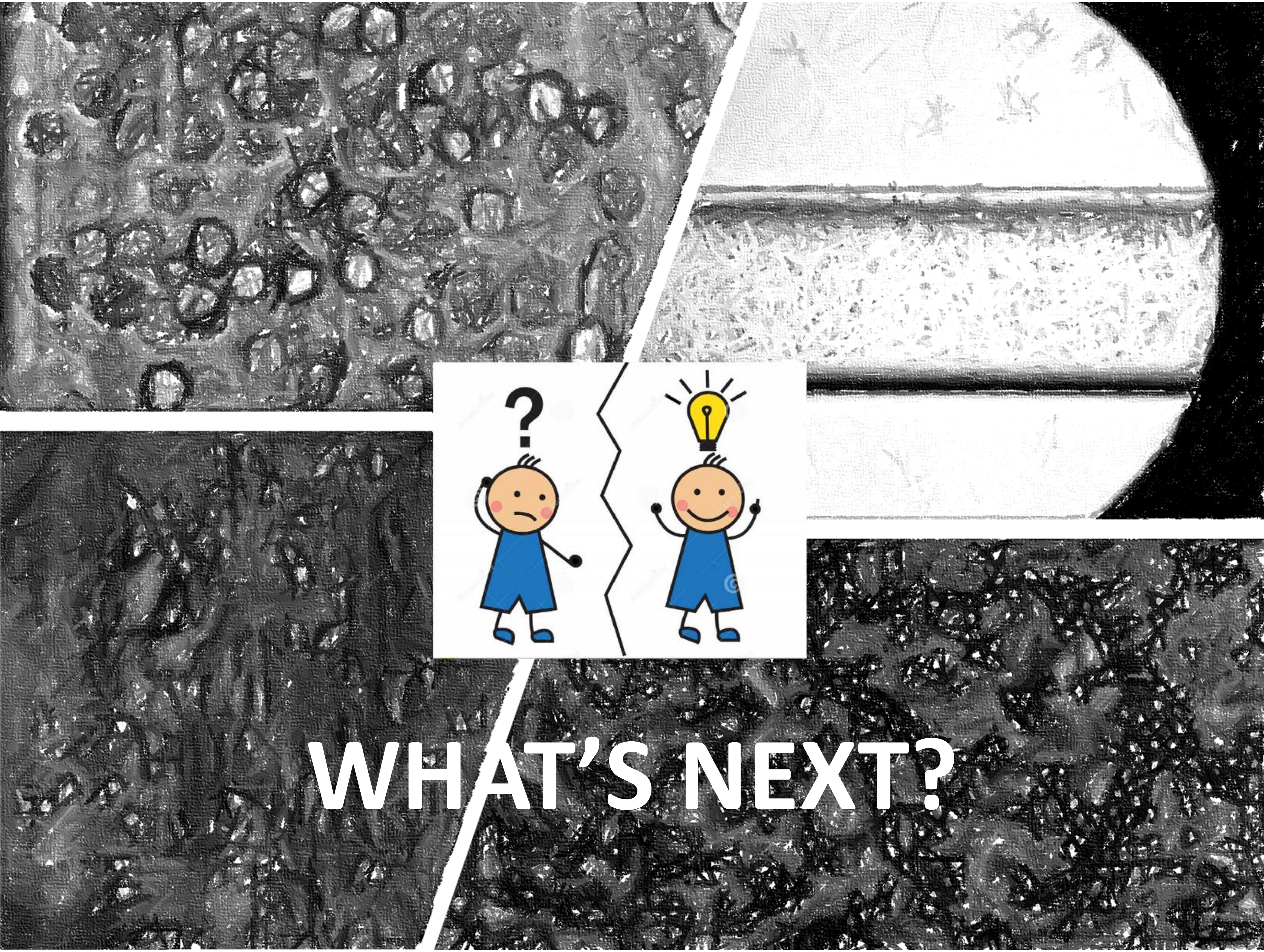
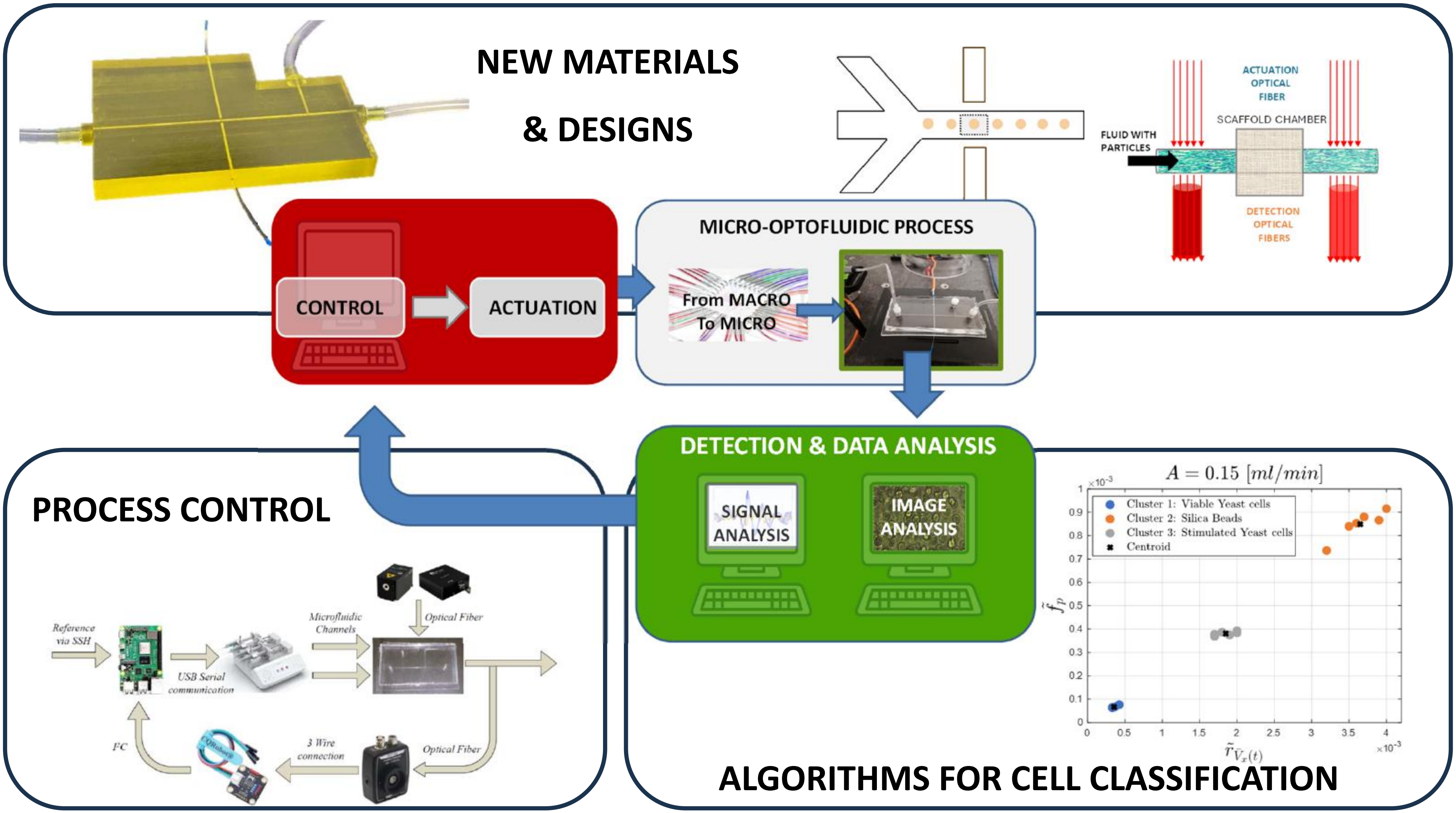

WHAT’S NEXT?



L. Saitta et al., **Projection Micro-Stereolithography to Manufacture a Biocompatible Micro-Optofluidic Device for Cell Concentration Monitoring**, Polymers, 2023

S. Moscato et al. , **Model Predictive Control framework for slug flow microfluidics processes Polymer**, Control Engineering Practice, 2024

E. Cutuli et al., **Automatic Label-Free Classification of Viable Cell on-a-Chip**, Biomedical Signal Processing and Control,

MATERIALS & FABRICATION

L. Saitta et al., **A Regression Approach to Model Refractive Index Measurements of Novel 3D Printable Photocurable Resins for Micro-Optofluidic Applications**, Polymers, 2023

G. Stella et al., **3D Printing Manufacturing of Polydimethyl-Siloxane/Zinc Oxide Micro-Optofluidic Device for Two-Phase Flows Control** , Polymers, 2022

L. Saitta et al. , **Projection micro-stereolithography versus master–slave approach to manufacture a micro-optofluidic device for slug flow detection**, International Journal of Advanced Manufacturing Technology, 2022

PROCESSES CONTROL

S. Gagliano et. al. , **A Real Time Feed Forward Control of Slug Flow in Microchannels,** Energies, 2019

MIICROFLUIDC SLUG PROCESSES

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THANKS

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