Towards the Generation of Fully Functioning Biomimetic Analytical Platforms for Water Quality Analysis Using Ionogels

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Add page numbers bottom left at very end

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References Makes sure you have

Add Andreau pic and BCN guys

Add Fig numbers to all pics

Presentation Outline

- ★ **Introduction to Water Quality Analysis**
- Optical Sensing Device for Lab-on-a-Disc
- Real Water Measurements:
  - pH value
  - turbidity
- ★ **Ionogel microvalves**
- Materials and optical setup used
- Expanding and Shrinking Processes
- Conclusions

National Centre for Sensor Research

- Over 260 f/t researchers and support staff
- 23 affiliated faculty
- Investments and income since 1999 now approaching €100 million
- 1500 m^2 well-equipped specialist lab space and offices
- Phase II expansion completed 2008 (1300 m^2)

CLARITY

The Centre for Sensor Web Technologies

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CLARITY CLARITY clarity-centre.org

The Centre for Sensor Web Technologies

BAS Centre for BioAnalytical Sciences

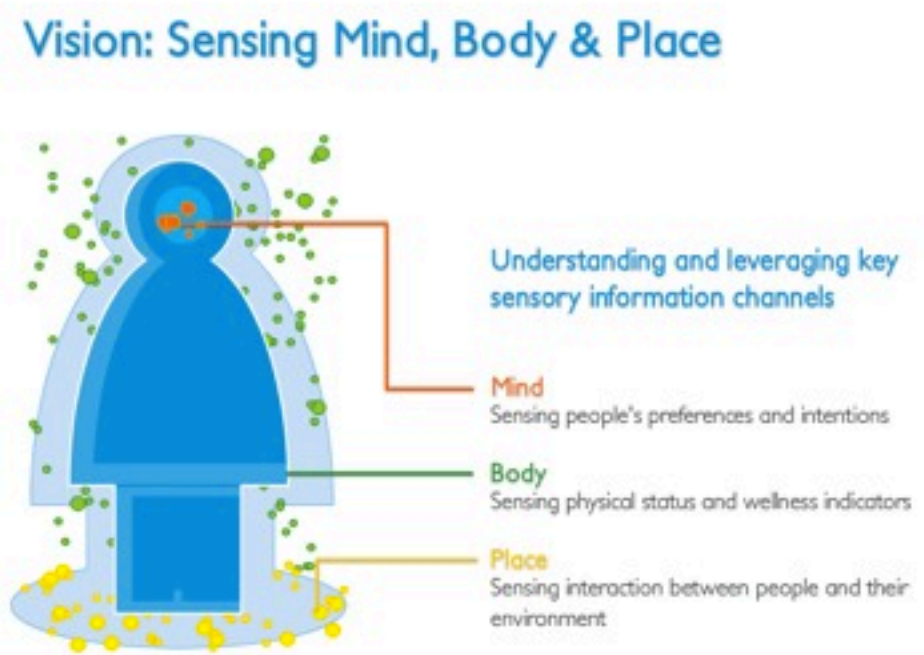
bdi biomedical diagnostics institute

Marine Institute

epa Environmental Protection Agency

NCSR National Centre for Sensor Research

CLARITY – SFI CSET



- 5-year, €16.4 million research program to develop next generation Sensor Web Technologies with significant environmental focus
- Brings together fundamental materials science, functional polymers, device prototyping, energy management, adaptive middleware, wearable sensors, distributed environmental monitoring.

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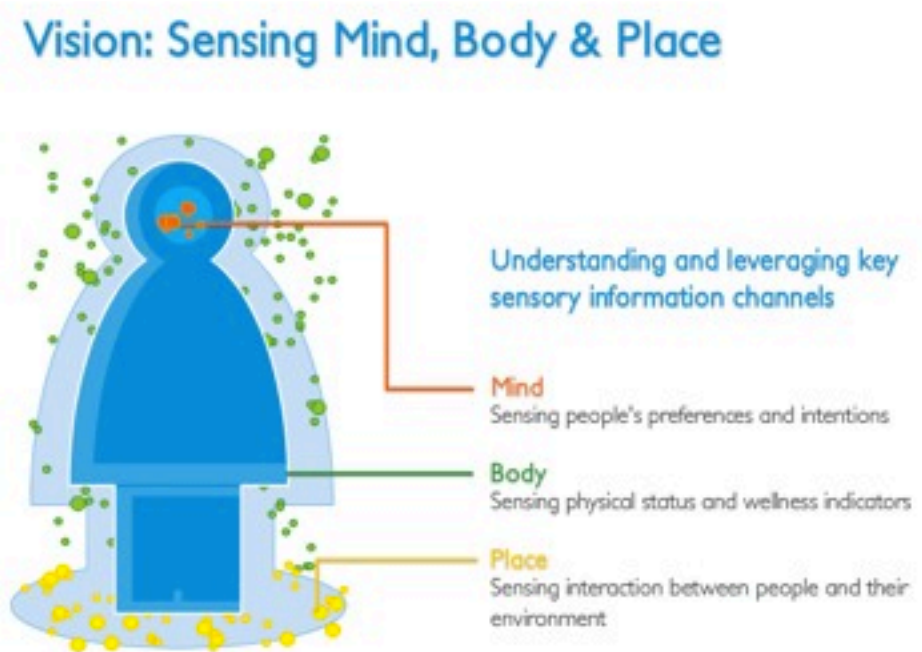

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Introduction: Water Quality

- With increasing concerns over water contamination, attention to proper water quality in an undeniable necessity in the developing world.

- The principal factors that are taken into consideration when determining water quality are:

- turbidity - suspended solids in water can stop light reaching submerged plants and can raise water temperature
- pH - excessively high and low pHs can be detrimental for the use of water.

- According to statistics of World Health Organizaton, over 3.5 million people die each year because of water-related diseases [1]

Wheres reference??

Water Sensors

Environmental Regulation

Challenges:

- The regulations are in place or on the way
- Regulations cannot be enforced without measurements
- Current norm is manual grab sampling 3 or 4 times a year
- We do not measure the status of our environment often enough in enough locations

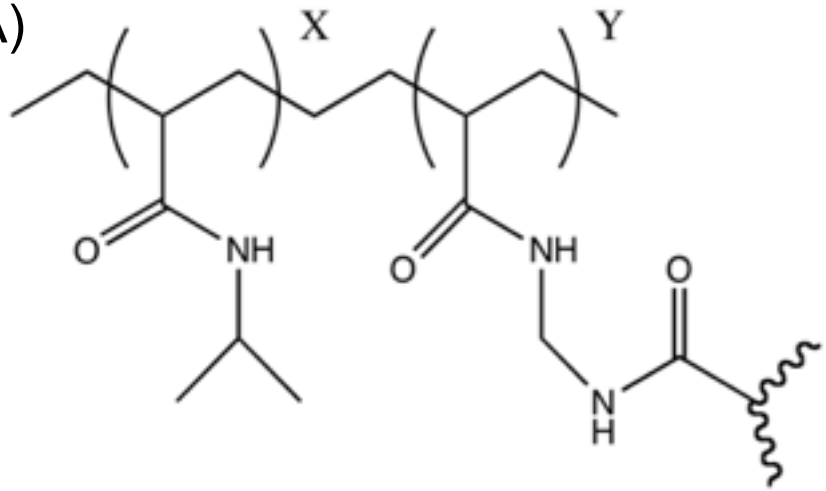
Solution:

- Simple: Measure **more often** in **more locations**

Why is this not happening?

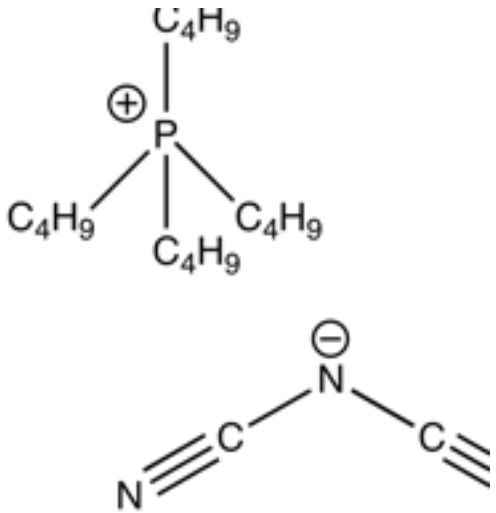
Our Sensor: Materials

A)



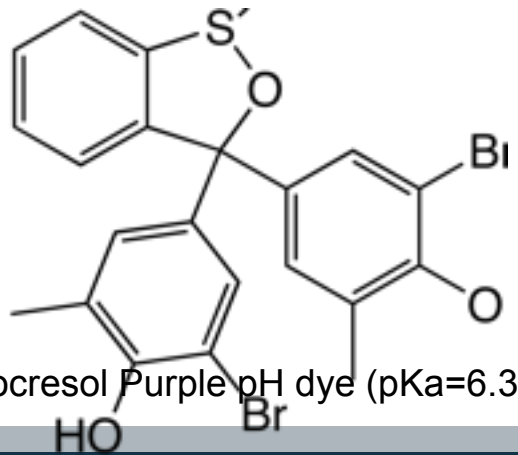
A) poly(N-isopropyl- acrylamide) and N,N-methylene-bis(acrylamide) cross- linked polymer in the ratio 100 (x):5 (y)

B)



B) the ionic liquid tetrabutylphosphoniu
dicyano-amide [$P_{4,4,4,4}$][dca]

C)

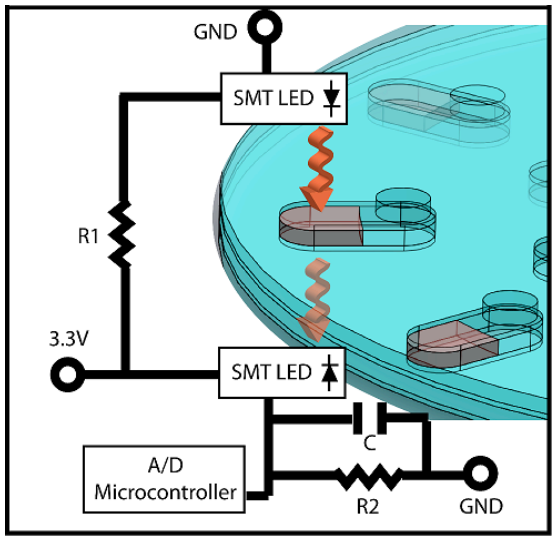


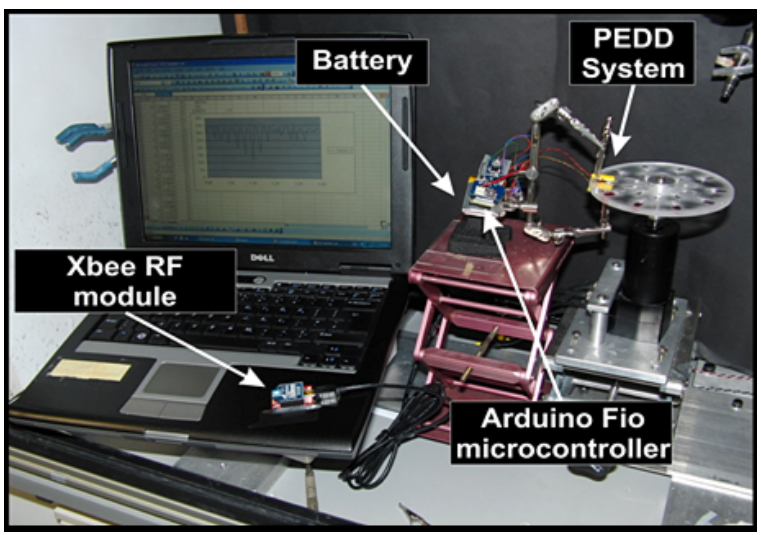
C) Bromocresol Purple pH dye (pKa=6.3)

Aci
enviro

- ILs are low melting point salts (<100 C) th
represent a new class of non-aqueous but polar solvents.
- Composed of ions: cations and anions.
- Designer solvents' as their properties can be adjusted to suit the requirements of a particular process.

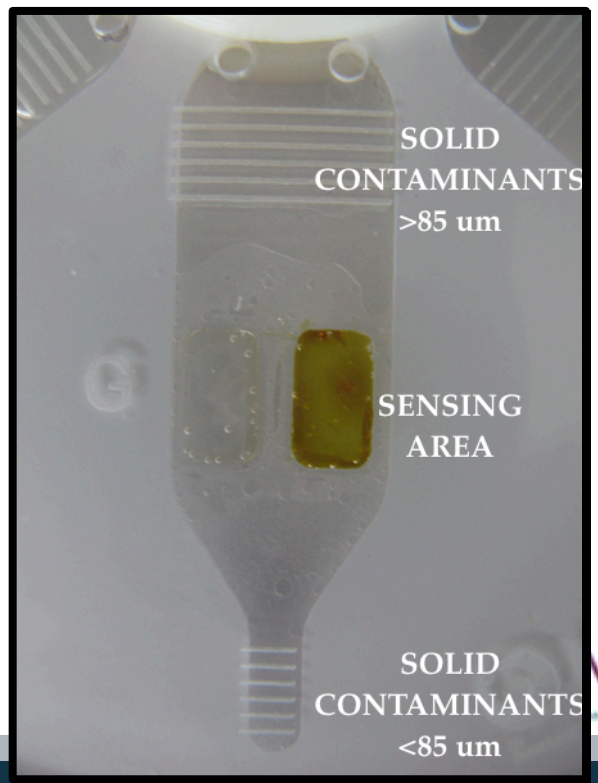
Our Sensor: Wireless Paired Emitter Detector Diode Device





- excellent sensivity and signal-to-noise ratio
- low power consumption,
- increasing spectral range coverage,
- intensity and efficiency,
- low cost,
- small size,
- ease of fabrication
- simplicity
- AND adjusts ideally to the system based on centrifugal Lab-on-a-disc!

Our Sensor: Lab-on-a-Disc



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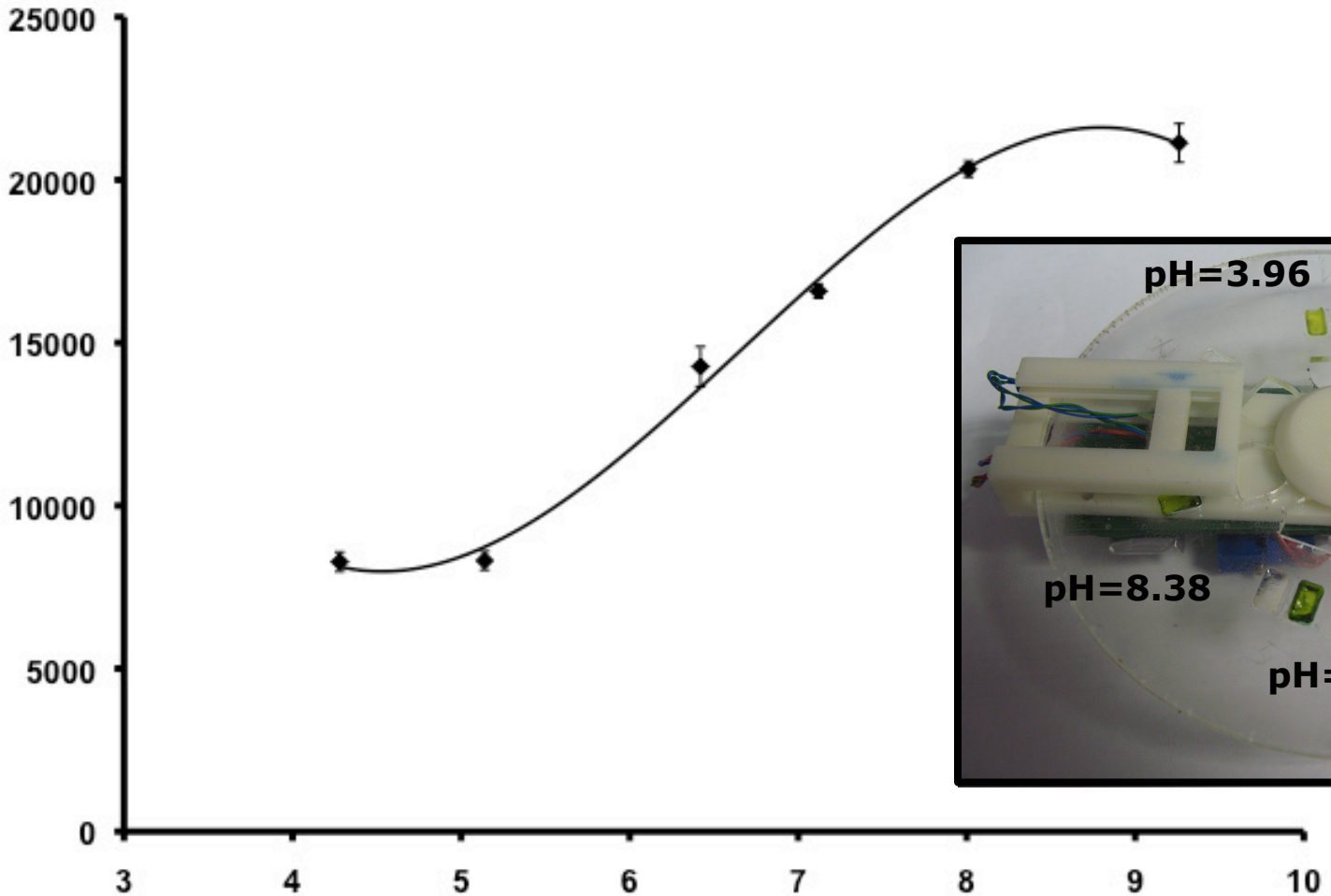
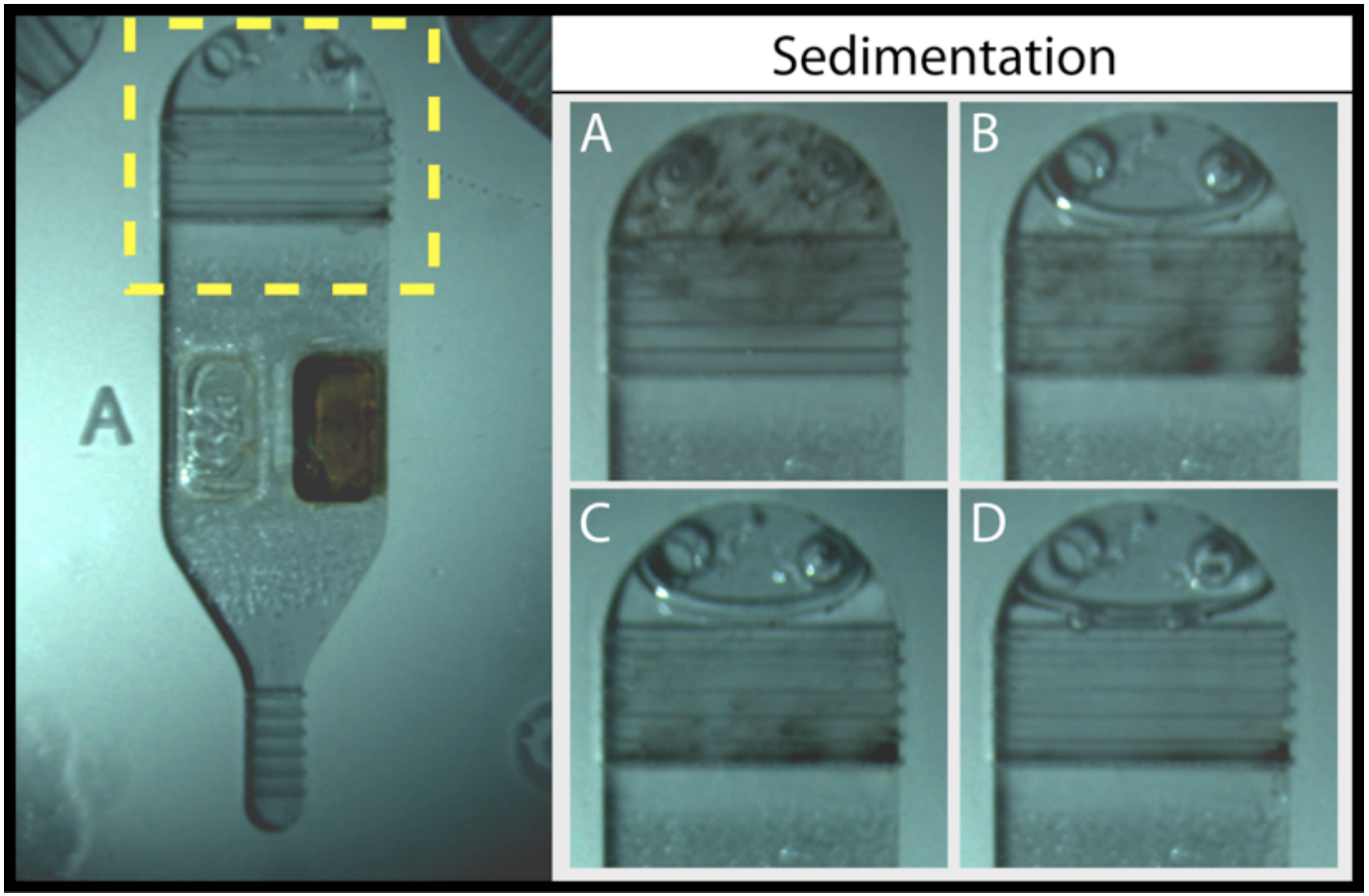
Calibration of the sensor



Real Water Analysis: Sampling

Tolka River, Dublin, Ireland

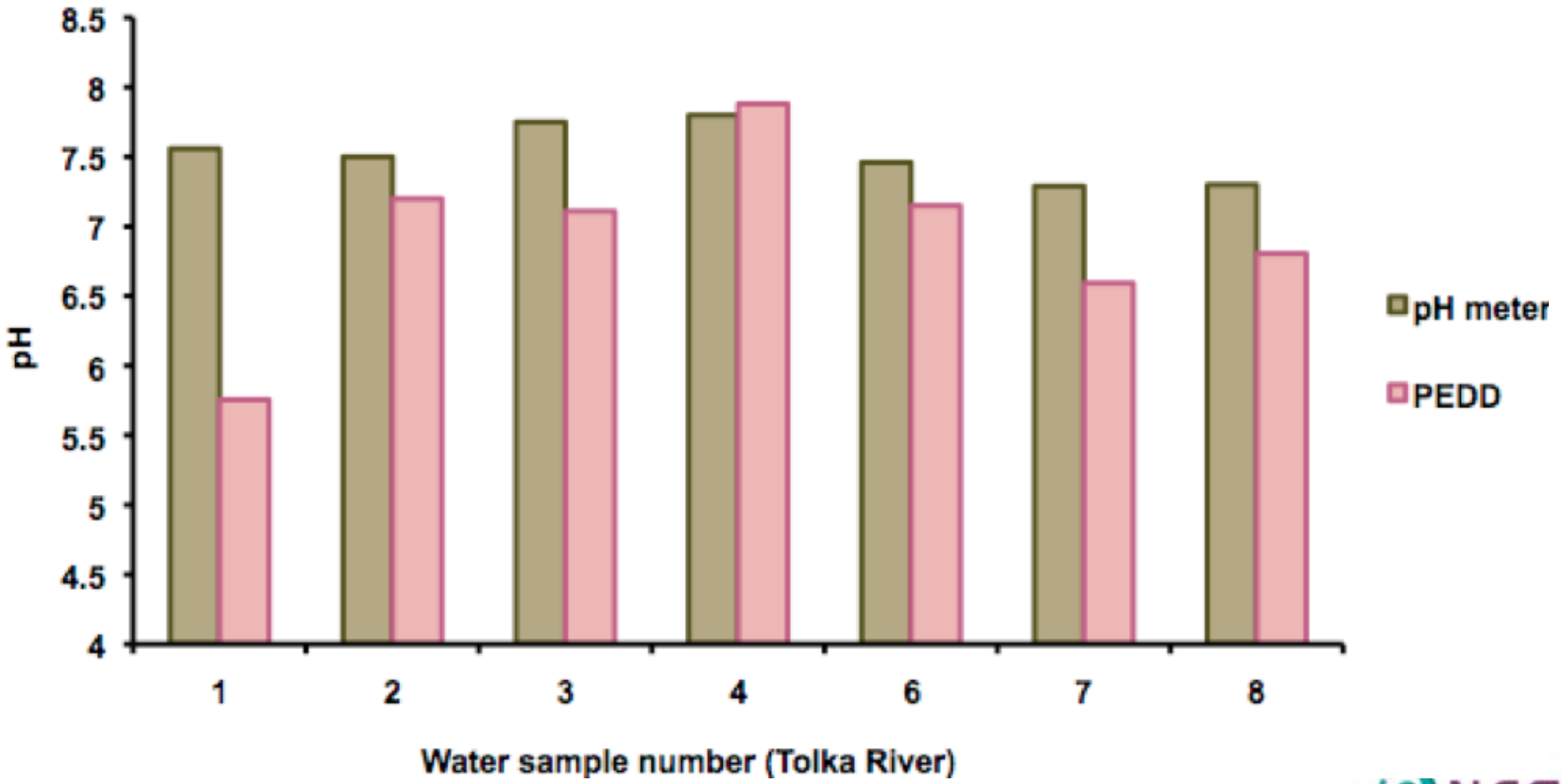
Real Water Analysis: Loading of sample during rotation



Images of a channel of the CD-chip during centrifugation at 1500 rpm.
A) the upper chamber is filled with sample, then the disc is spun for two minutes and all the liquid is transferred to the sensing area (B-D). Solid contents are accumulated in the first chamber (>85μm diameter) (B-D) and at the bottom of the channel (<85μm diameter).

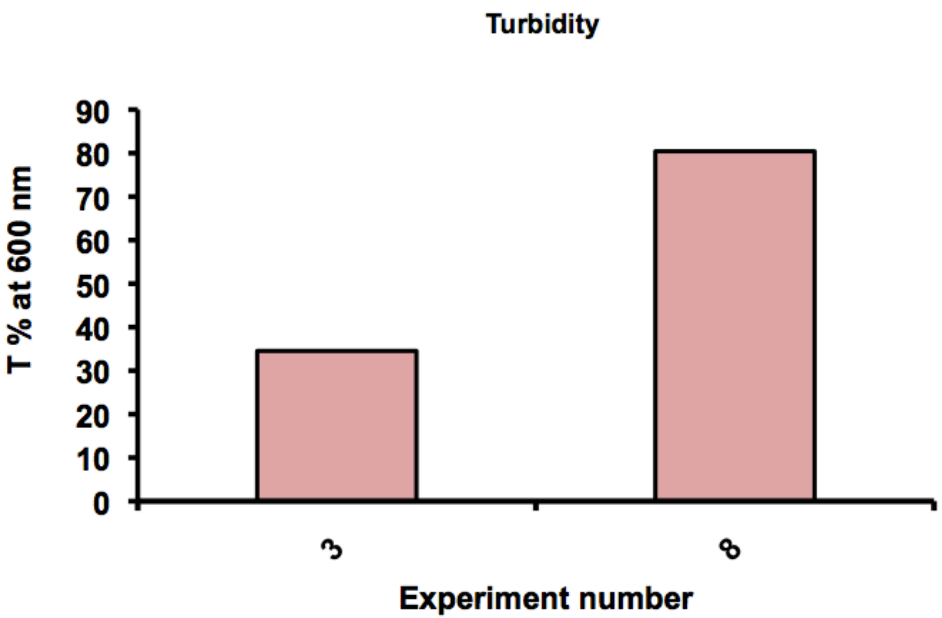
Real Water Analysis: pH

Water pH analysis using a commercially available pH-meter and the PEDD lab-on-a-disc device.

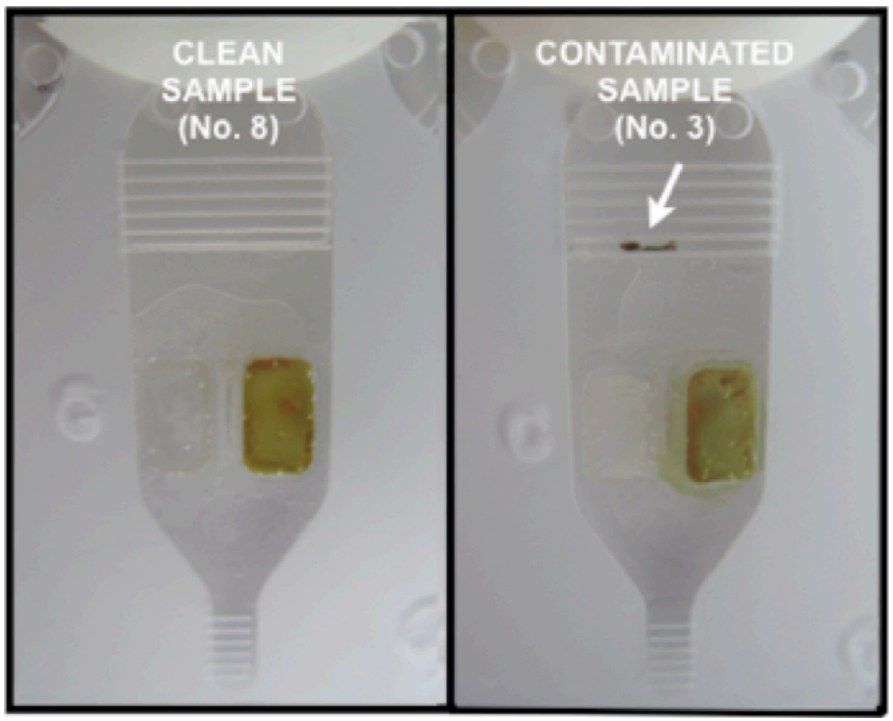


Real Water Analysis: Turbidity

a)



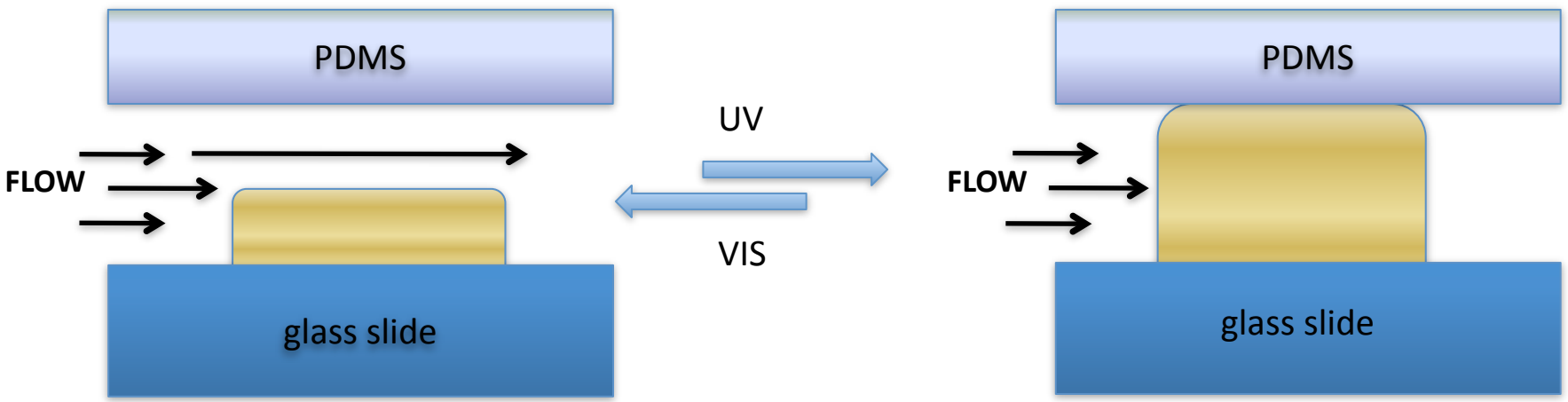
b)



a) Turbidity measurements using a UV-VIS spectrometer (transmittance) and b) two channels with river samples; one is clean (left) while the other contents solids in the upper chamber (right).

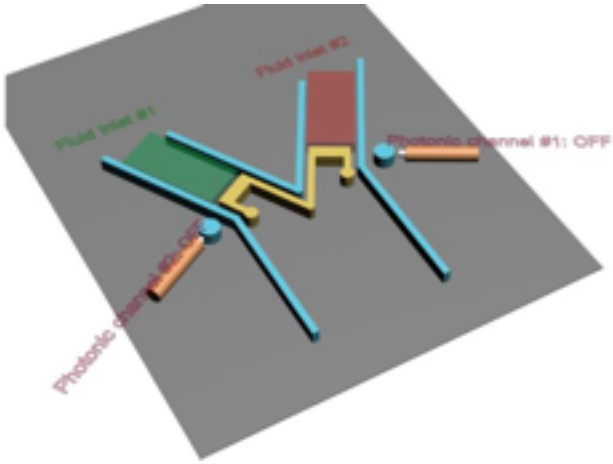
Ionogel Microvalves

- by photo-polymerising ionogels with incorporated spiropyran the ionogels retain the spiropyran chromphoric properties
- in HCl the ionogel structures exhibit a drastic and rapid expnding effect and a colour change to yellow was observed due to the presence of the protonated merocyanine form.
- upon exposure to white light, the ring-closing mechanism of the merocyanine occurs and spiropyran is formed

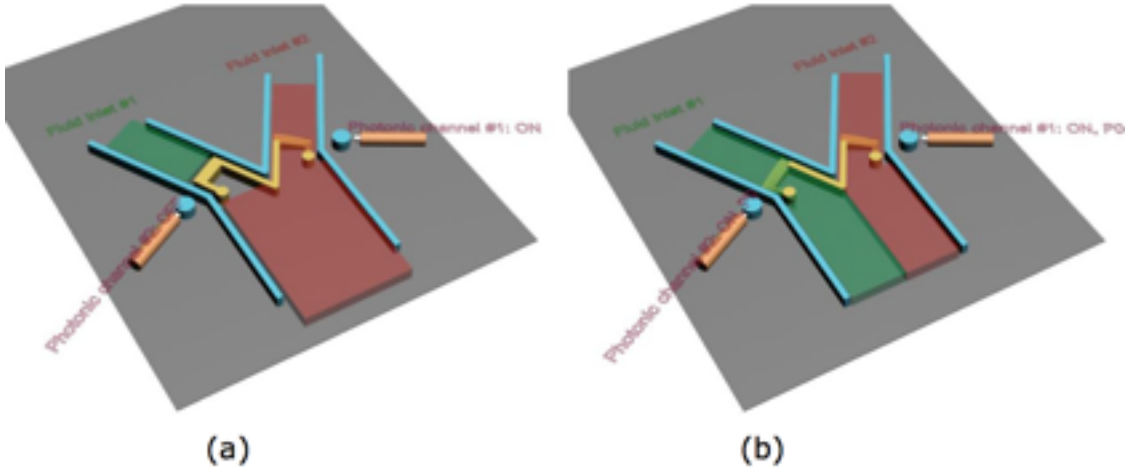


Photonically controlled actuators in micro- and nano-fluidics.

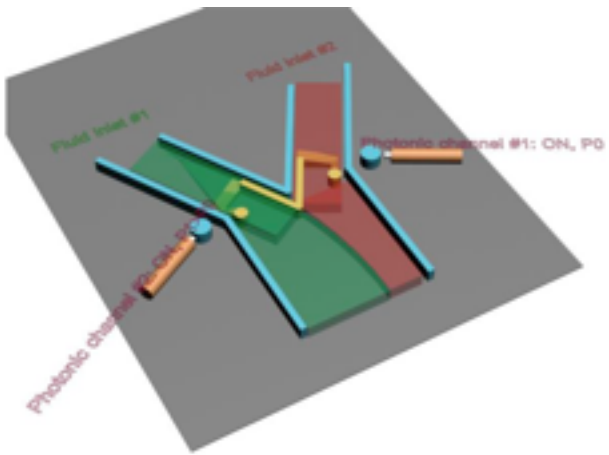
Photonic ionogel-based tunable micromixer



Photonic ionogel-based micromixer consisting on a Y-shaped micro-fluidics and two photonic channels. [2]



(a) Actuation on the photonic channel #1 allows red fluid to reach the detecting region. (b) Actuation on both photonic channels with identical optical power P0. Both ionogel valves provide 50% to the total analyte flow.



Actuation on both photonic channels with different optical power (channel 1, P0: channel 2, P1>P0). Ionogel valves contribution to the total analyte flow varies.

[1] F. Benito-Lopez, M. Czugala, Project proposal: Novel Functional Materials Based on Ionic Liquids (Ionogels) as Photonically Controlled actuators in Micro- and Nano-fluidics, 2010.

Materials

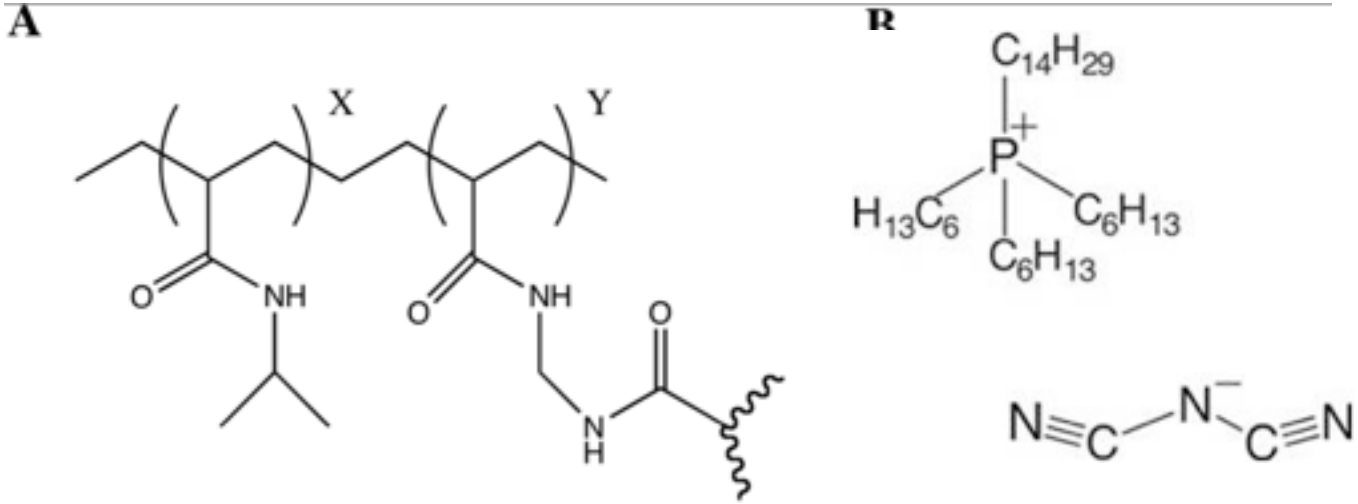


Figure 2: Molecular structures of the two components that form the ionogel material: A) poly(N-isopropyl- acrylamide) and N,N-methylene-bis(acrylamide) cross- linked polymer in the ratio 100 (x):5 (y) b) the ionic liquid trihexal-tetradecyl phosphonium dicyano-amide [$P_{6,6,6,14}$][dca]

C

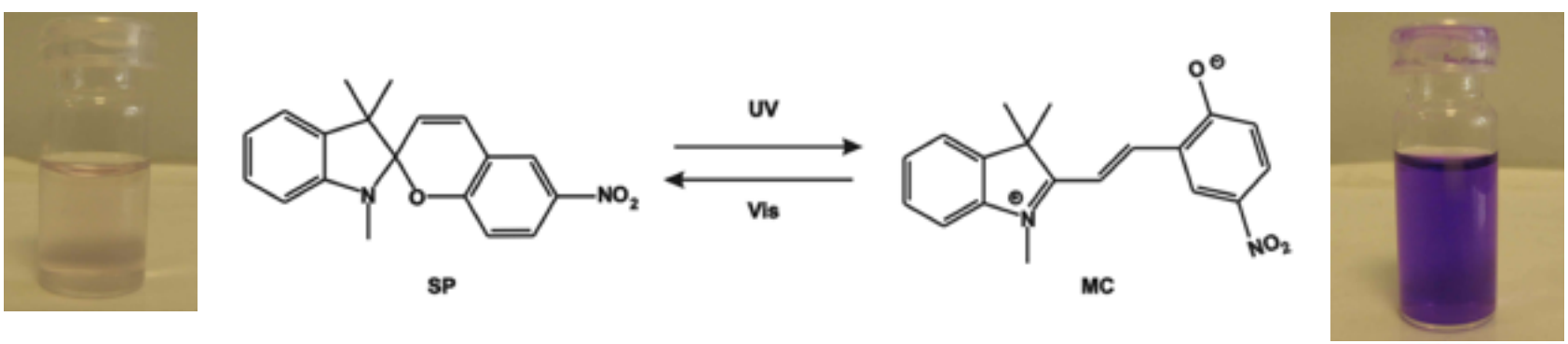
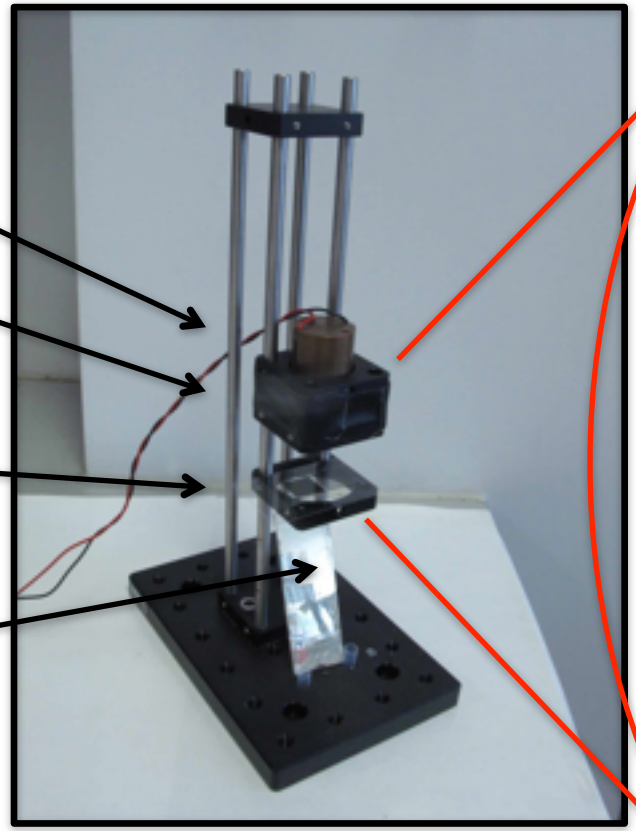
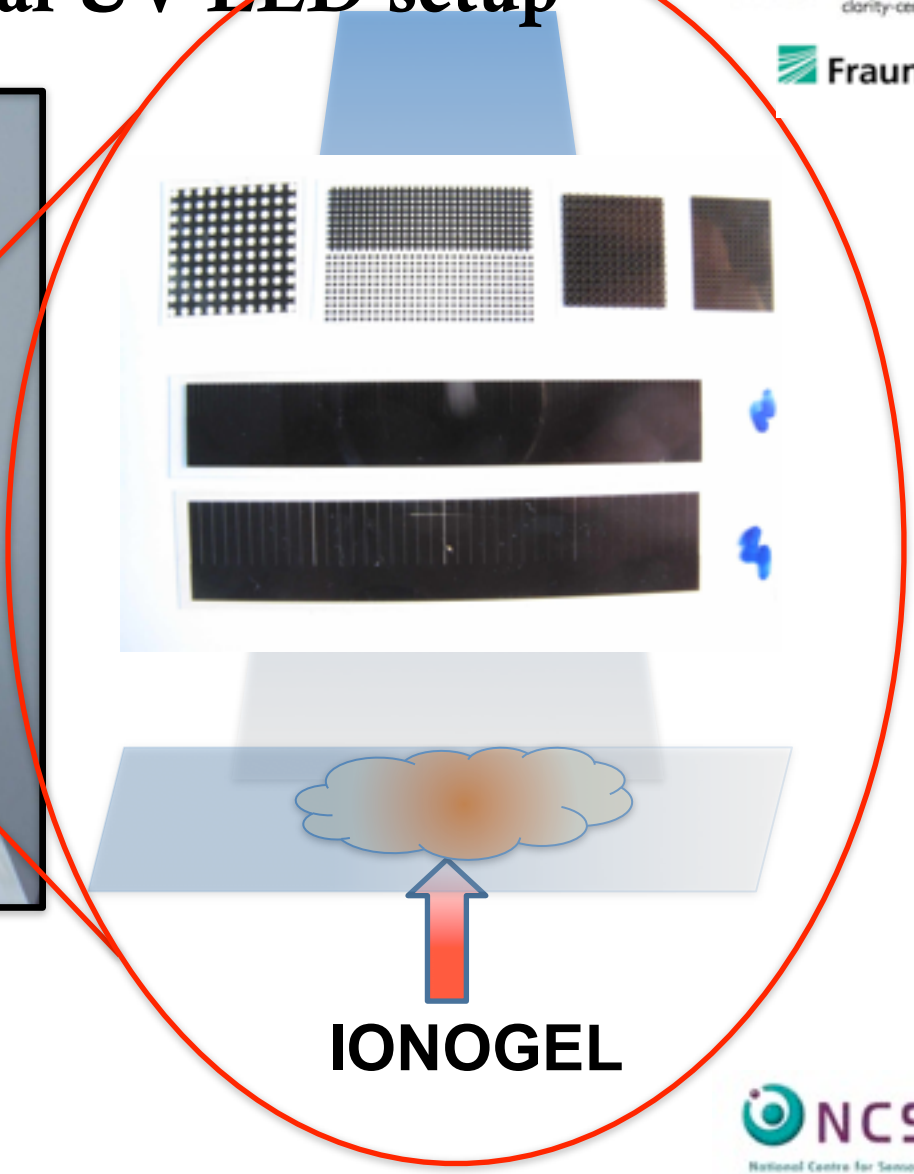


Figure 3: Interconversion between two thermodynamically stable states using UV and visible light: a spiropyran (SP) form and a merocyanine (MC) form.

Photopolymerization of ionogel microstructures with optical UV-LED setup system



The optical UV-LED setup.



- exposure for 20 minutes
- U=3.5 [V], I = 500 [mA]
- d=3 cm behind lens.

Surface modification of glass substrate

-washing with IPA, water, drying with N_2,

- O_2 plasma treatment,

- dipping in water solution of silane agent
(3- (Trimethoxysilylpropylmethacrylate):

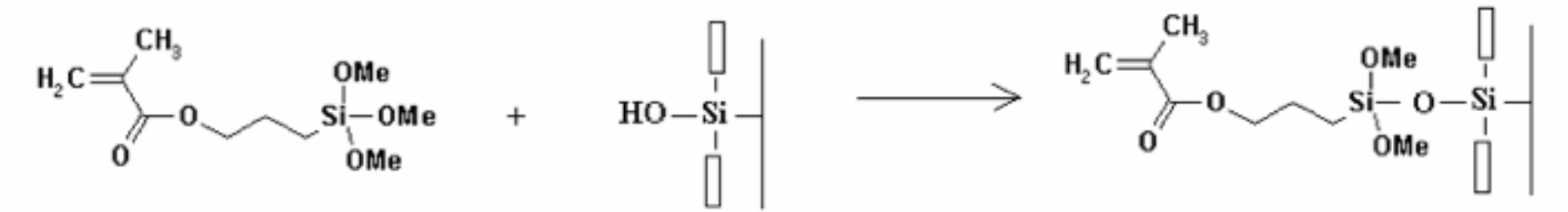
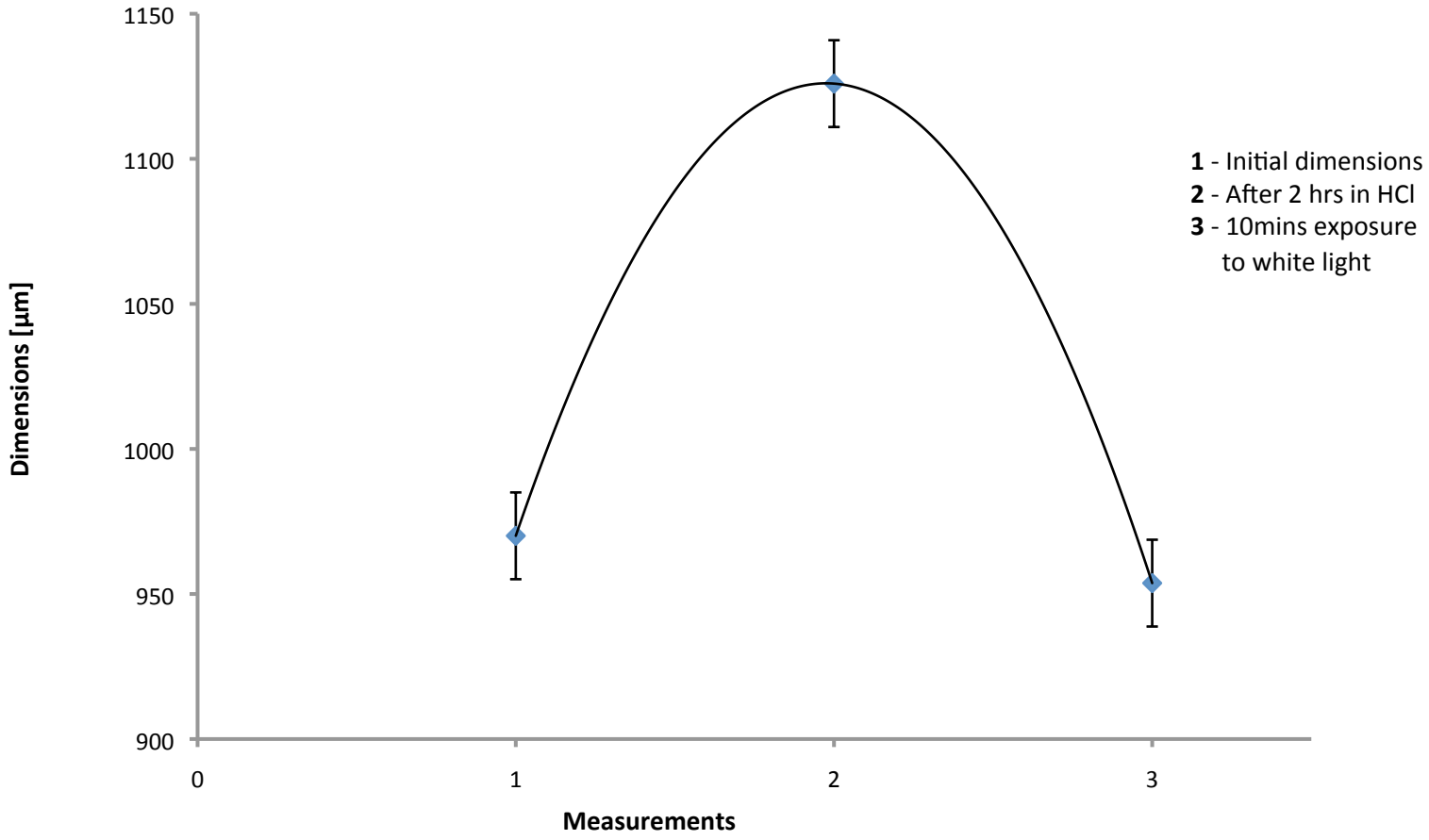


Figure 8 : Representation of silanization reaction [2].

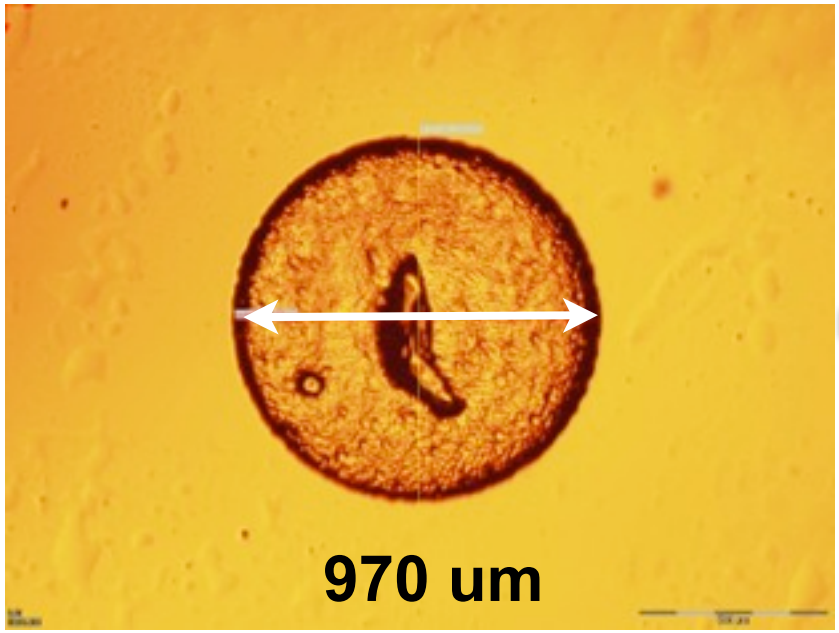
[2] B. Candice, A Two-Chromophore photolithography photopolymerization, IPM Fraunhofer, 2010

Expanding and Shrinking Process

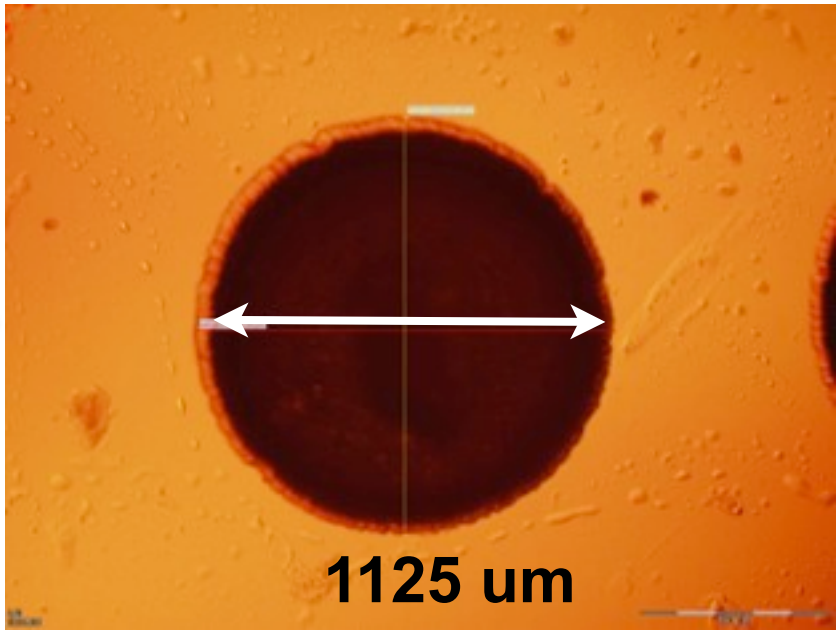


Expanding

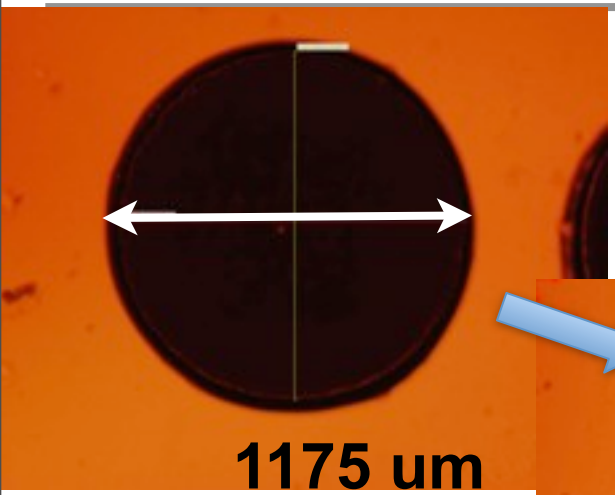
- Using Microscope



1mM HCl

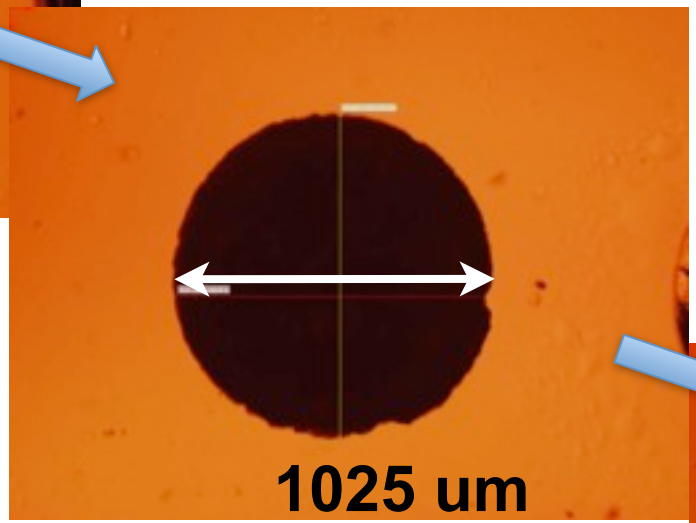


Shrinking



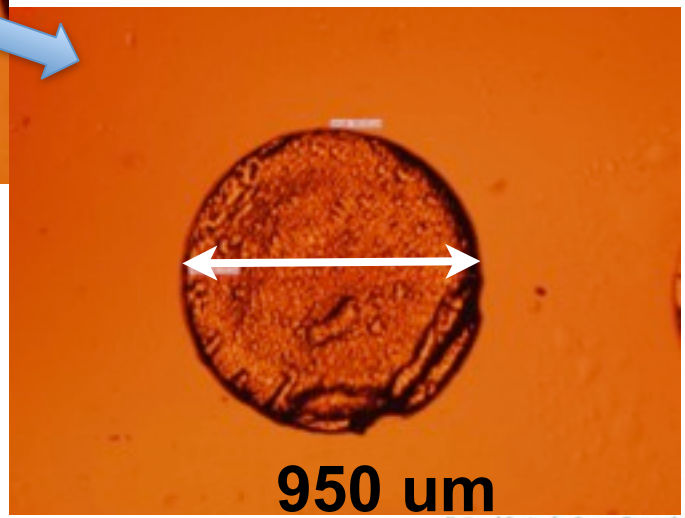
1175 um

White light – 3mins



1025 um

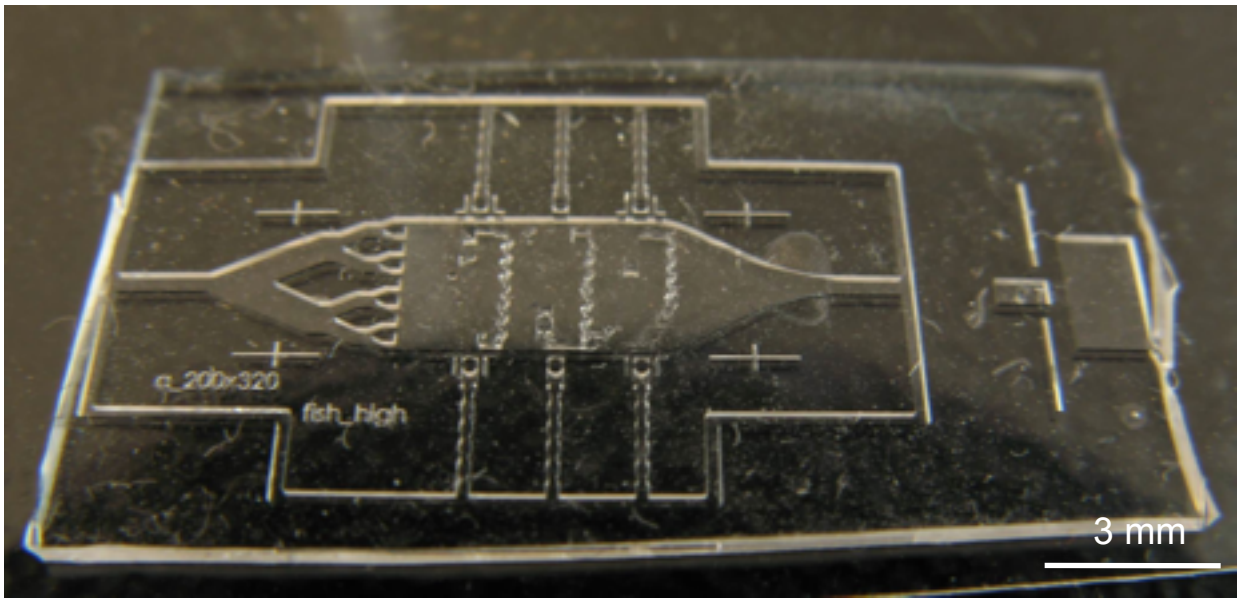
White Light - 10mins



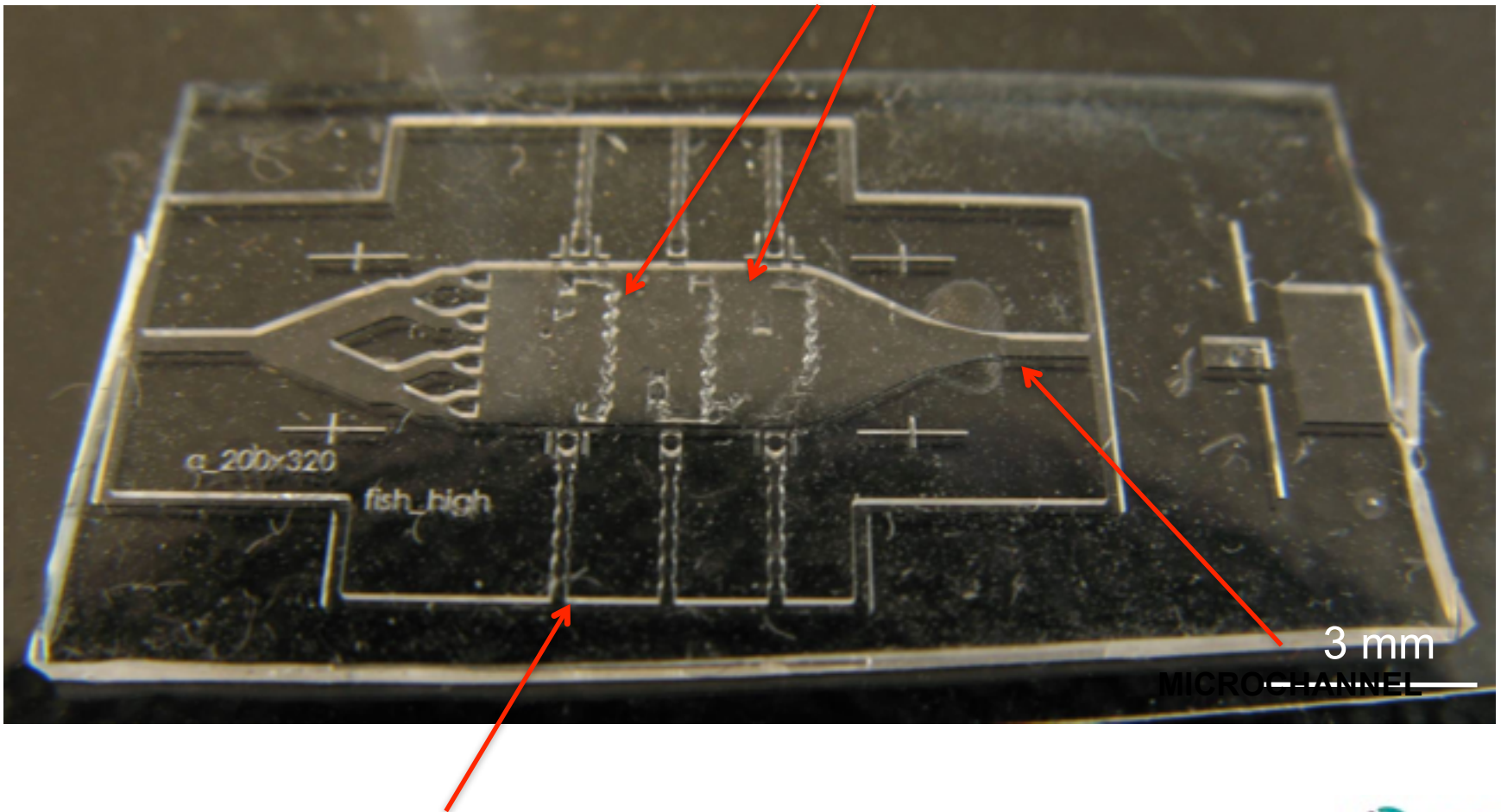
950 um

10 mins --> 225 um Difference

Fabricated microchip



Fabricated microchip



Fabrication of ionogel microvalves

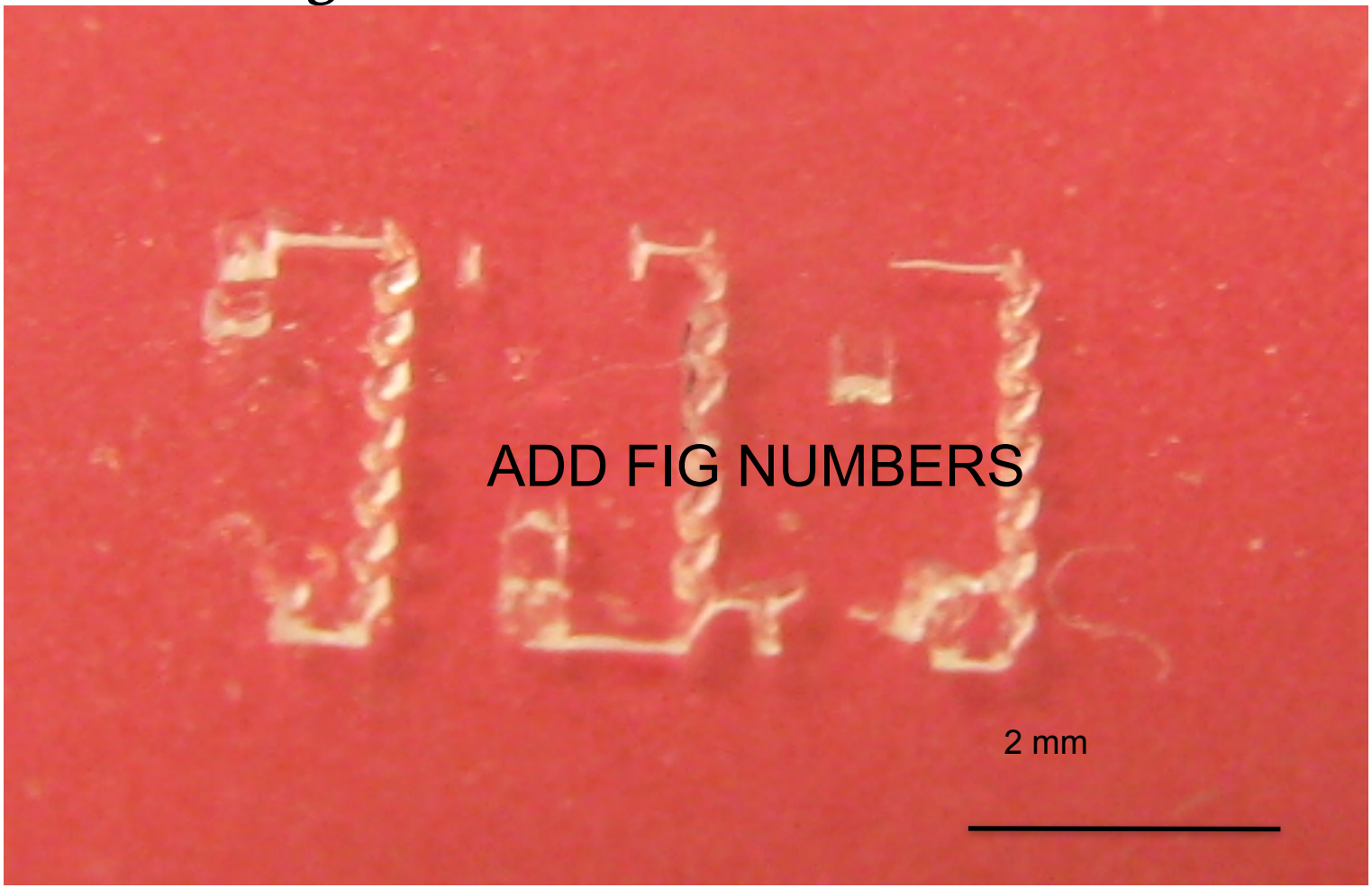


Figure X: Microvalves made in ionogel.

Fabrication of ionogel microvalves

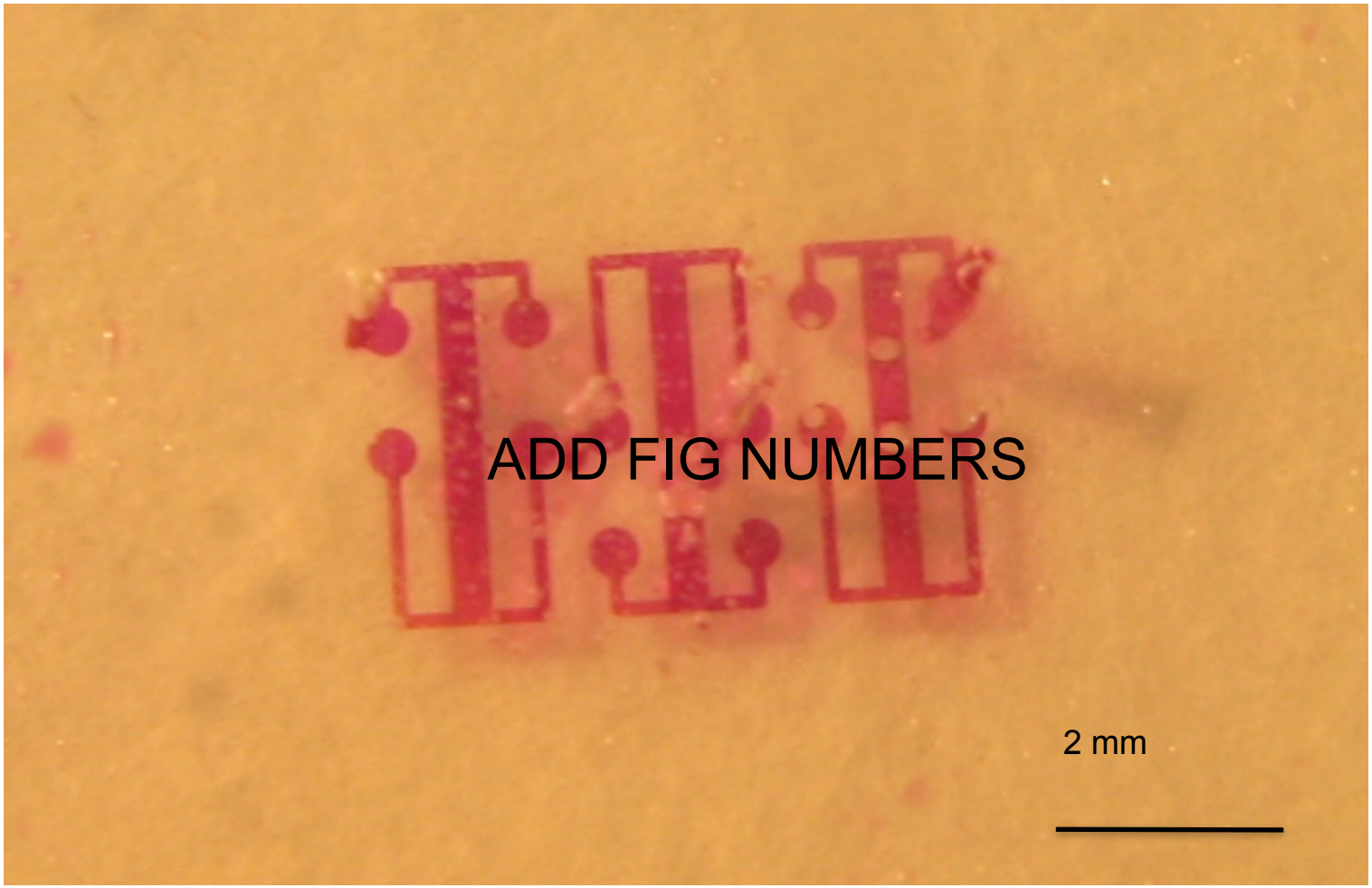


Figure Y: Microvalves made in ionogel with spiropyran.

Conclusions:

- A novel optical sensing configuration for lab-on-a-disc water quality measurement applications has been developed.
- Instrumentation incorporates low power detection coupled with wireless communication and power supply onto Lab-on-a-disc system.
- The potential for wireless paired emitter detector diode device to be versatile and cheap alternative optical detector for microfluidic applications in water quality monitoring.
- The CD designed for multi-parameter water analysis allowed not only for pH measurement, but also the solid contaminants test of the sample.
- Valves

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Thank You for Your Attention!