

University of Minho  
School of Engineering  
R&D Centre Algoritmi  
Dept. Industrial Electronics



# LAB-ON-A-CHIP for SPECTROPHOTOMETRIC ANALYSIS of BIOLOGICAL FLUIDS

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- **MOTIVATION and OBJECTIVES**
- **THIS BIOLOGICAL MICROSYSTEM ADVANTAGES**
- **LAB-ON-A-CHIP CONCEPT**
- **LAB-ON-A-CHIP DESIGN and FABRICATION**
  - Microfluids
  - Optical Filters
  - Detection and Readout Electronics
- **EXPERIMENTAL RESULTS**
- **CONCLUSIONS**



## Prevention, diagnostic and disease treatment

- Biochemical analysis of biological body fluids by spectrophotometry
- Carried out in clinical analysis laboratories



## Disadvantages of nowadays clinical analysis systems

- Results become available after several hours (days)
- Mistakes in logistics: lost samples and mislabeling



## Automated equipment



- Reduce errors
- High sample and reagent volumes
- Analysis system expensive
- Does not contribute to patient comfort



## Reagent strips



- Available for a limited set of biomolecules to be analyzed
- Color readout is merely qualitative



## Lab-on-a-chip to quantify the concentration of the biomolecules in biological fluids

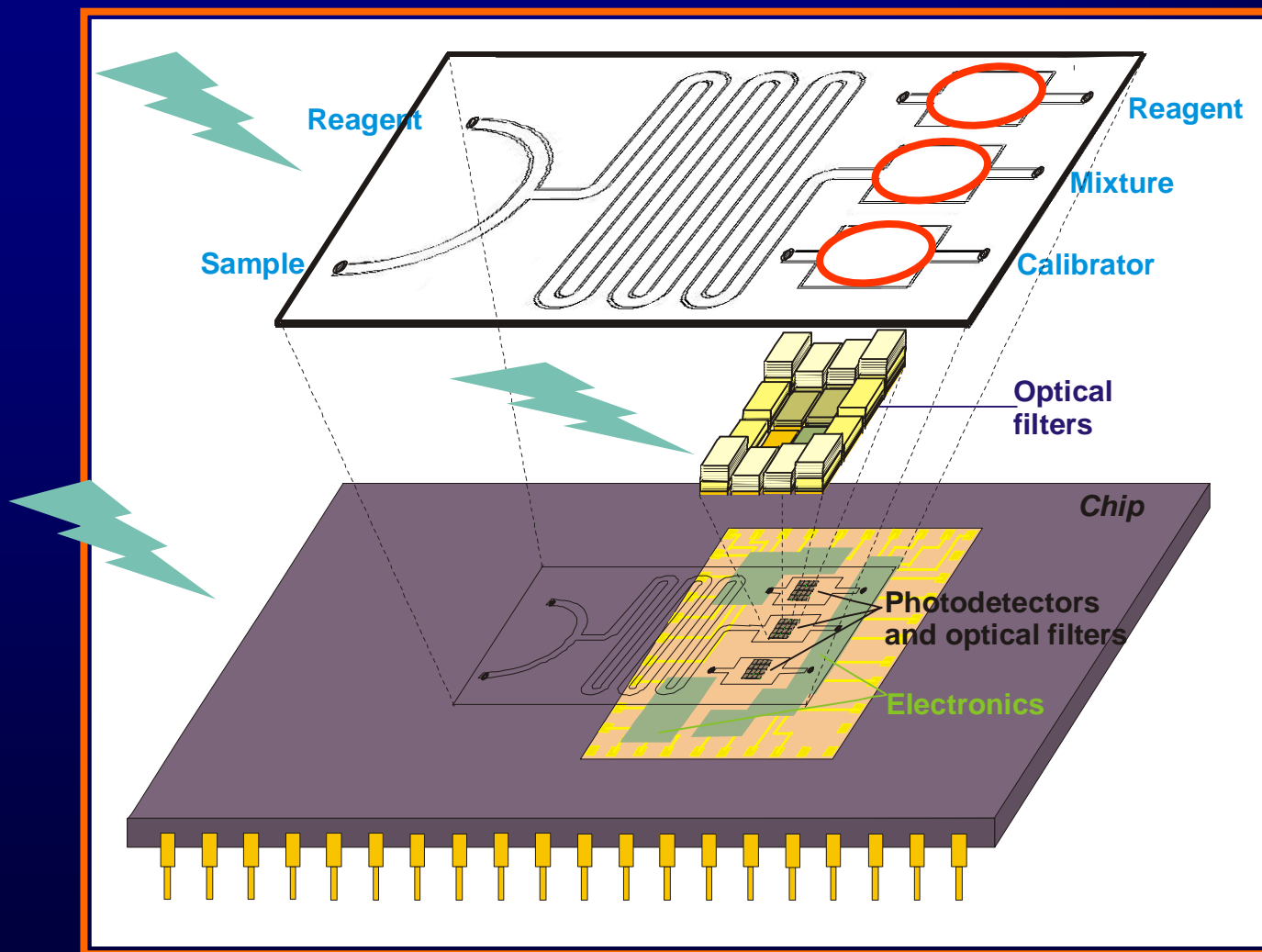
- Colorimetric detection by optical absorption
- Instantaneous, reliable and precise results
- Portable
- Patient comfort
- Small size
- Low cost analysis system
- Better quality in the health care services



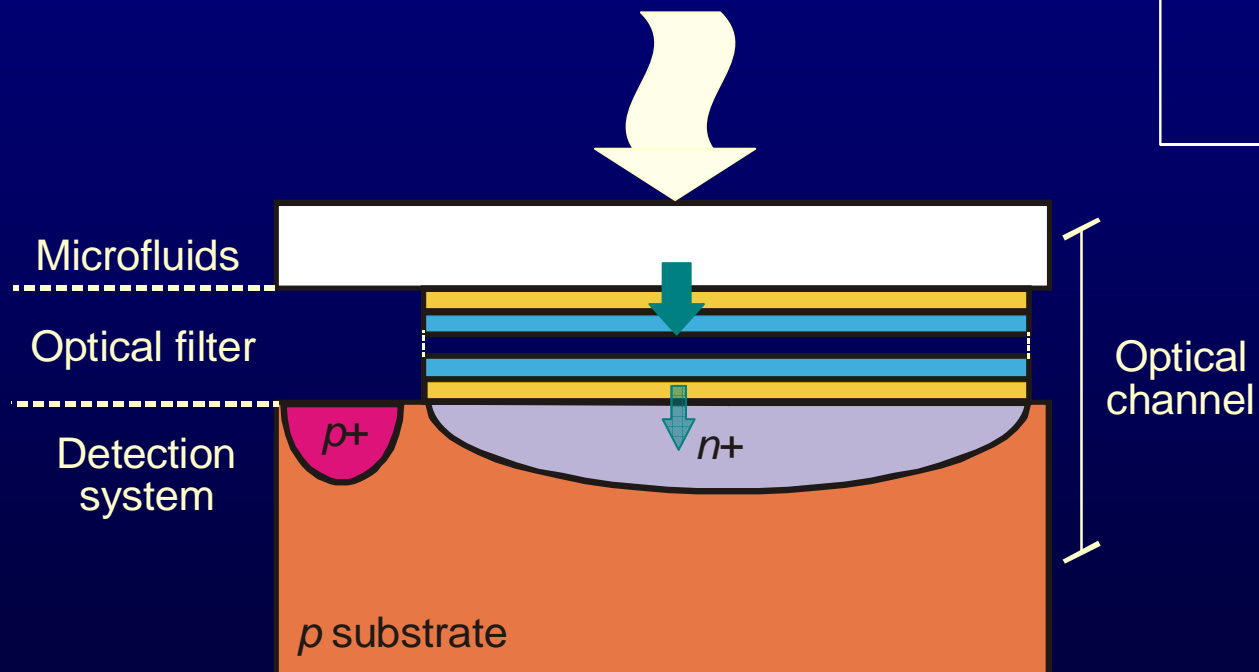
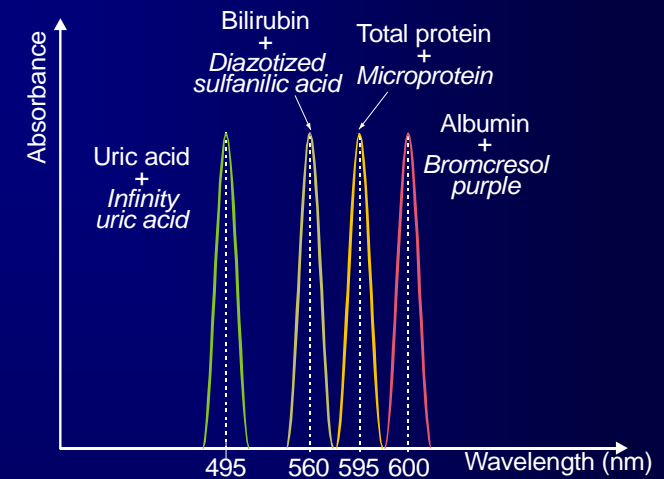
- Small size, low consumption and portability
  - In-situ measurements
  - Analytical testing times and costs reduced
  - Instantaneous results
  - Low quantities of reagents and samples
  - Reduction of the cost associated with the destruction of the used samples and reagents
  
- Low cost for high-volume production equipment
  
- Improve laboratory safety

# LAB-ON-A-CHIP CONCEPT

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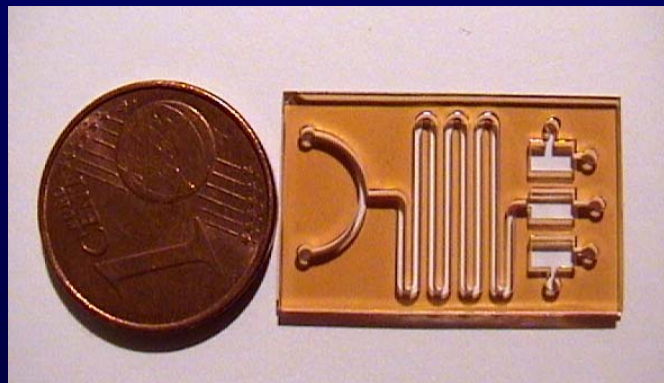
# LAB-ON-A-CHIP OPERATION





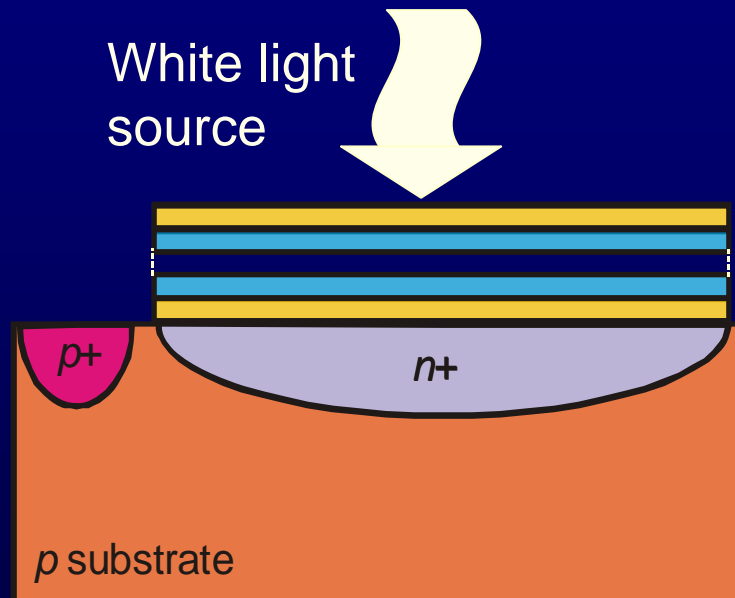
## Microchannels fabricated using SU-8 photoresist techniques

- Low-cost and biocompatible process
- UV lithography semiconductor compatible (transparency foil mask)
- Microchannels with very low roughness → suitable for optical absorption measurements





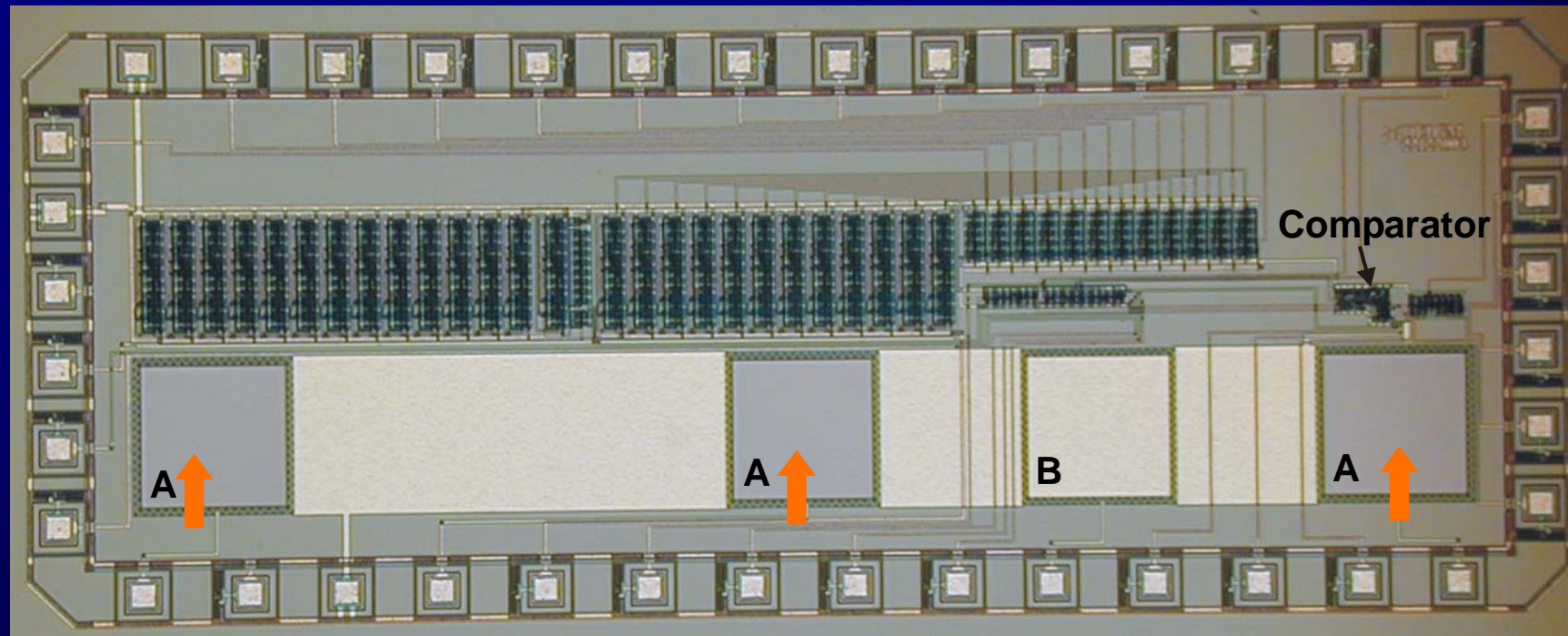
## Portability



- Structurally optimized for:
  - high transmittance
  - high selectivity (low **FWHM**)
- FP thin-films optical resonators with dielectric mirrors ( $\text{TiO}_2$  and  $\text{SiO}_2$ )
- High reflectivity with low absorption losses

Layers post-processed on top of the photodiodes by Ion Beam Deposition (IBD)

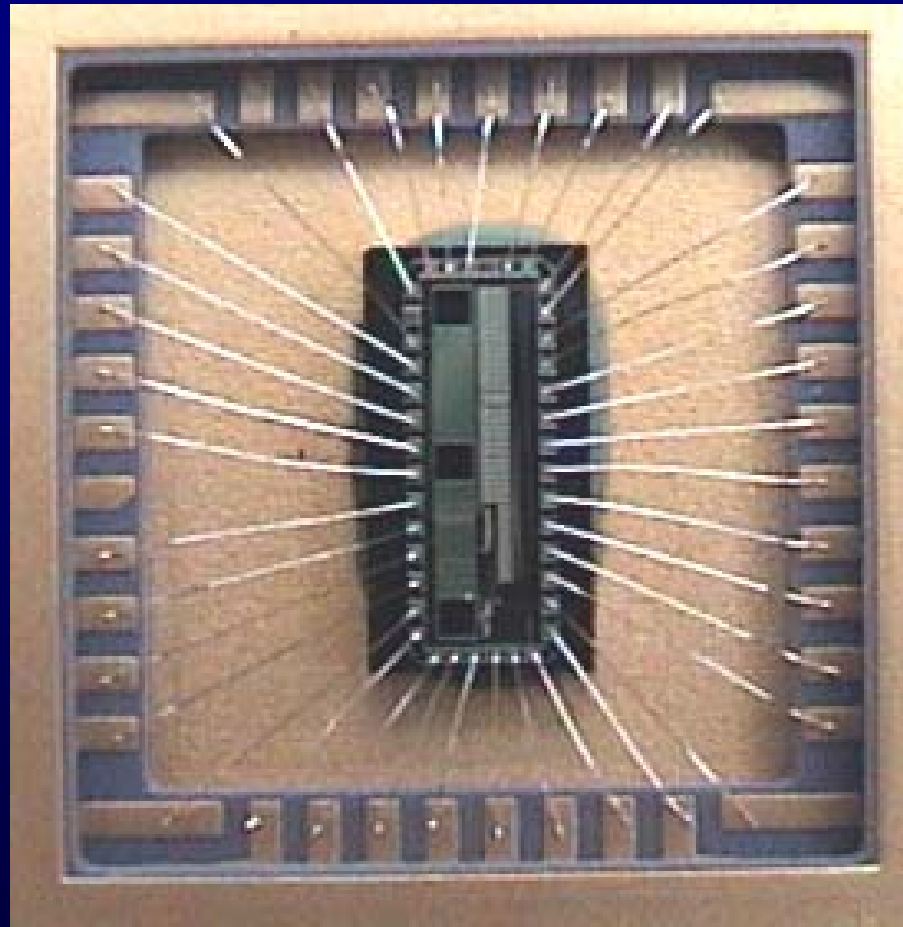
# DETECTION and READOUT



- 1.6  $\mu\text{m}$  n-well CMOS standard process, with double-metal and single-polysilicon
- Each optical channel area is  $500 \mu\text{m} \times 500 \mu\text{m}$

# CMOS CHIP

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## Light-to-frequency converter



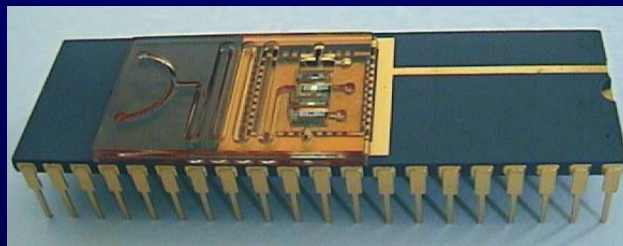
Light intensity  
~~decrease~~

- The converter output frequency is directly proportional to the light intensity

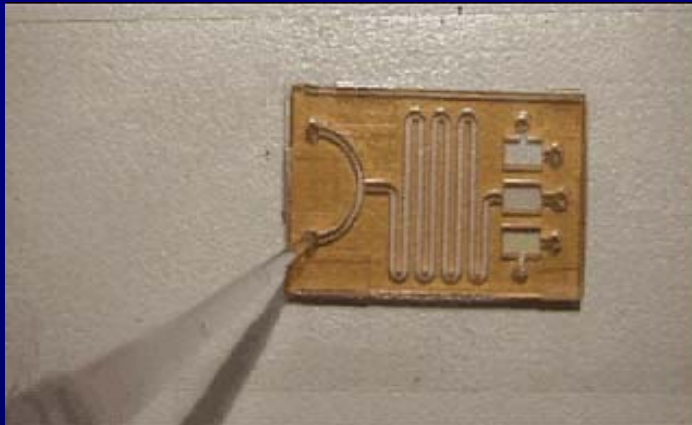
# FLUIDS MIXING



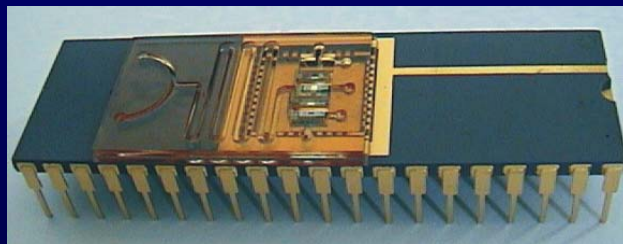
Fluids inlet and mixing



# FLUIDS DETECTION



Fluids inlet and mixing

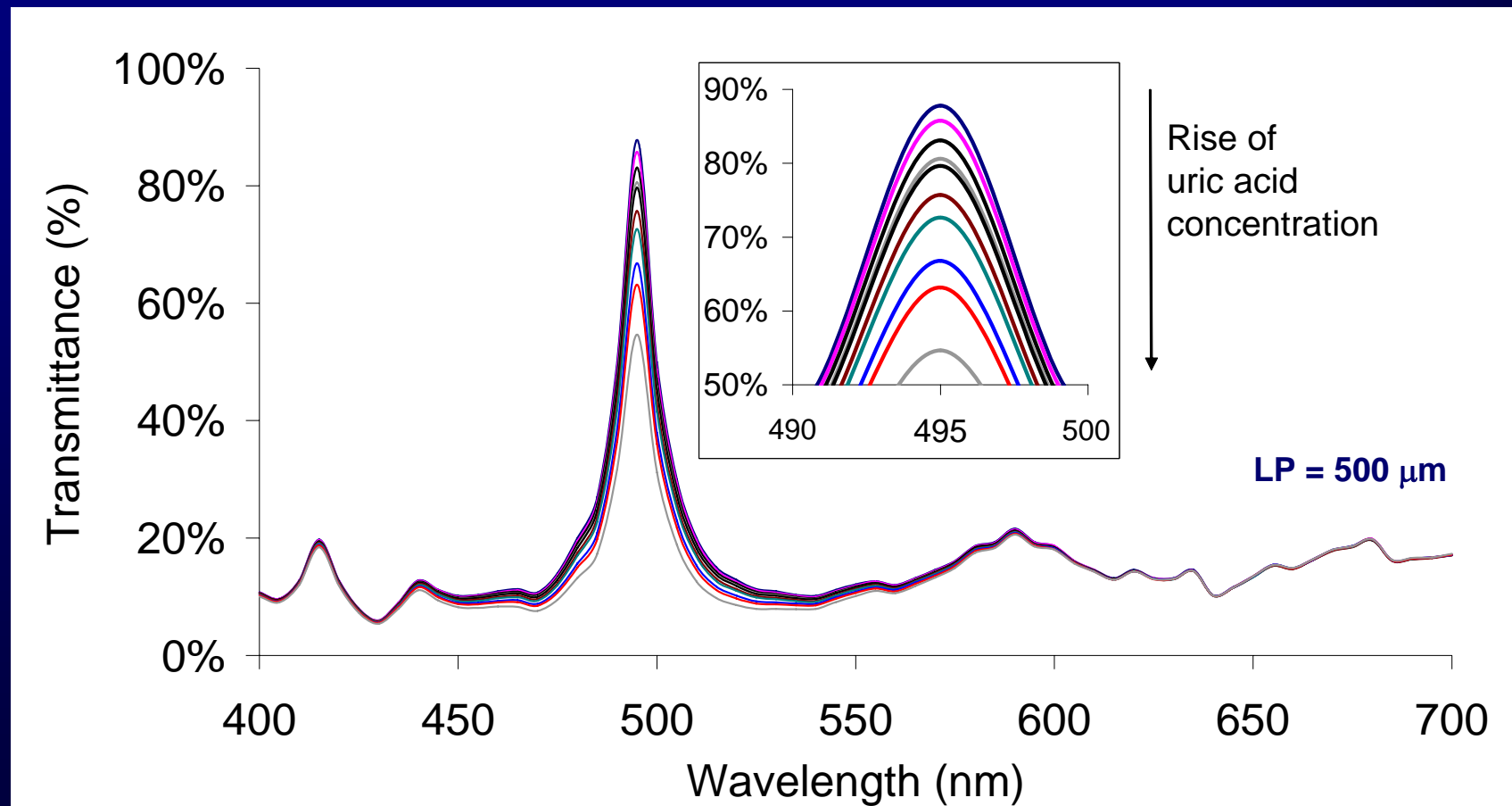


Transmittance measurements



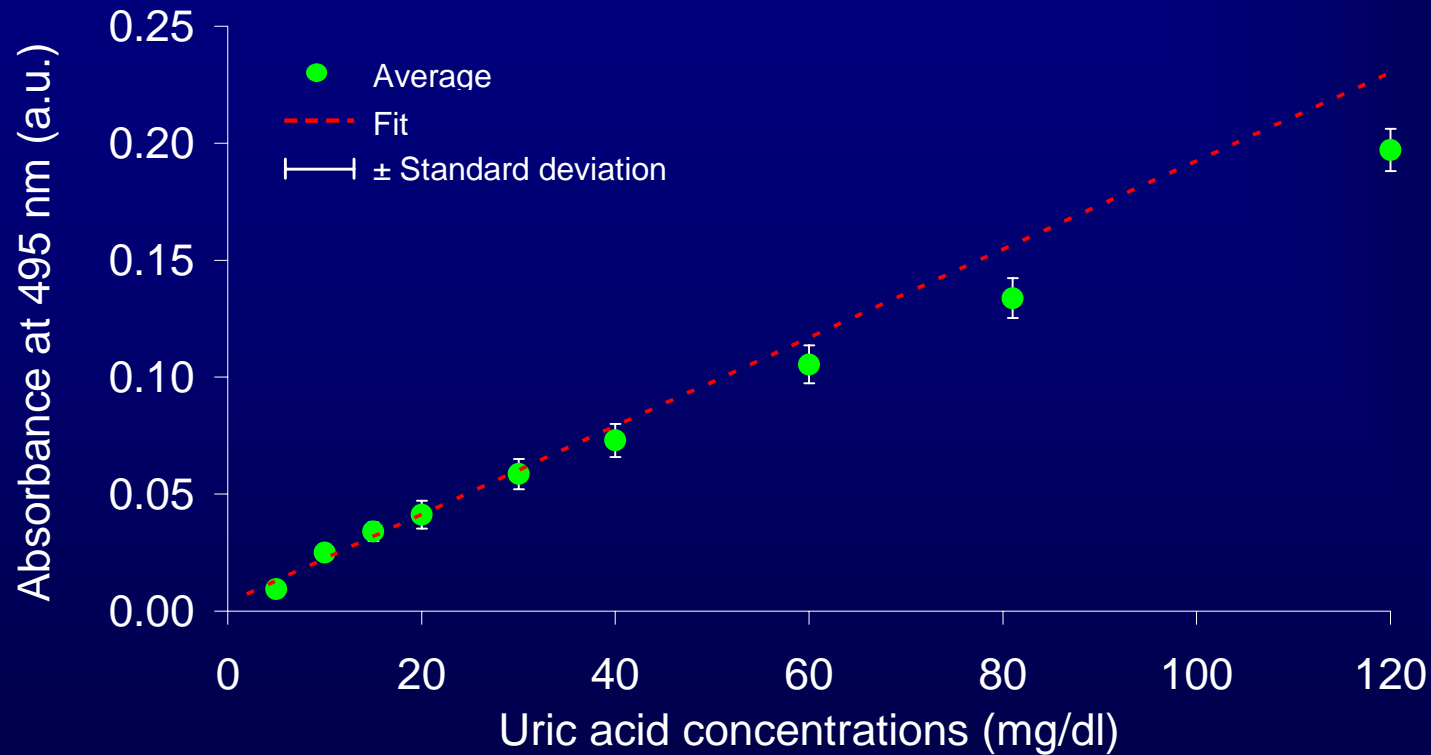


## Spectrophotometric analysis of uric acid in urine concentrations from 5 mg/dl to 120 mg/dl





## White light source



Linear conc.  
range (mg/dl)

Slope (a. u.) dl/mg

Intercept (a. u.)

Correlation  
coefficient ( $R^2$ )

0 – 30

$(1.9 \pm 0.4) \times 10^{-3}$

$(3 \pm 2) \times 10^{-3}$

0.98016

# CONCLUSIONS



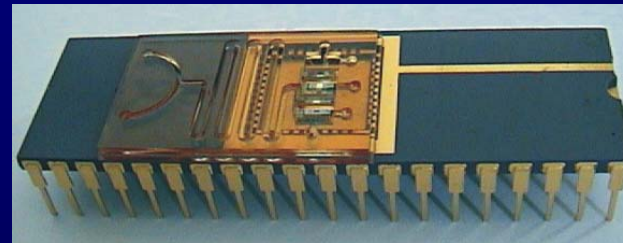
- Lab-on-a-chip for biological fluid analysis by spectrophotometry with instantaneous results (analysis can be performed at any location)
- Its performance was successfully demonstrated in the quantitative measurement of uric acid in urine
- This lab-on-a-chip avoids the need of expensive readout optics and opens the door to low-cost disposable devices

# ACKNOWLEDGEMENTS

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