

SPIROPYRAN MODIFIED PDMS MICRO-FLUIDIC CHIP DEVICE FOR PHOTONICALLY CONTROLLED SENSOR ARRAY DETECTION OF METAL IONS

Fernando Benito-López

Outline

- **Introduction.**
- **Micro-fluidic device fabrication.**
- **Experimental set-up.**
 - **Micro-fluidic device functionalisation.**
- **Results and Discussions.**
- **Conclusions.**
- **Acknowledgments.**

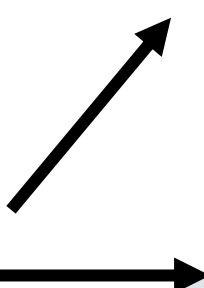
Introduction

MICRODEVICE & MICROREACTOR:

- **THREE-DIMENSIONAL STRUCTURES (MICROCHANNELS)**
 - **DIAMETERS 10 - 500 μM**
 - **MANIPULATE REAGENT SOLUTIONS**
 - **FABRICATED: GLASS, QUARTZ, SILICON, POLYMERS, METALS**
- **LAMINAR CONTINUOUS FLOW REGIME ($\text{Re} < 2300$)**

ADVANTAGES

- **SMALL CHARACTERISTIC DIMENSIONS**
 - **SMALL INTERNAL VOLUMES**
 - **HIGH SURFACE-TO-VOLUME RATIO**
- **CONTINUOUS FLOW MODE**



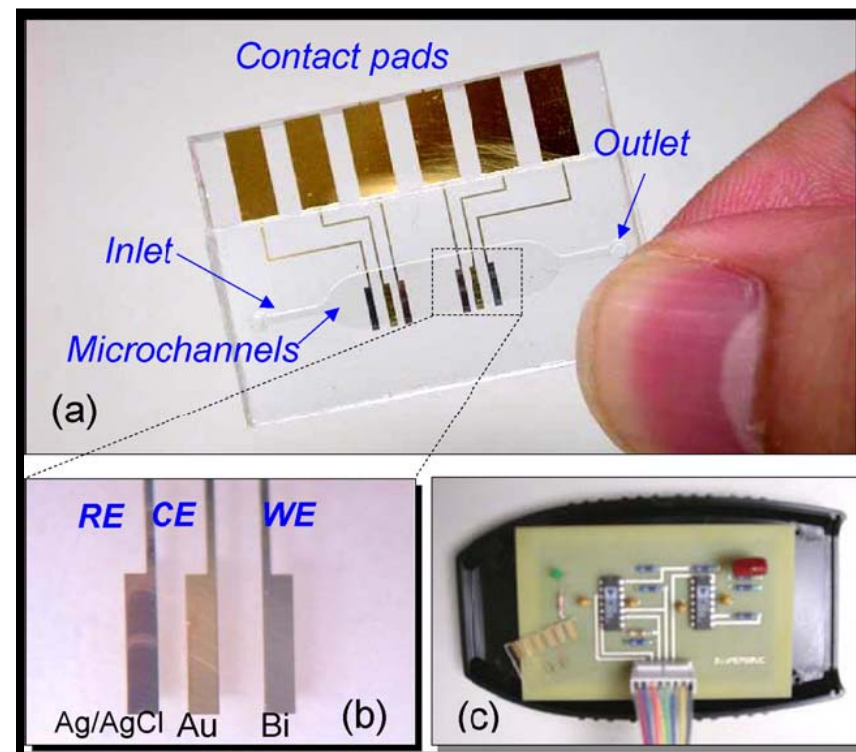
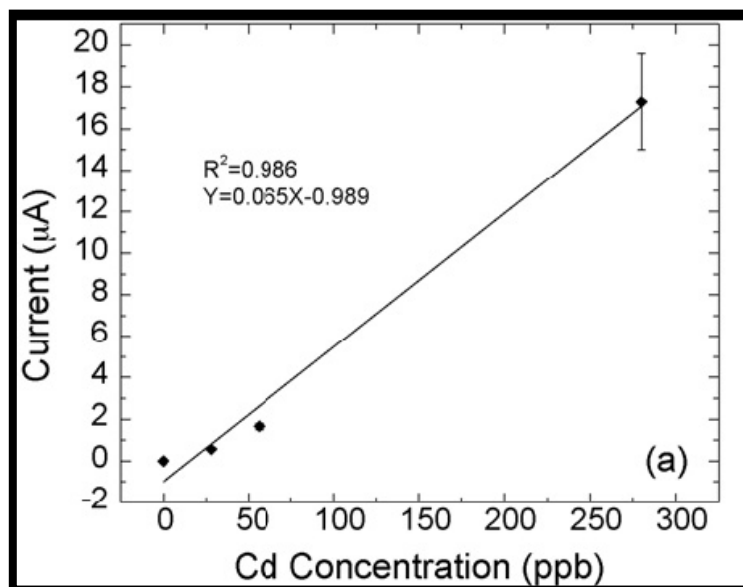
**IMPROVE HEAT AND MASS
TRANSFER RATES
MIXING**

**REAL-TIME MEASUREMENTS
FAST ANALYSIS PROTOCOLS**

SMALLER AND PORTABLE SYSTEMS RELAX SAFETY ISSUES, SAVE COSTS, MATERIALS AND INCREASE PERFORMANCES BY INTEGRATING MINIATURIZED COMPONENTS.

Introduction

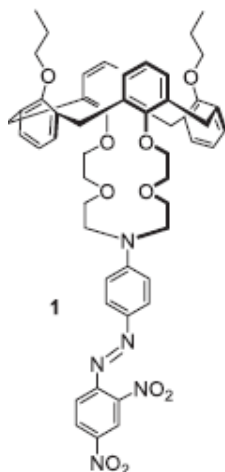
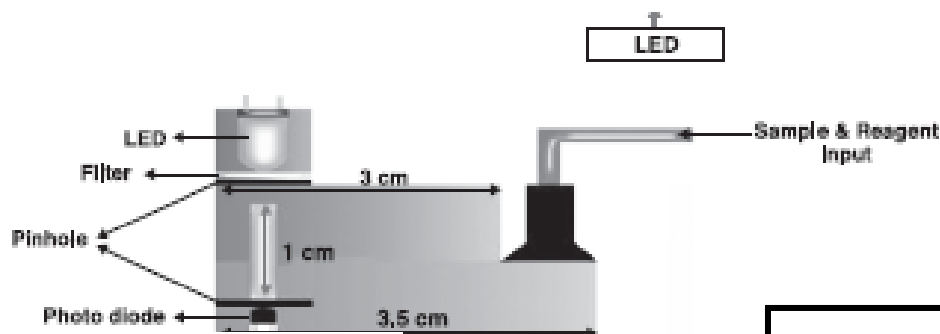
METAL ION SENSOR MICRO-FLUIDIC DEVICES



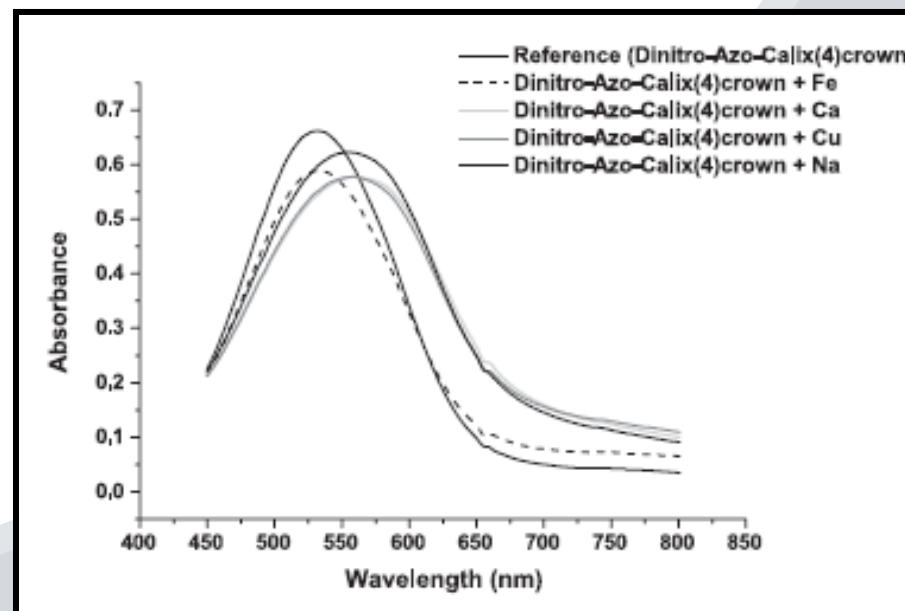
Environmentally friendly disposable sensors with microfabricated on-chip planar bismuth electrode for *in situ* heavy metal ions measurement, Zoua, Z., *et al. Sens. Actuators B*, 134, 2008, 18–24.

Introduction

METAL ION SENSOR MICRO-FLUIDIC DEVICES



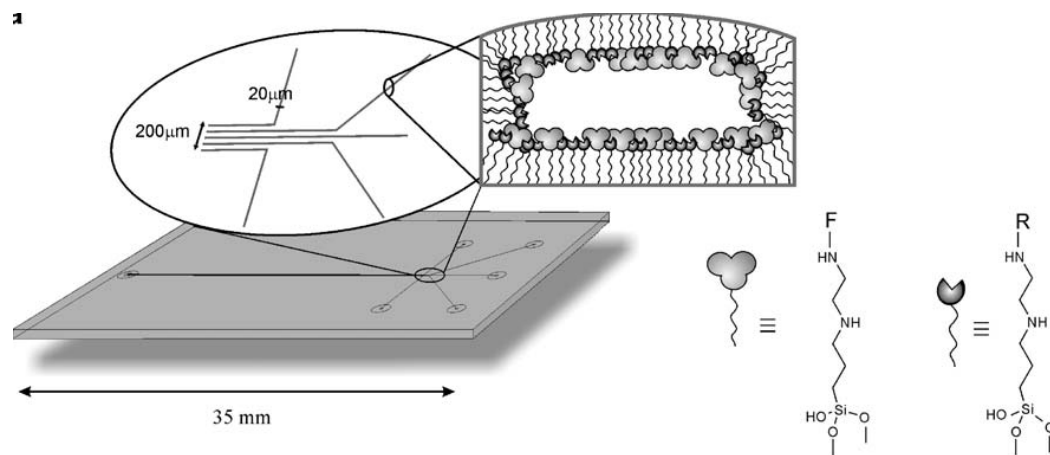
Dinitro-azocalix[4]azacrown (DAC)



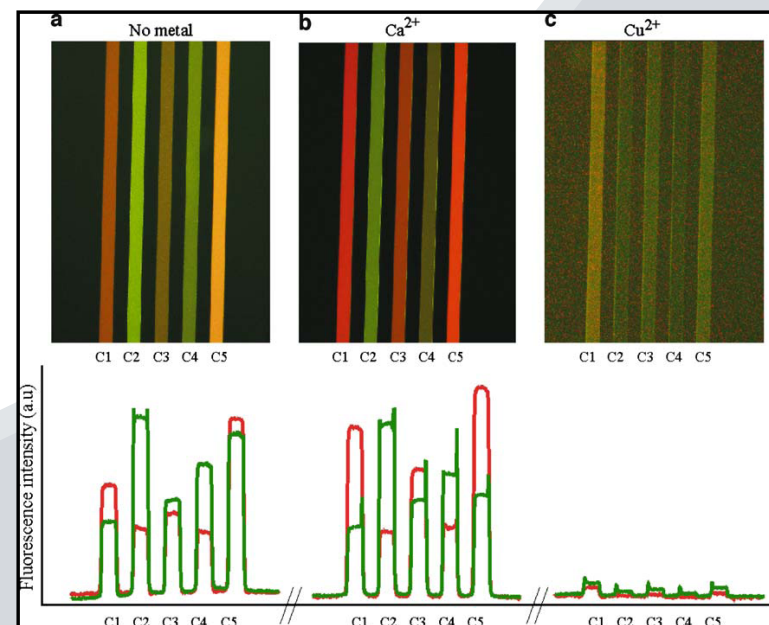
Development of a microchip metal ion sensor using dinitro-azocalix[4]azacrown, Park J.M. *et al. Microchem. J.*, 80, 2, 2005, 139-144.

Introduction

METAL ION SENSOR MICRO-FLUIDIC DEVICES



SELF ASSEMBLE MONOLAYER

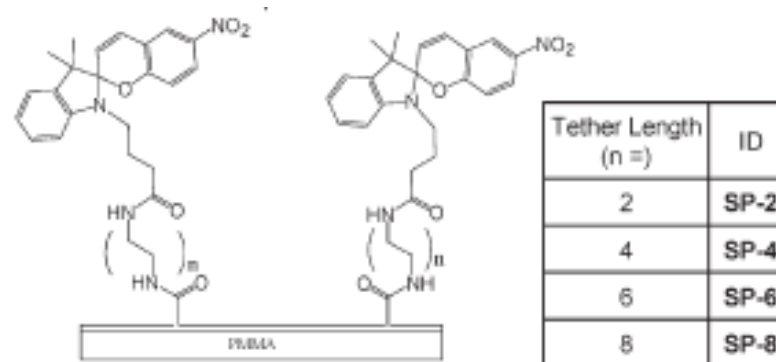
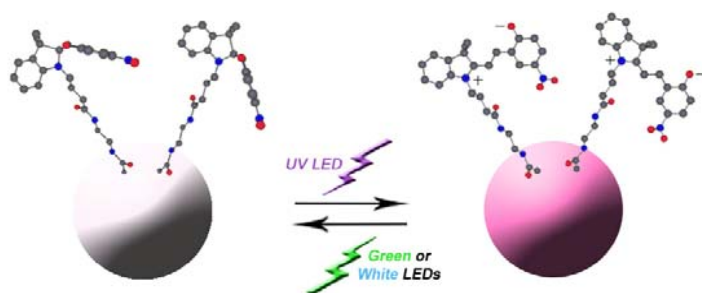
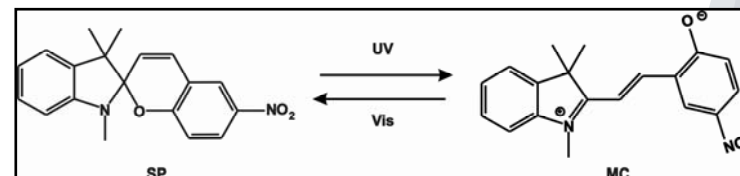


Fluorescent sensor array in a microfluidic chip, Basabe-Desmonts L., *et al. Anal. Bioanal. Chem.*, 390,1, 2008, 307-315

Introduction

PHOTO-SWITCHABLE SPIROPYRANS

- NEW ROUTES TO MULTI-FUNCTIONAL MATERIALS.
- PHOTO-REVERSIBLE INTERCONVERSION.
- INCORPORATED INTO MEMBRANES AND BEADS. FOR IMPROVED ROBUSTNESS AND EASE OF HANDLING.
- THEY HAVE METAL ION-BINDING AND MOLECULAR RECOGNITION PROPERTIES. (MOLECULAR PROBES)



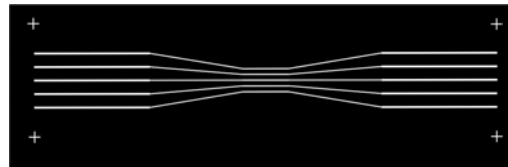
Scarmagnani S. *et al. J. Mat. Chem.*, 18, 42, 2008, 5063-5071.

Byrne R., *et al. J. Mat. Chem.* 2006, 16, 1332 – 1337.

Device Fabrication

Rapid phototyping and replication technique

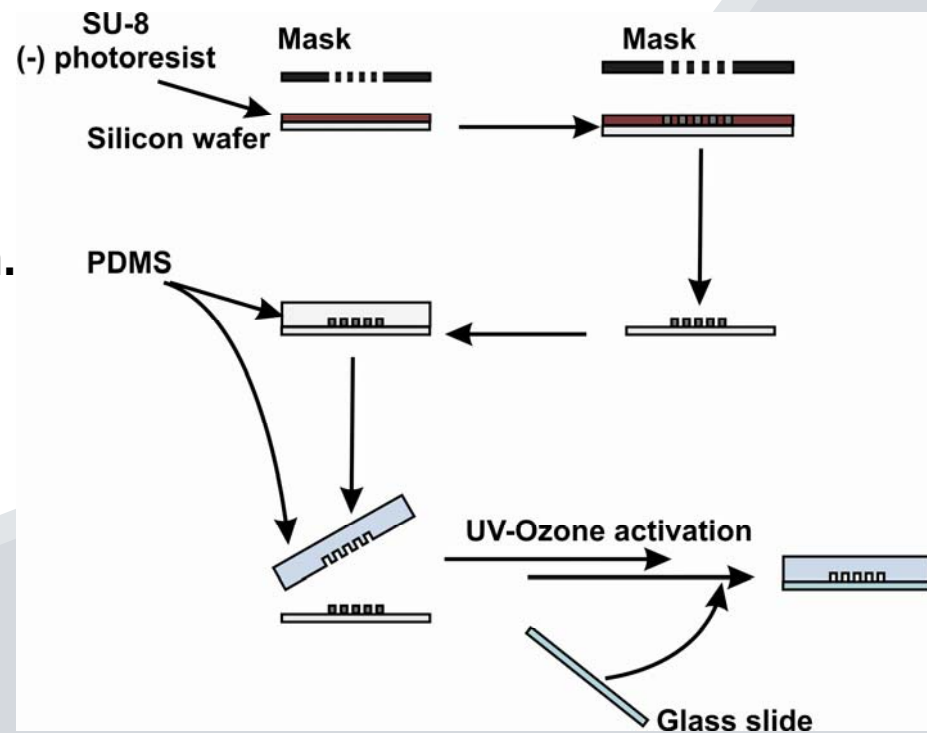
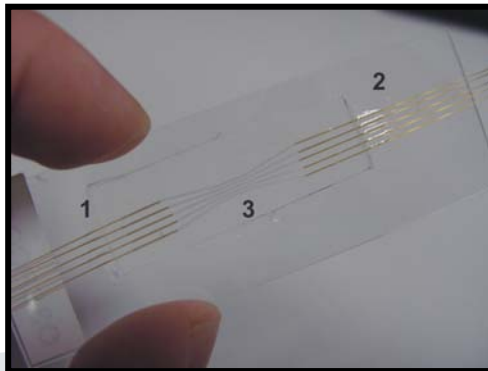
1. Mask Fabrication:



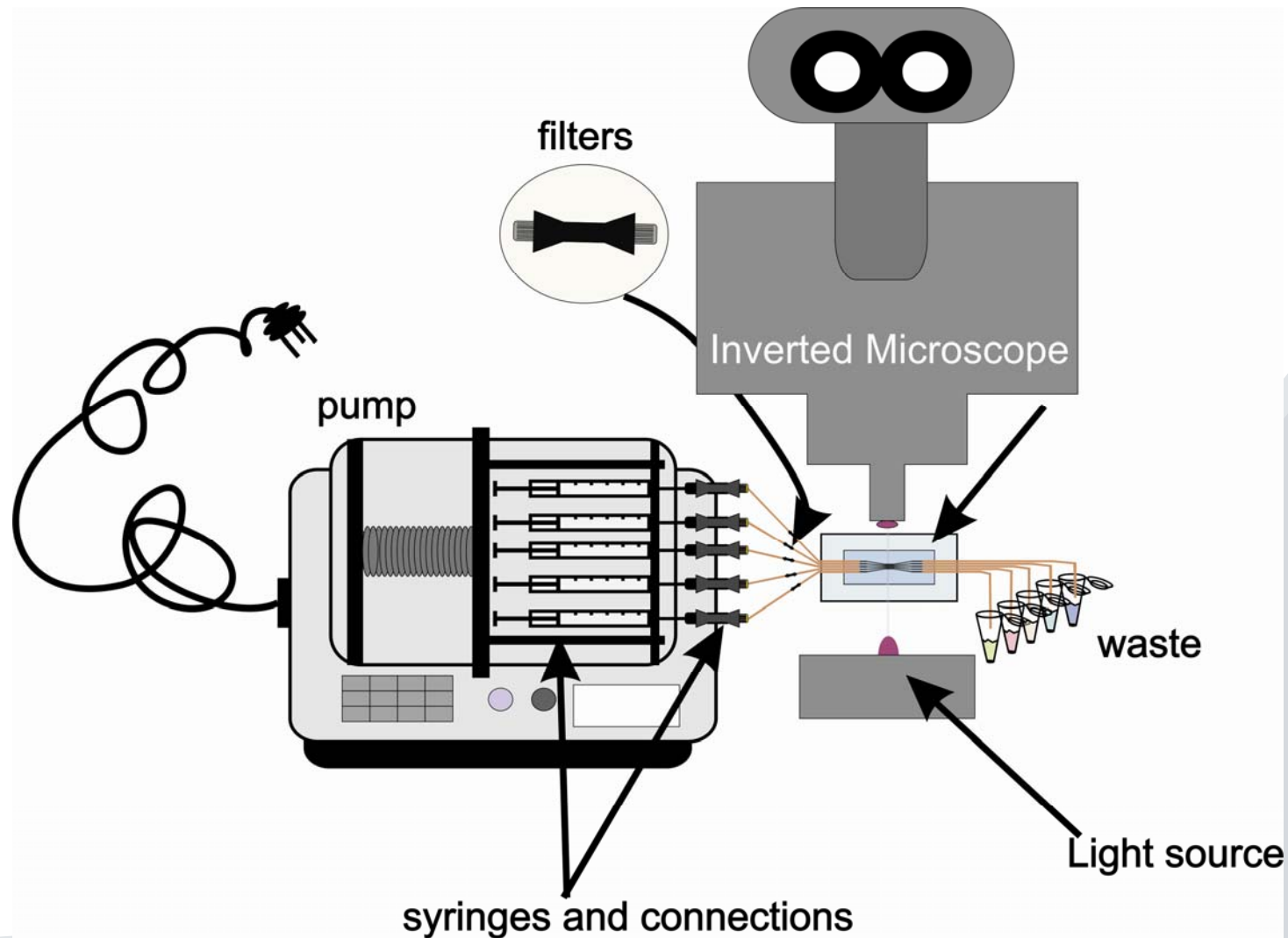
94 μm depth
150 μm width channels

2. Contact Photolithography:

3. Microfluidic Connections Insertion.



Experimental Set-up



Device Functionalisation

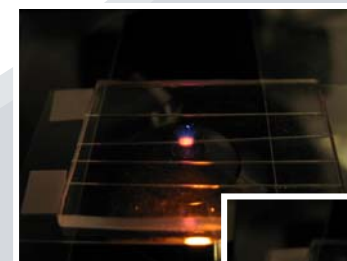
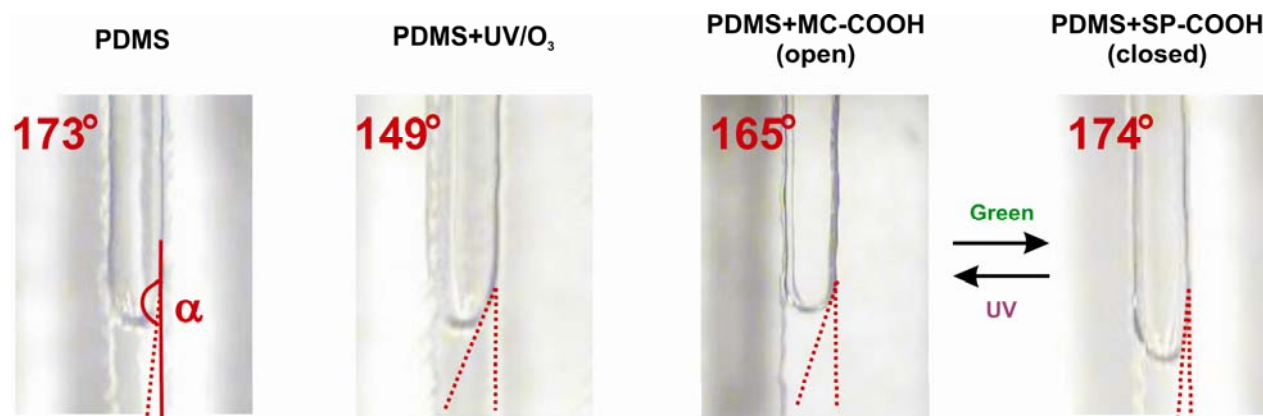
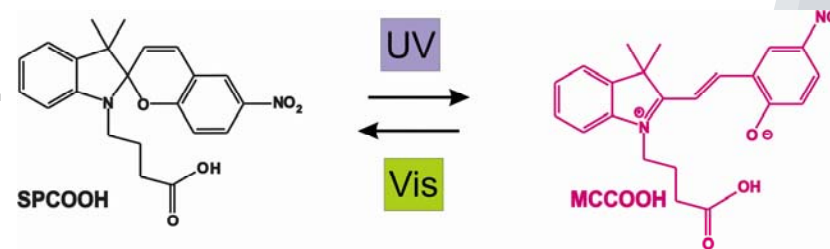
1. Exposure of the PDMS chips to UV/ozone.

2. Sealing to the glass slide.

3. Fill the activated channels with a solution of MC-COOH in ethanol.

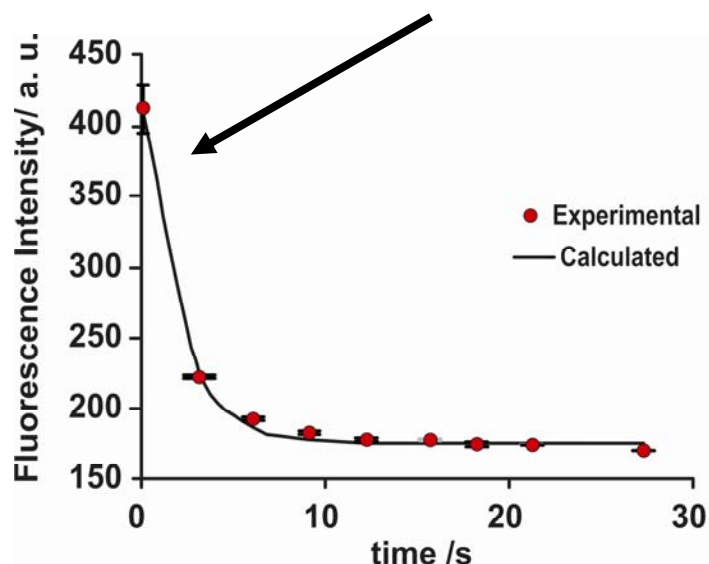
4. Chips placed in an oven for 2 h at 60 °C in the dark.

5. Sonication in ethanol for 15 min to eliminate any not immobilised SP-COOH.

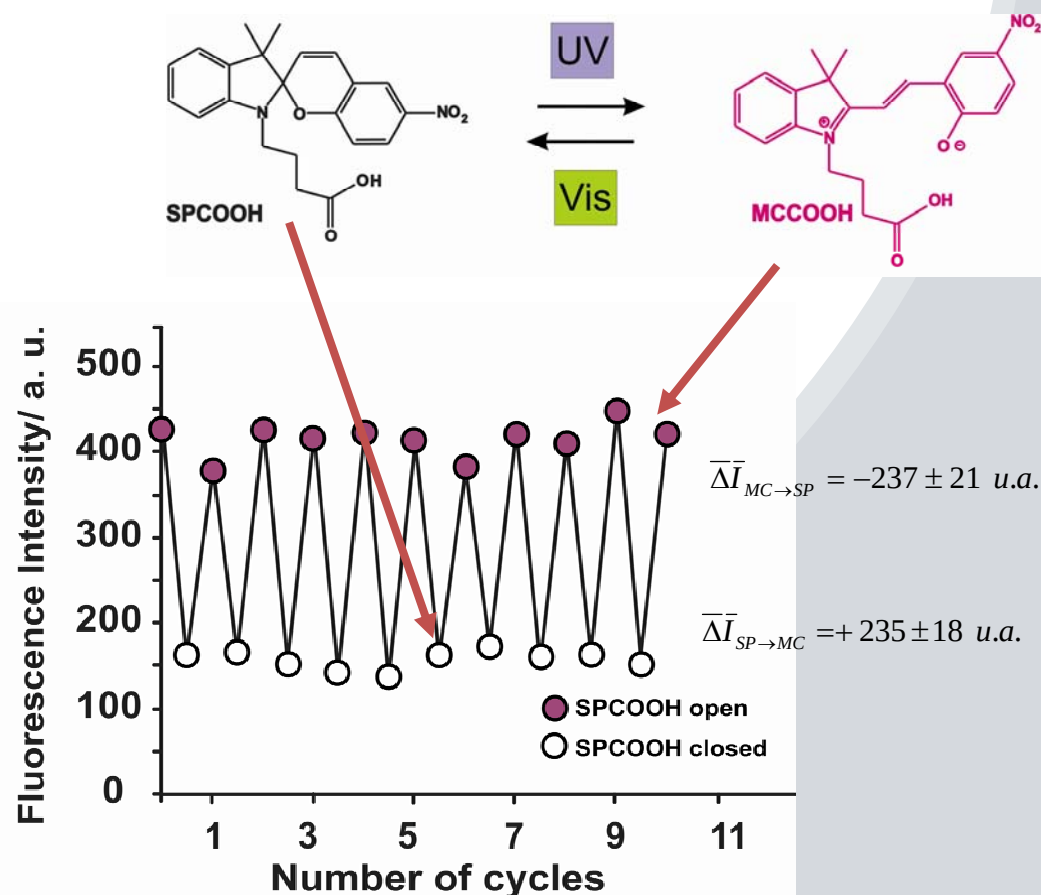


Switching Characterization

GREEN LIGHT IRRADIATION

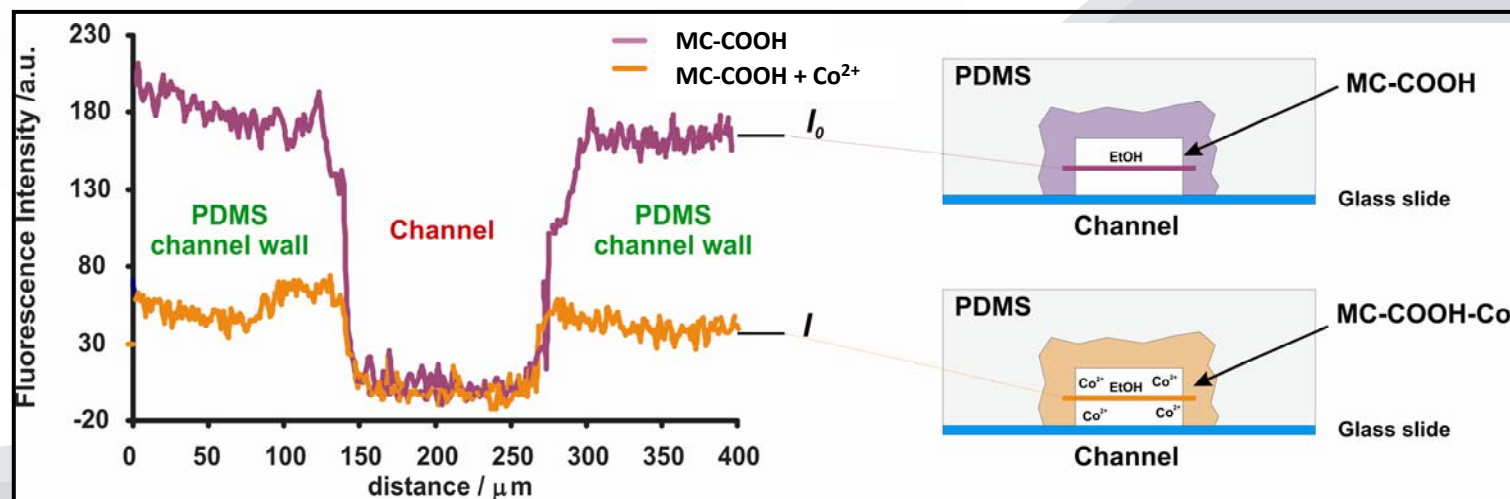
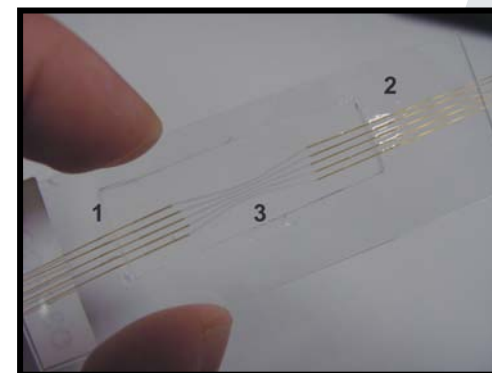
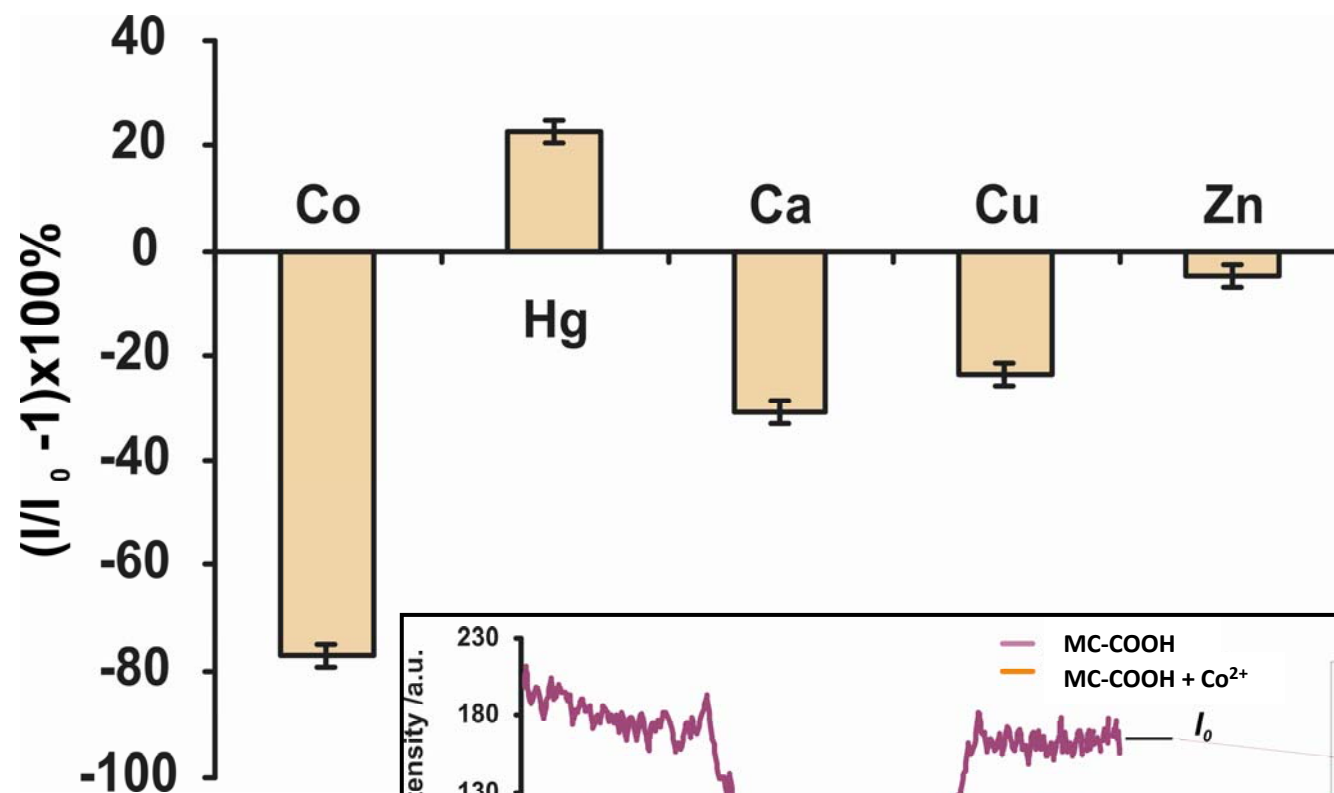


$$k = 0.51 \pm 0.05 \text{ s}^{-1}$$

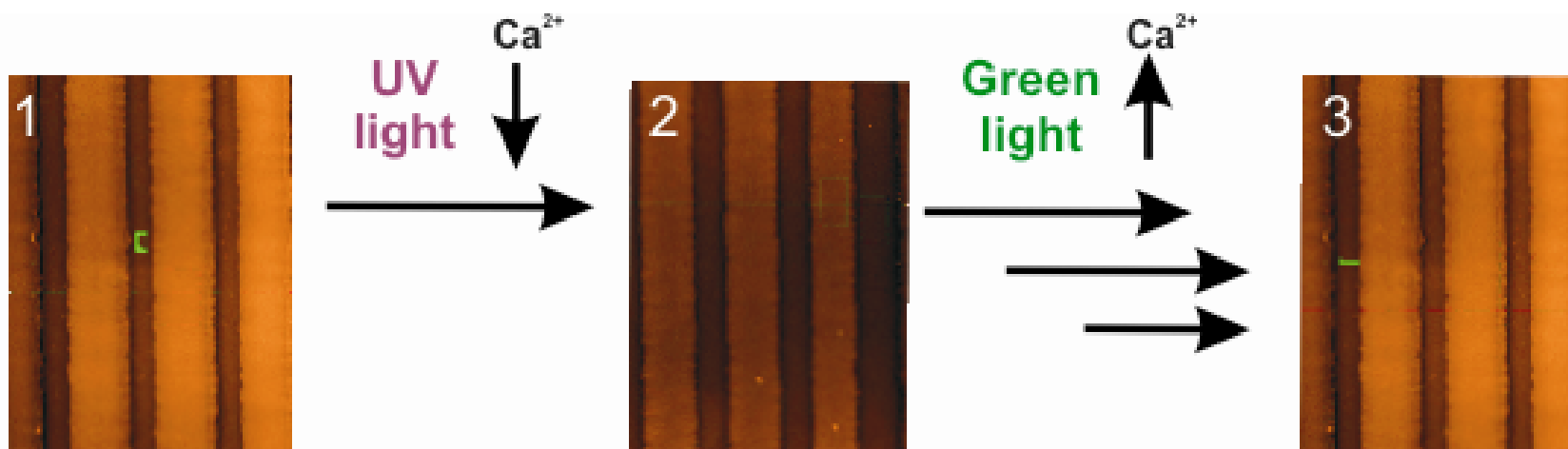


Cycles are reproducible and repeatable, with no hysteresis.
The micro-fluidic device can be used 10 times, without significant photobleaching.

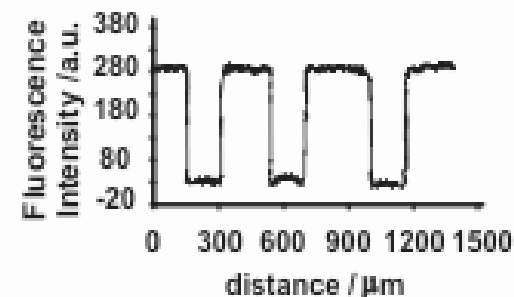
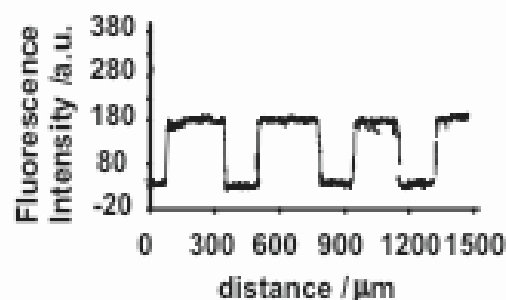
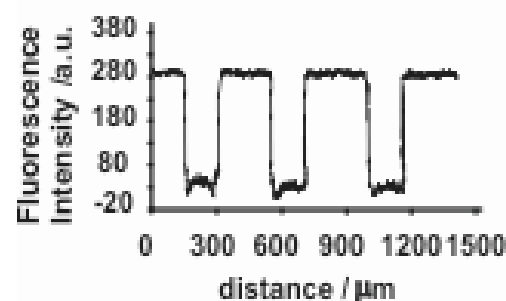
Results & Discussions



Results & Discussions

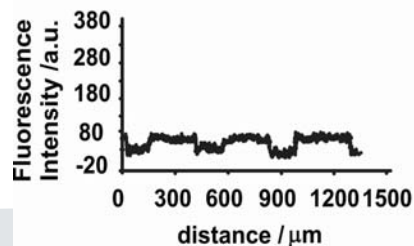
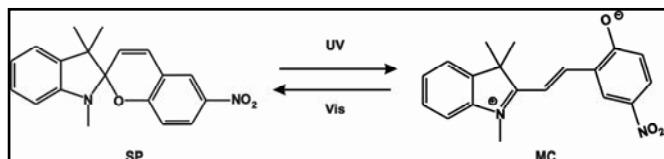


After 3 capture/release
metal experiments

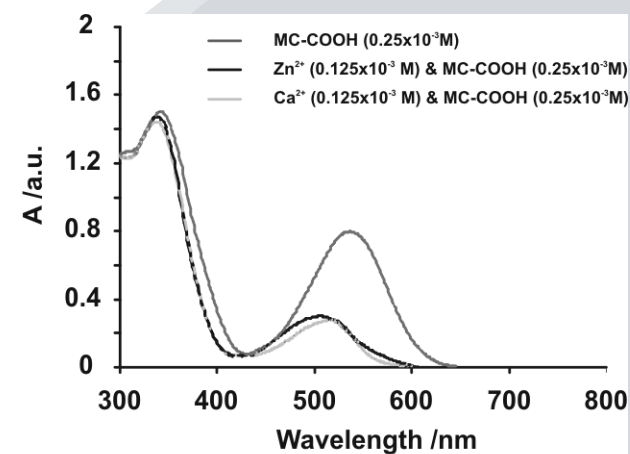
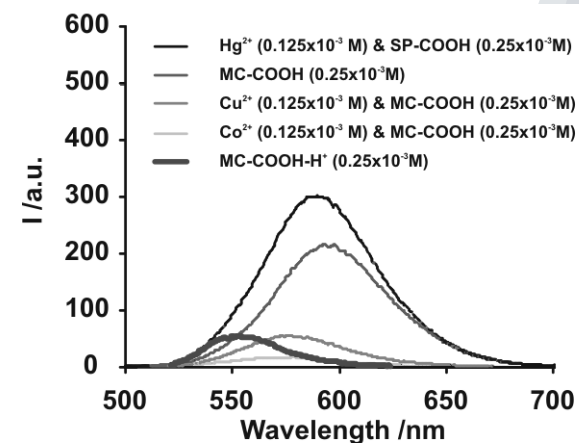
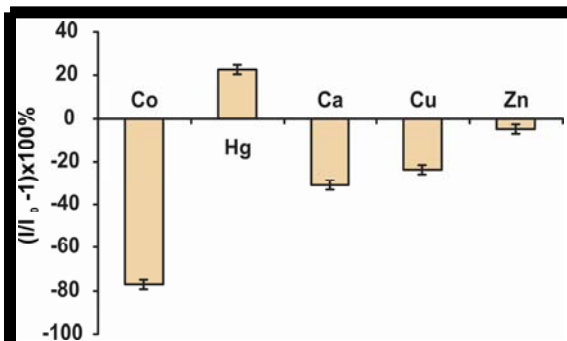
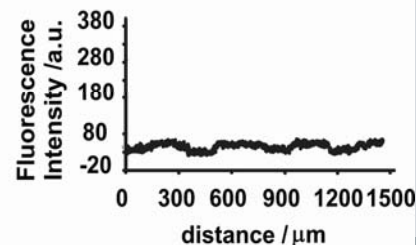


Results & Discussions

Blank experiments



Cu^{2+} ions capture/release experiment



Conclusions

- **An array of micro-channels in a PDMS chip can be fabricated and subsequently functionalised with photochromic spiropyran (SP-COOH).**
- **This platform displays photo-controlled uptake and release of certain metal ions, and examination of fluorescence emission can provide evidence of which ions are present.**
- **This behaviour is fully reversible through multiple cycles. In addition, the platform is inexpensive, and can be made using relatively simple equipment.**

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