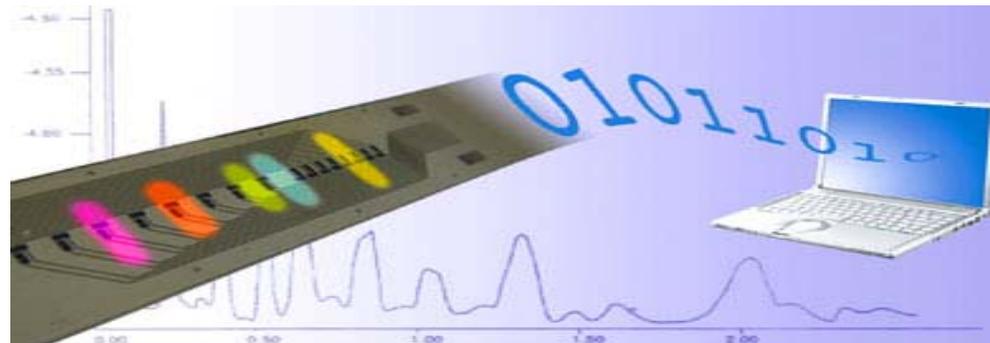


# SMART TLC PLATE

Prof. Giampiero de Cesare

Department of Electronic Engineering  
University of Rome "La Sapienza"



Here we are



# The Group

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- **Professors:**

- Prof. Giampiero de Cesare
- Prof. Domenico Caputo
- Prof. Augusto Nascetti

- **PhD Students:**

- Ing. Riccardo Scipinotti

- **Collaborators:**

- Ing. Matteo Ceccarelli
- Ing. Roberto Intrieri

- **External collaborations:**

- Prof. C. Manetti, Dept. of Chemistry, University of Rome “La Sapienza”
- Prof. C. Fanelli, Dept. of Plant Biology, University “La Sapienza”
- Dott.ssa A. Ricelli, CNR Institute of Biomolecular Chemistry
- Dott. M. Tucci, ENEA CRE Casaccia, Anguillara

# Group Activities

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- **Materials:** properties of amorphous silicon
- **Devices:** stacked structure of different amorphous silicon layers
  - UV-vis photosensor
  - Single and multicolor photodetector
  - Solar cell
  - Stress sensor
- **Systems:** application of a-Si:H devices
  - Optoelectronic

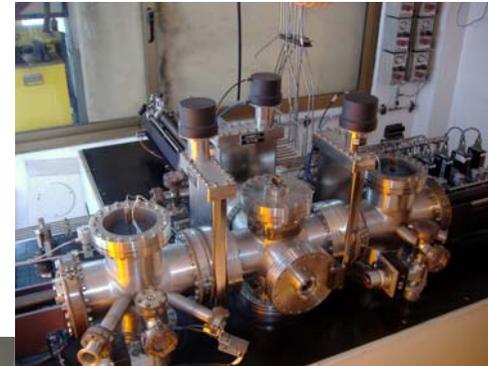
# Facilities

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- **Device Design and Simulation**
  - DIFFIN (a-Si:H devices), FEMLAB, ORCAD, DESSIS, CADENCE
- **Process Technologies**
  - Deposition
  - Lithography
  - Etching
- **Device Characterization**
  - Electrical (Cryostat for low-T, I-V, C-V, transient response)
  - Optical (Quantum efficiency, Absorption Coefficient)

# Deposition Technologies

- 3-chamber UHV PECVD (a-Si:H)
- Thermal Evaporation Unit
- Sputtering Unit
- Spin Coaters
- Electroplating system



# Patterning

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- **Litography**

- Photoplotter Unit
- Mask Aligner (up to 30cm×30cm)
- Spin coaters



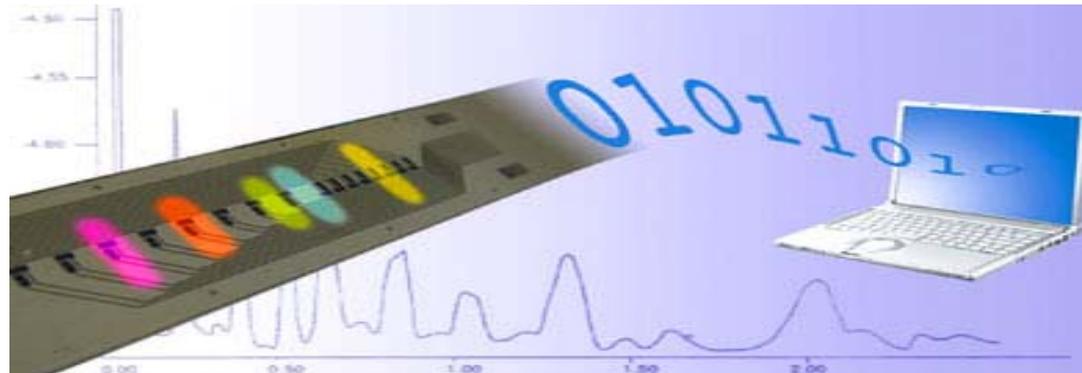
- **Etching**

- 2-chamber Reactive Ion Etching Unit
- Sputter Etching Unit
- Chemical Bench for wet etching processes



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# SMART TLC PLATE



BUSINESS LAB project  
supported by FILAS for spin-off opportunity

# Chromatography

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- Chemical-physical method for separating different components of a mixture

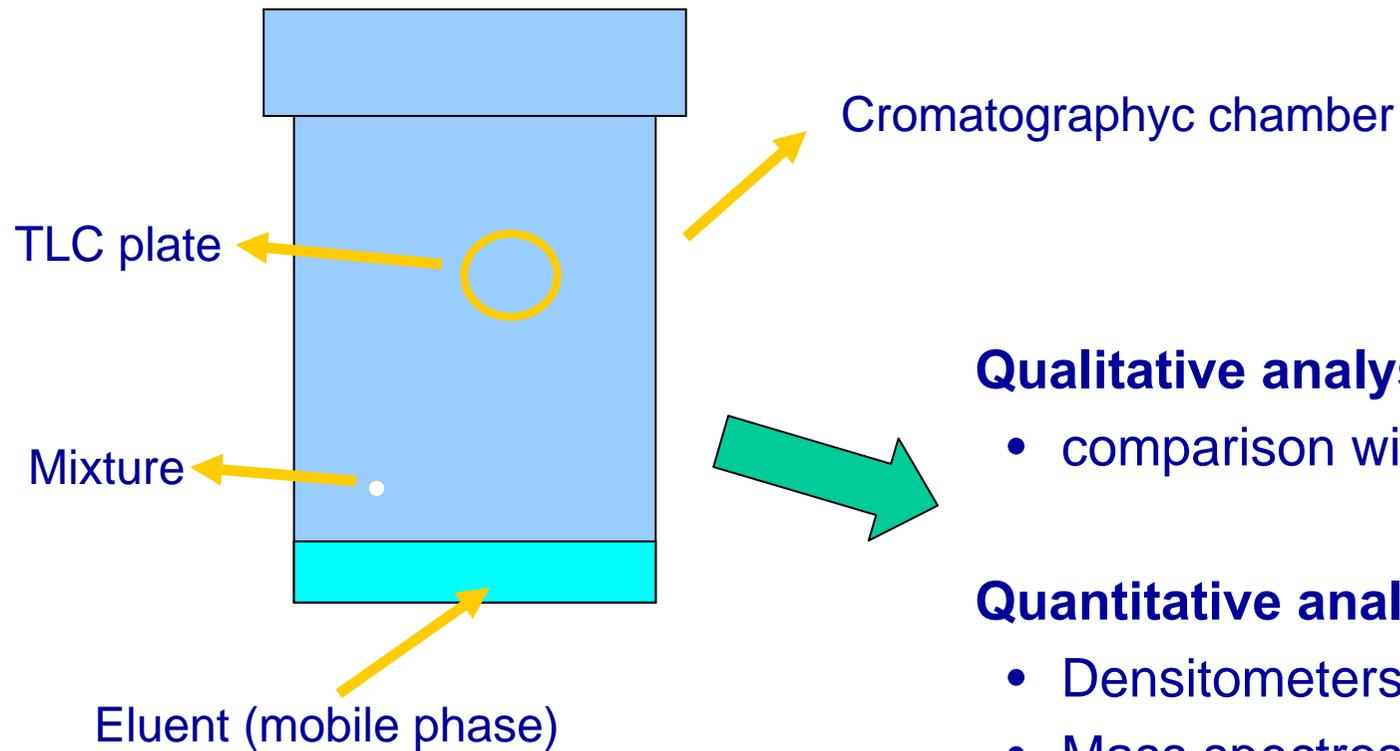
– Stationary phase      **SEPARATION**  
– Mobile phase            Different affinity of components

- Traditional methods: Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC),

## Thin Layer Chromatography (TLC)



# Thin Layer Chromatography



## Qualitative analysis:

- comparison with standards

## Quantitative analysis:

- Densitometers
- Mass spectroscopy
- CCD

# Aim of this work

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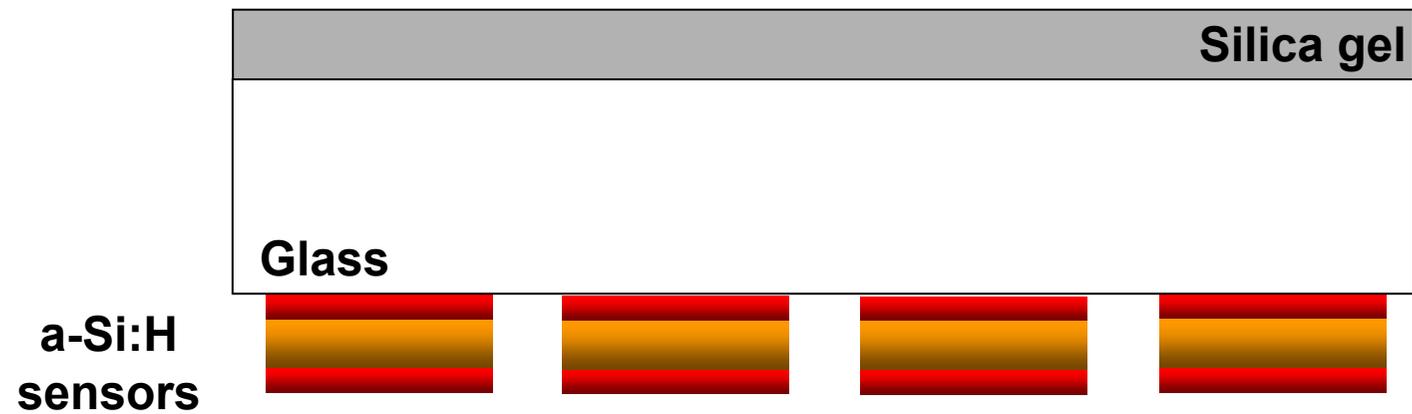
## System for detection of chromatographic run

- Real-time
- Quantitative analysis
- Low cost

# SMART Glass

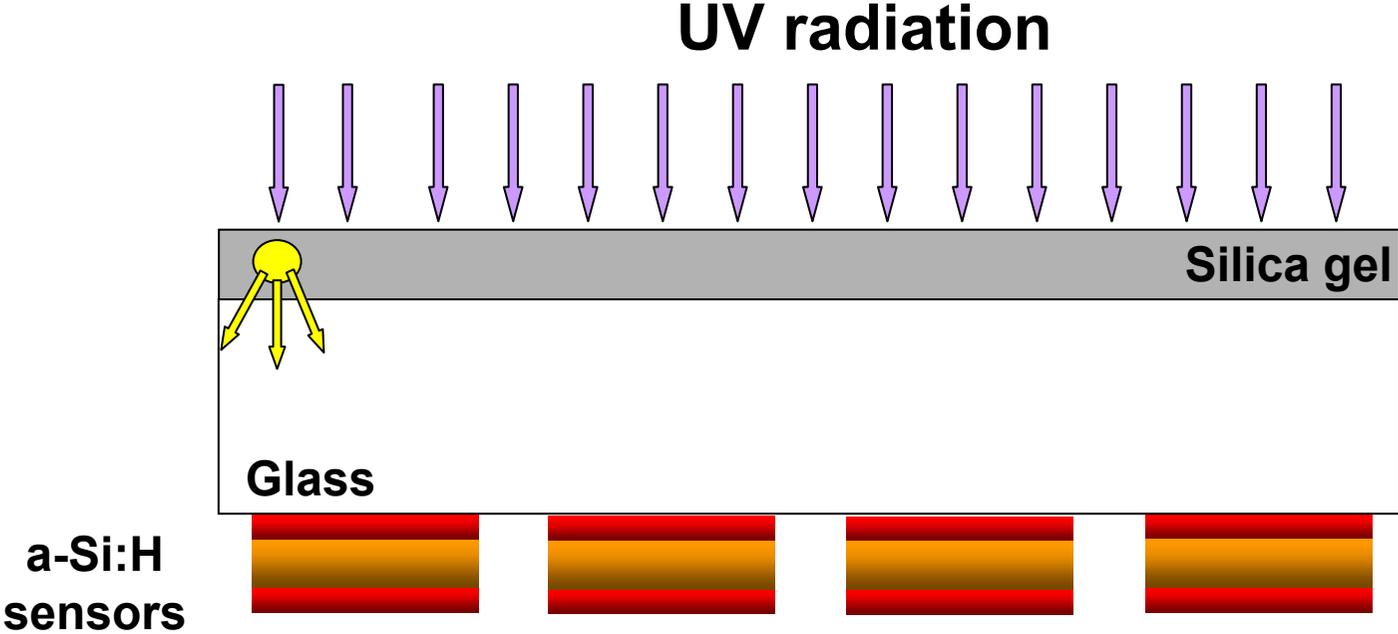
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## Amorphous silicon photodiode array integrated with TLC plate



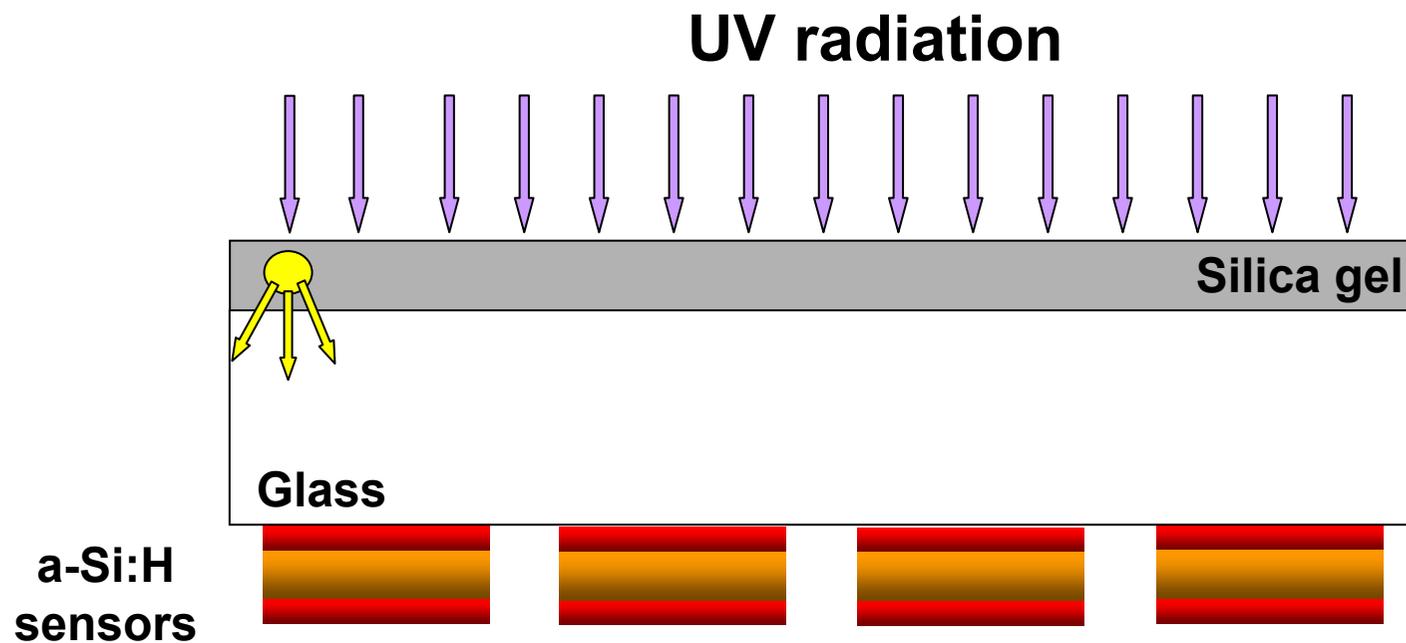
# SMART Glass

## Amorphous silicon photodiode array integrated with TLC plate



# SMART Glass

## Amorphous silicon photodiode array integrated with TLC plate

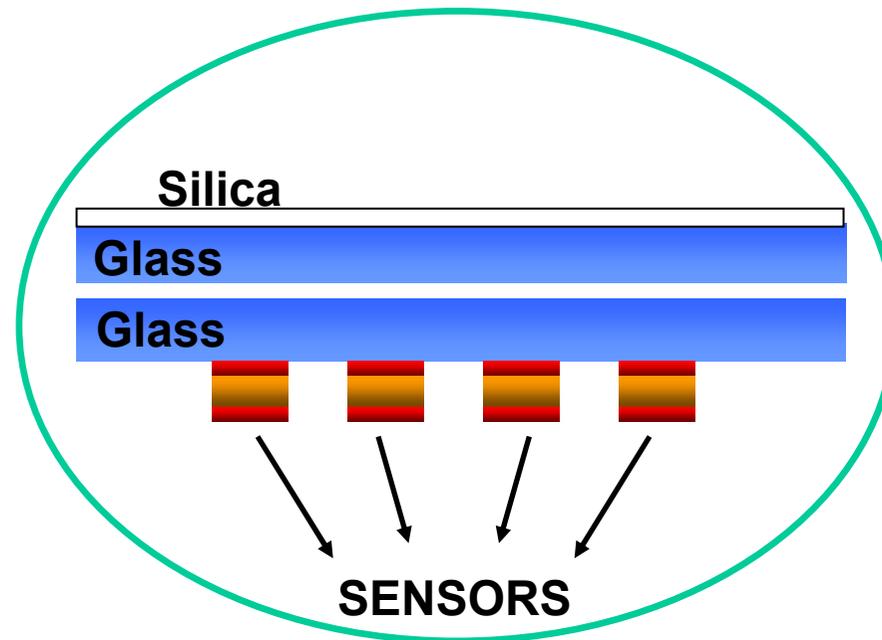


$$I_{ph} = \sigma \cdot P_{INC} \approx \text{Analyte concentration}$$

# SMART Glass

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## Linear array of sensors

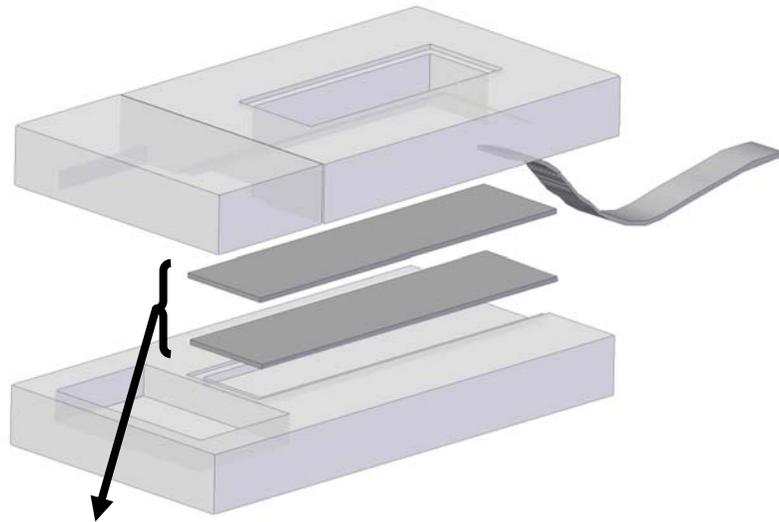


Two separate glasses

Tuning and testing of the system

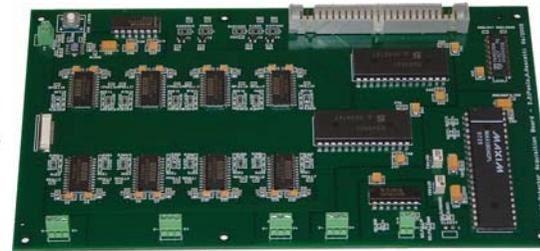
# Detection system

Chromatographic chamber



**SMART GLASS**

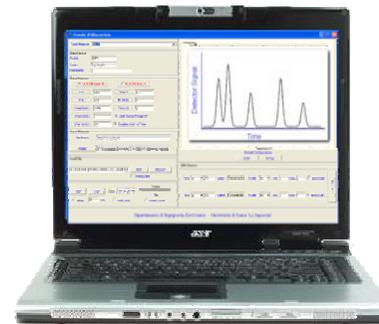
Hardware



**Acquisition and A/D conversion**



**Microcontroller**



**Software**

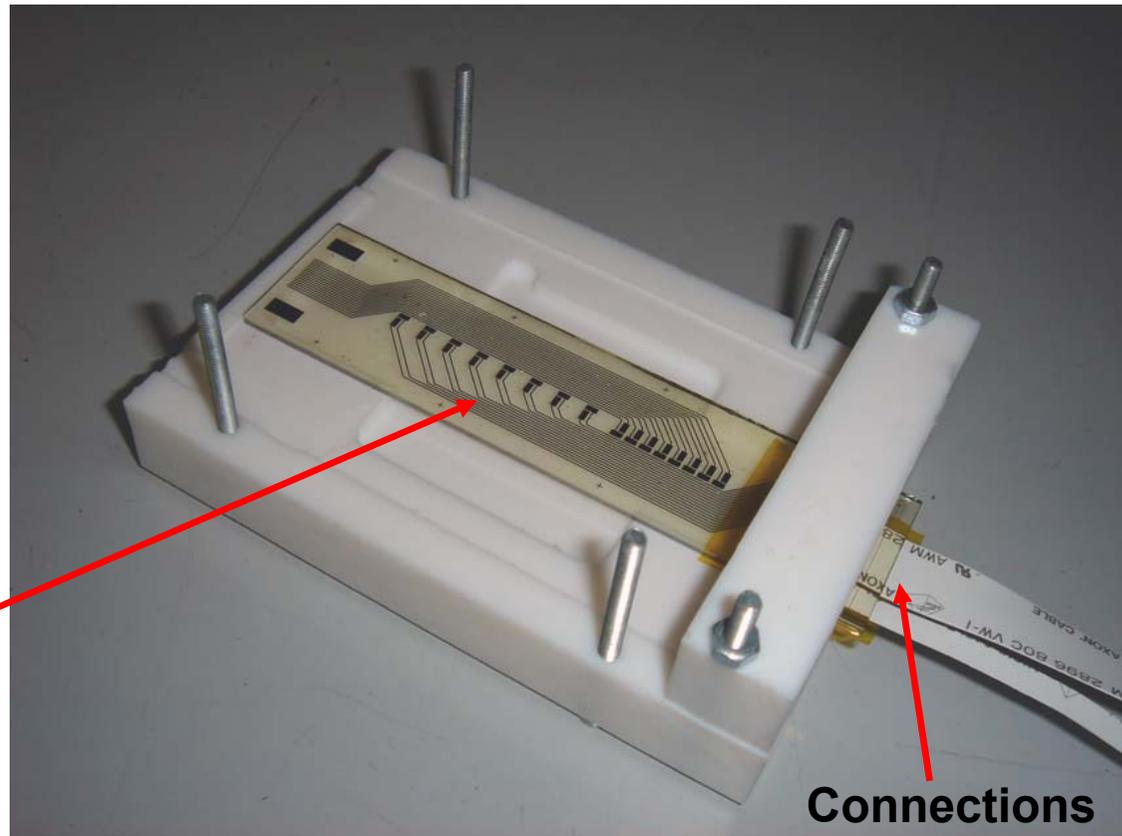


# Chromatographic chamber

- Chemical inert material: TEFLON
- Horizontal run

**Electrical part**

**Sensor array with electrical contacts**

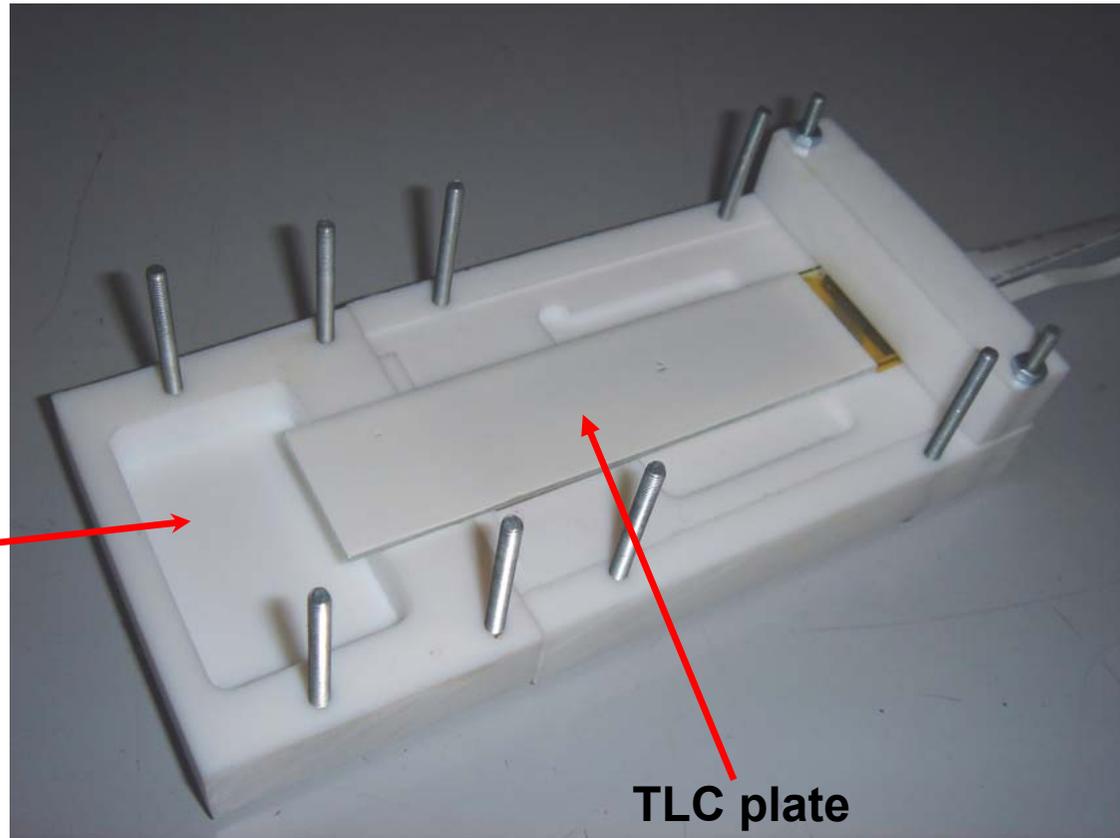


# Chromatographic chamber

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**Chemical part**

**Reservoir for the  
mobile phase**



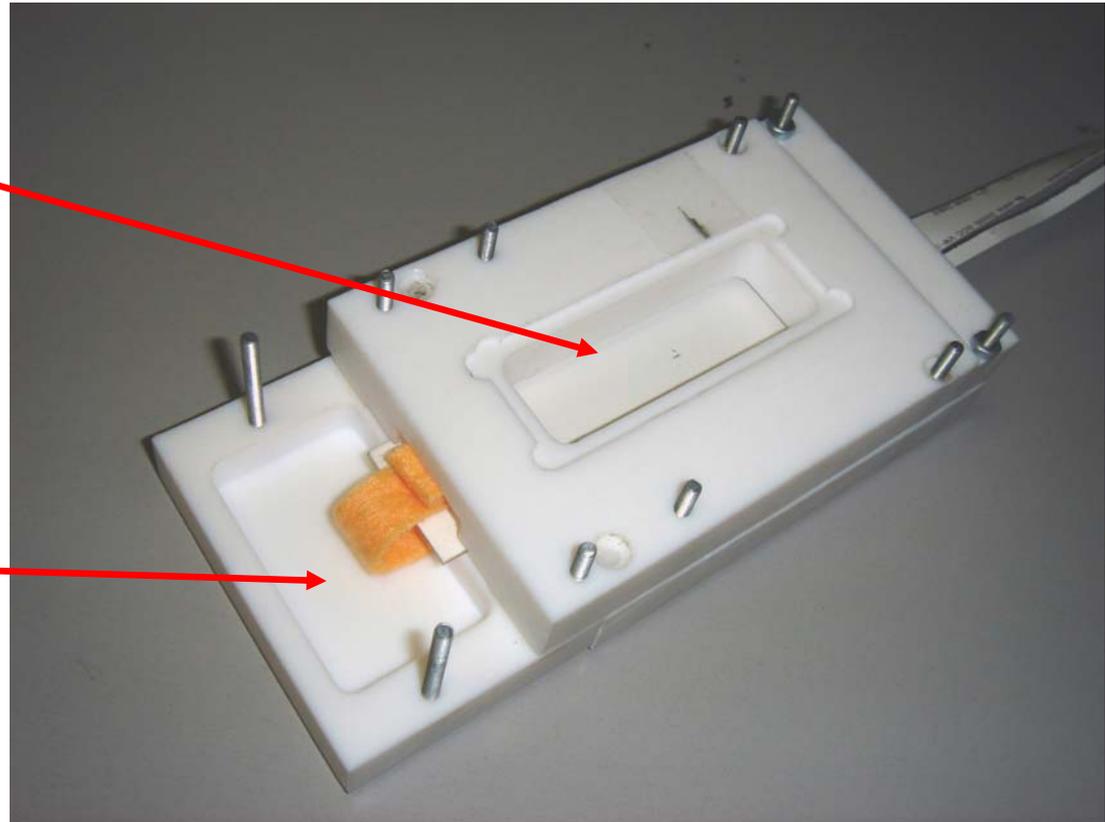
**TLC plate**

# Chromatographic chamber

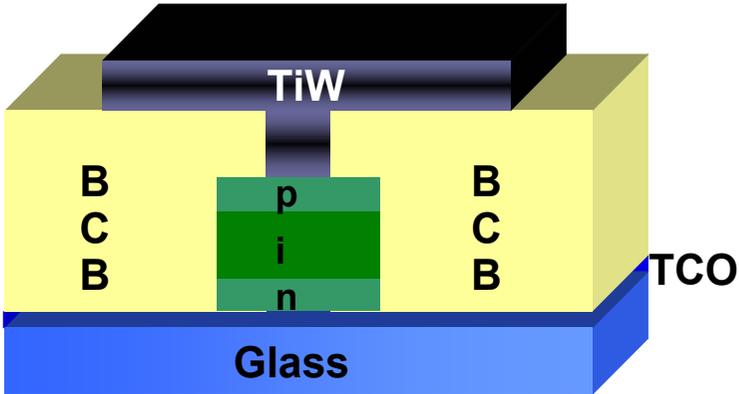
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Quartz window

Eluent carrier



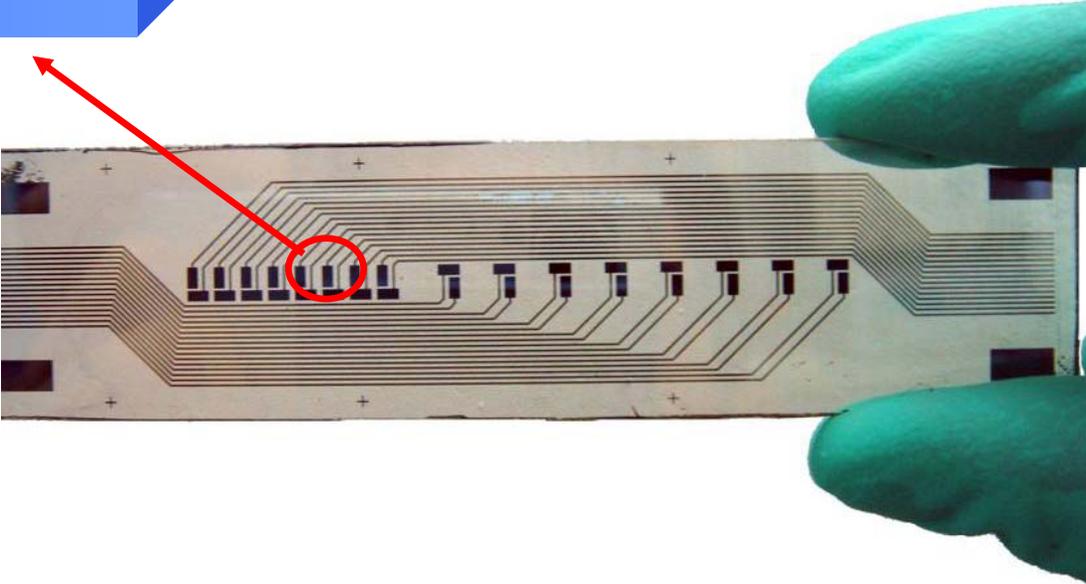
# Sensor arrays



**Linear array: 2x8 sensors**

**Sizes: 1x2 and 2x1 mm**

**Pitches: 2.5 and 5 mm**



# Sensor modeling and fabrication

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- **Specifications:**
  - Low dark current ( $I_{dk}$ ) for better SNR
  - Photoresponse not sensitive to the excitation light
  - Quantum efficiency spectral matched to the analyte emission spectra
- **Modeling**
  - Numerical a-Si:H device simulator

# Experimental details

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- **Excitation light**

- UV LEDs: NSHU550A from Nikia Corporation
- Emission peak at 375 nm

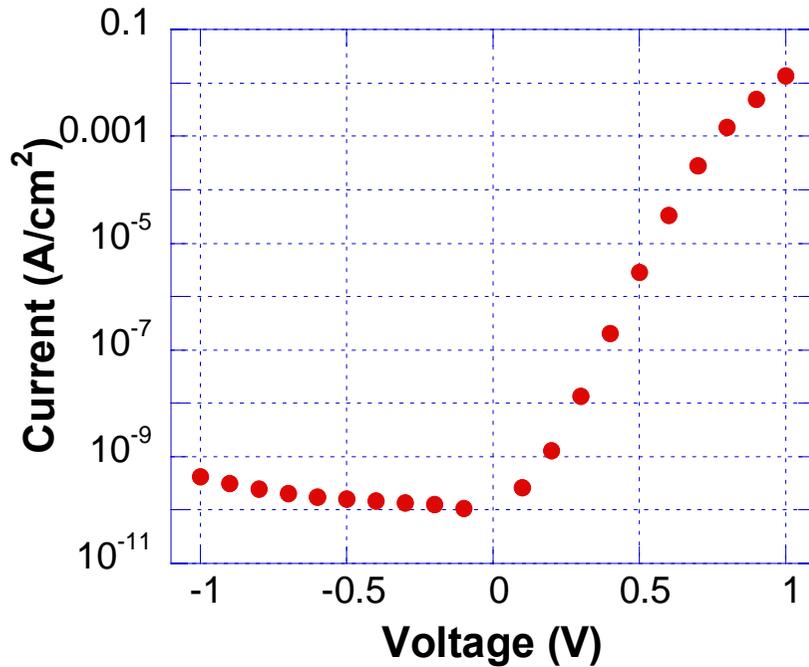
- **Analyte**

- Fluorescein dissolved in ethanol
- Emission peak at 514 nm

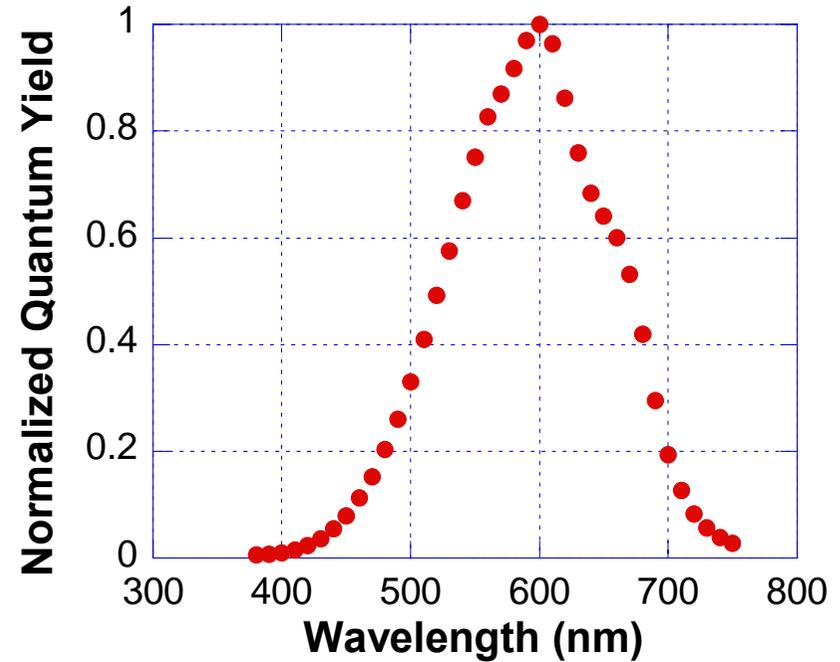
- **Thicknesses**

- n 70 nm
- i 250 nm
- p 20 nm

# Sensor characterization



$I_{dk} \sim 10^{-10} \text{A/cm}^2$  at reverse  $V_{bias}$

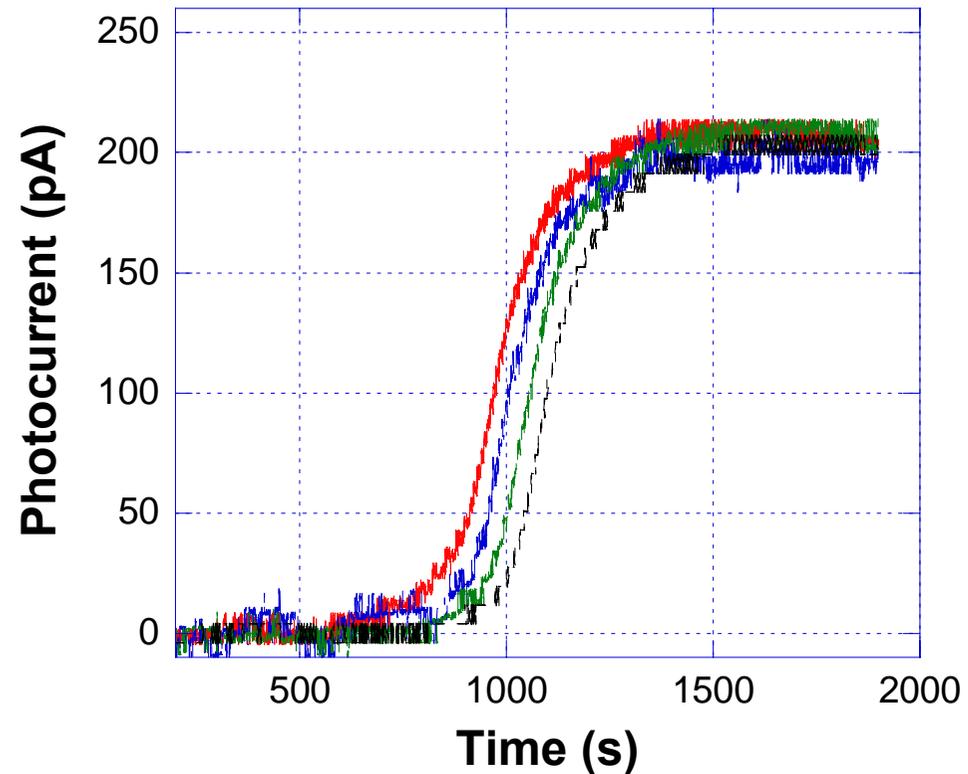
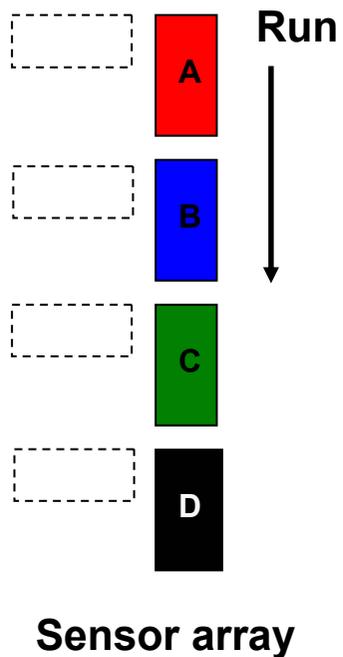


Responsivity (R) ~ 110 mA/W @ 515 nm

$$R_{514}/R_{375} > 10^2$$

# Experimental results

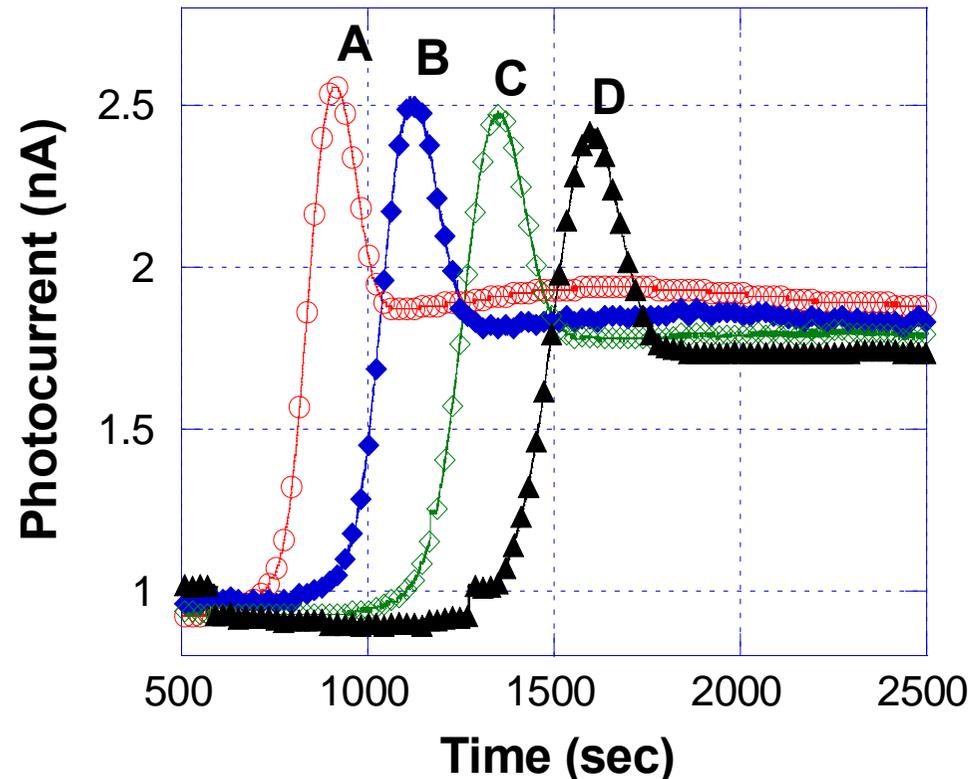
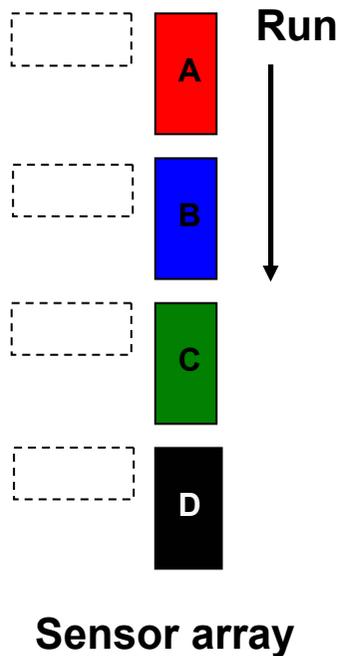
- **Analyte:** no
- **Mobile phase:** ethanol



- Wetting silica gel: sigmoidal behavior

# Experimental results

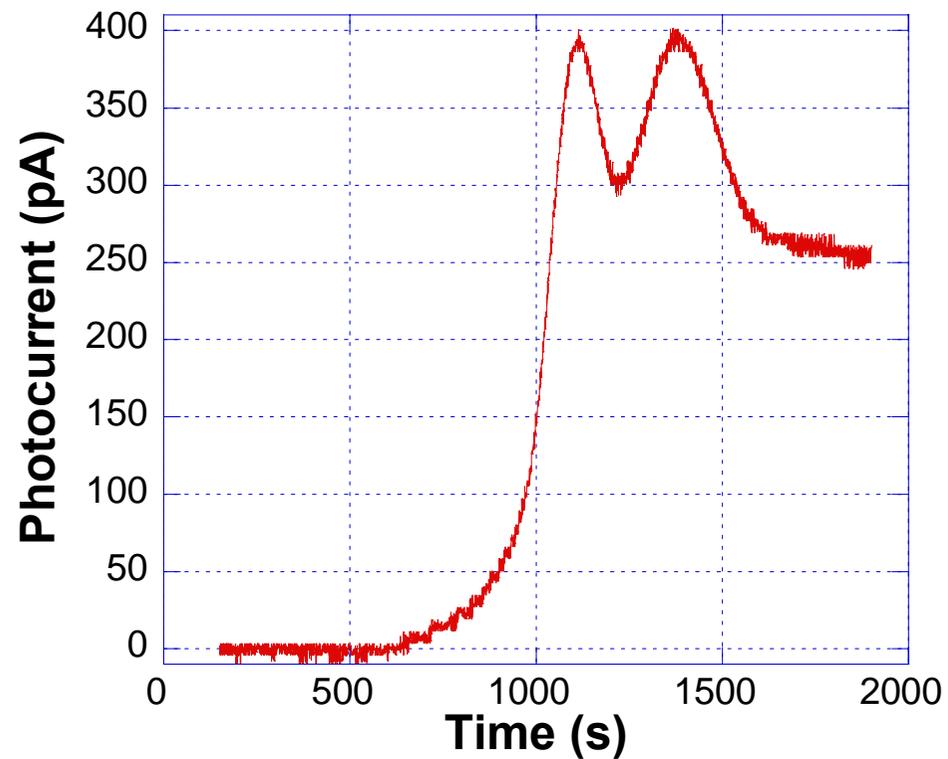
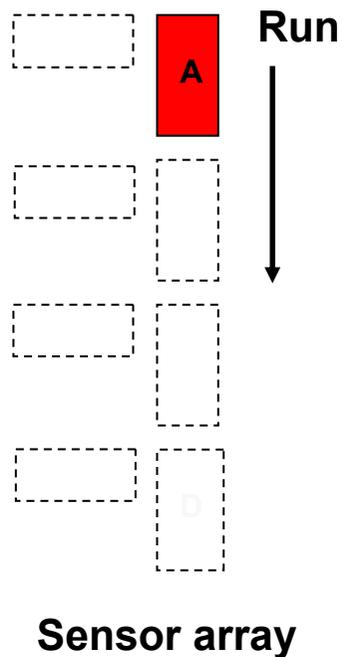
- **Analyte:** fluorescein
- **Mobile phase:** ethanol



- Fluorescein signal: Gaussian behavior

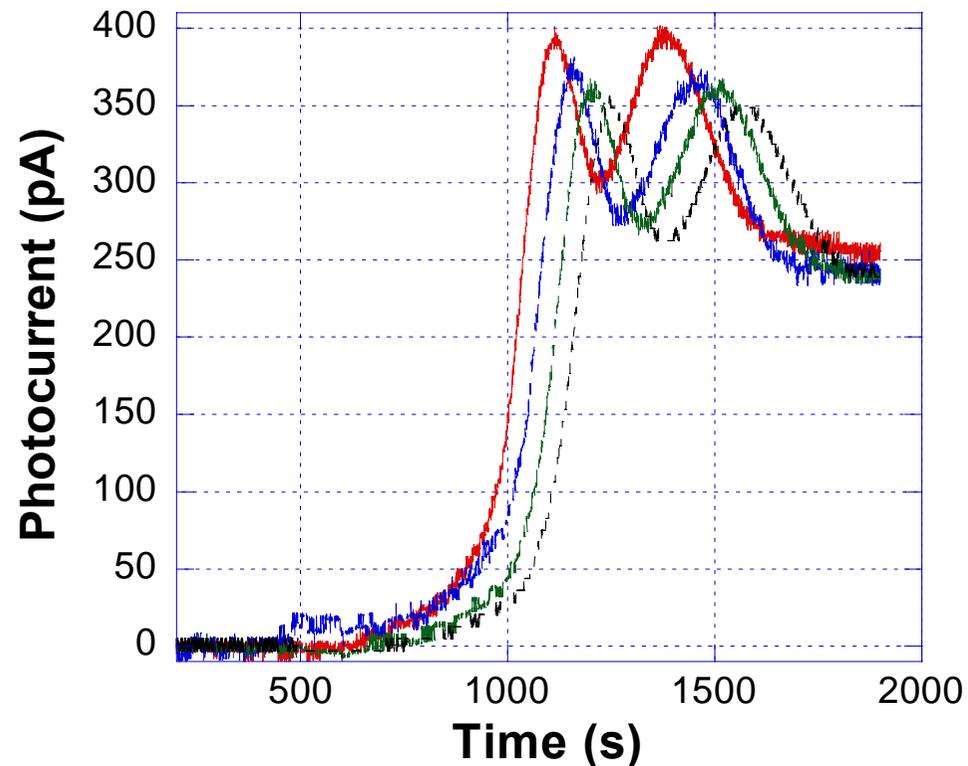
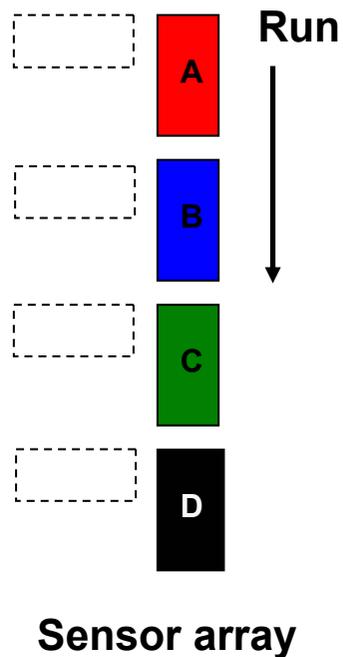
# Experimental results

- **Analyte:** green highlighter + fluorescein
- **Mobile phase:** ethanol



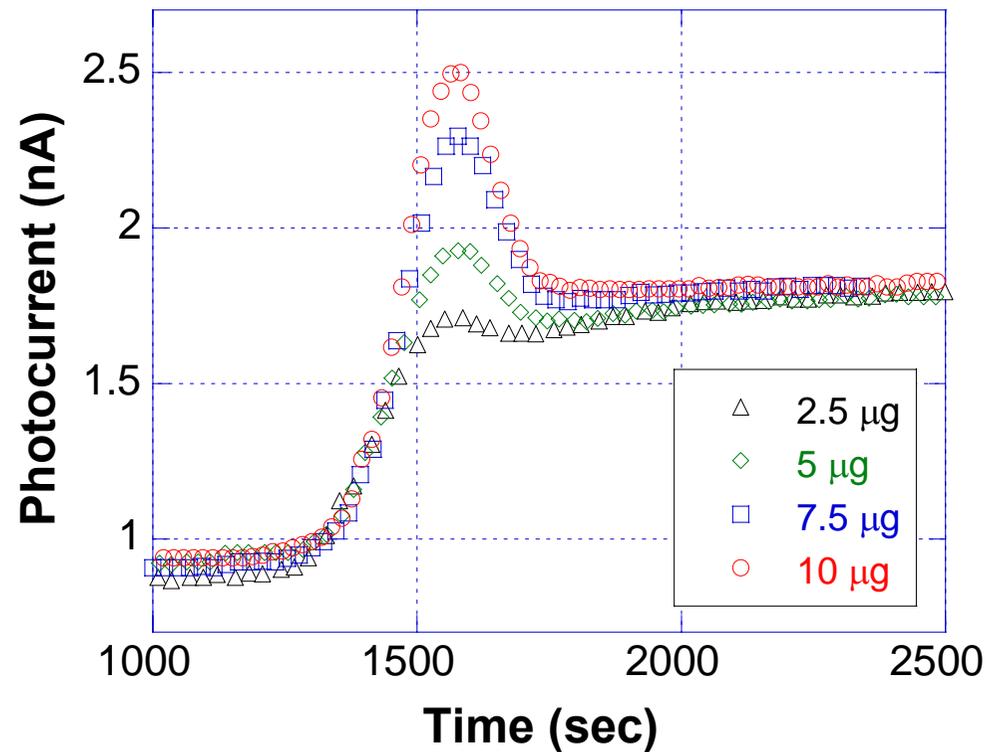
# Experimental results

- **Analyte:** green highlighter + fluorescein
- **Mobile phase:** ethanol



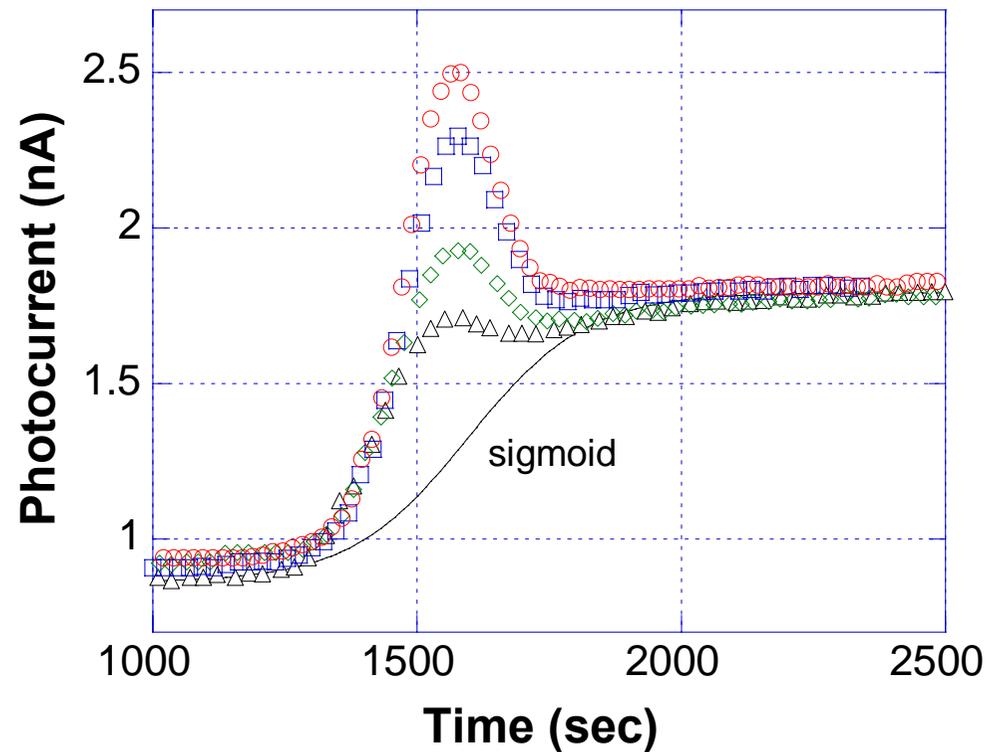
# Experimental results

- **Analyte:** fluorescein at different concentrations
- **Mobile phase:** ethanol



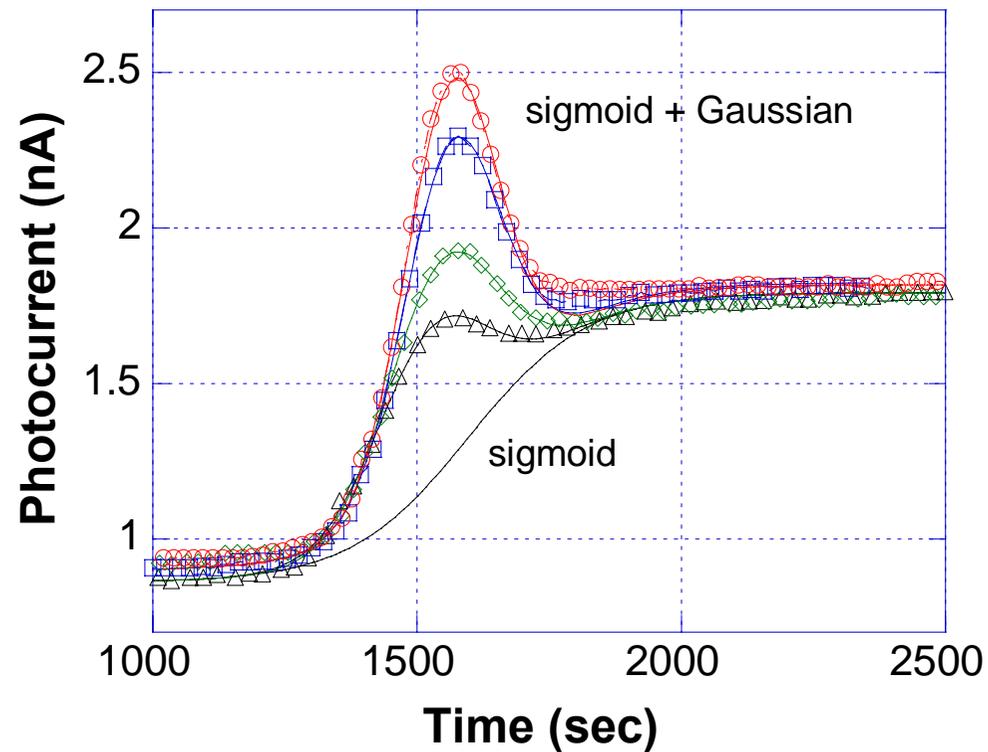
# Experimental results

- **Analyte:** fluorescein at different concentrations
- **Mobile phase:** ethanol



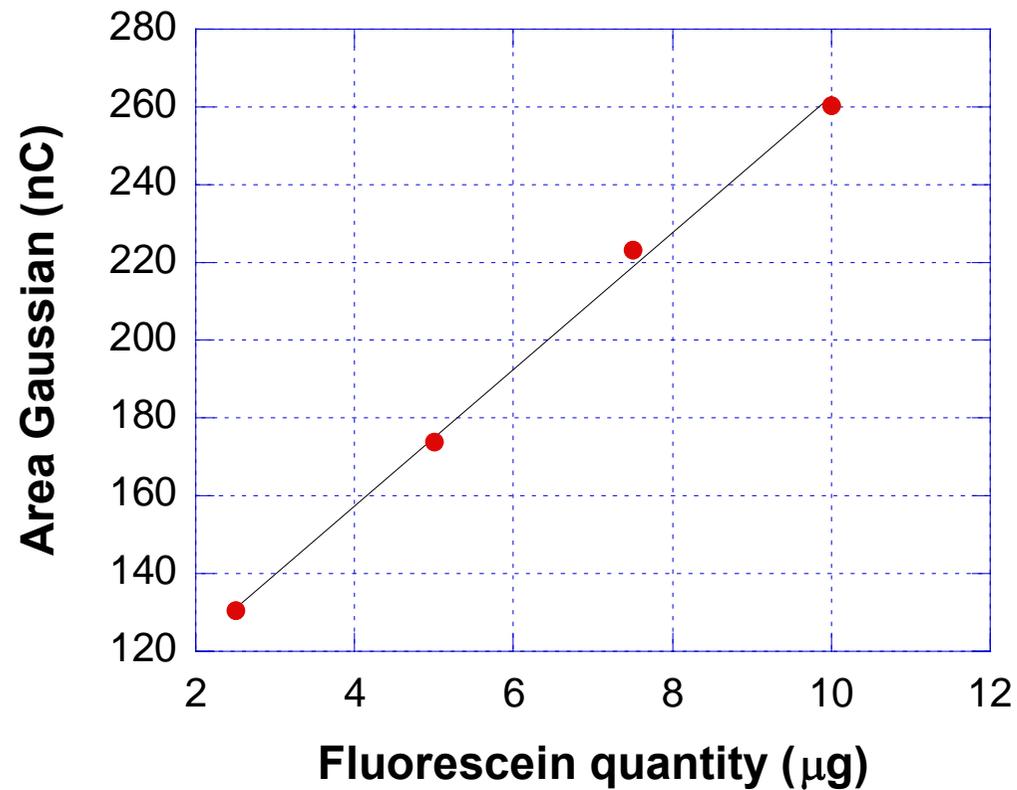
# Experimental results

- **Analyte:** fluorescein at different concentrations
- **Mobile phase:** ethanol



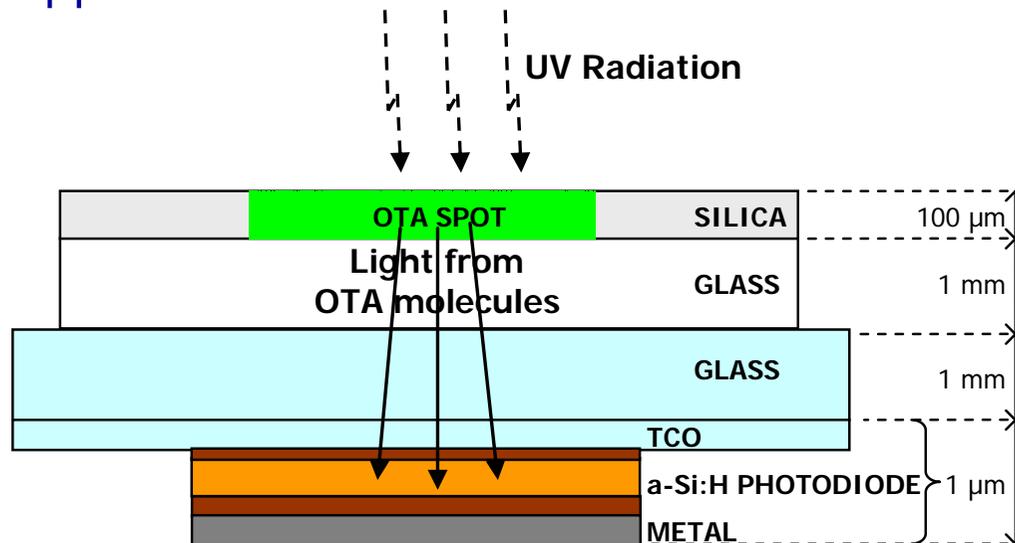
# Experimental results

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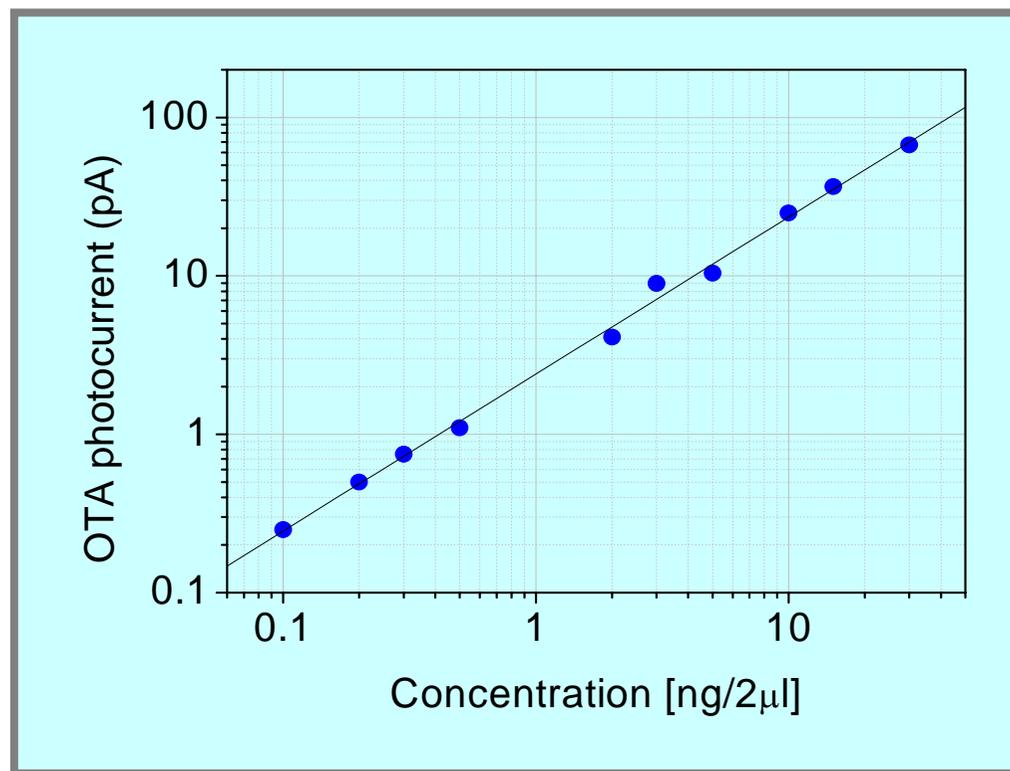


# Food quality control

- Ocratoxin A (OTA) micotoxin present in wine, in beer, in raw coffee.
- Law limit: 2 ppb



## Food quality control (OTA)



- Minimum detectable limit:  $\sim 0.05$  ng/ $\mu$ l

# Conclusions

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- SMART GLASS as innovative chromatographic system
  - TLC plate
  - linear array of amorphous silicon sensors
- Application
  - real-time monitoring
  - quantitative analysis
  - Food quality control (OTA)