Towards Bioinspired MicroSystems

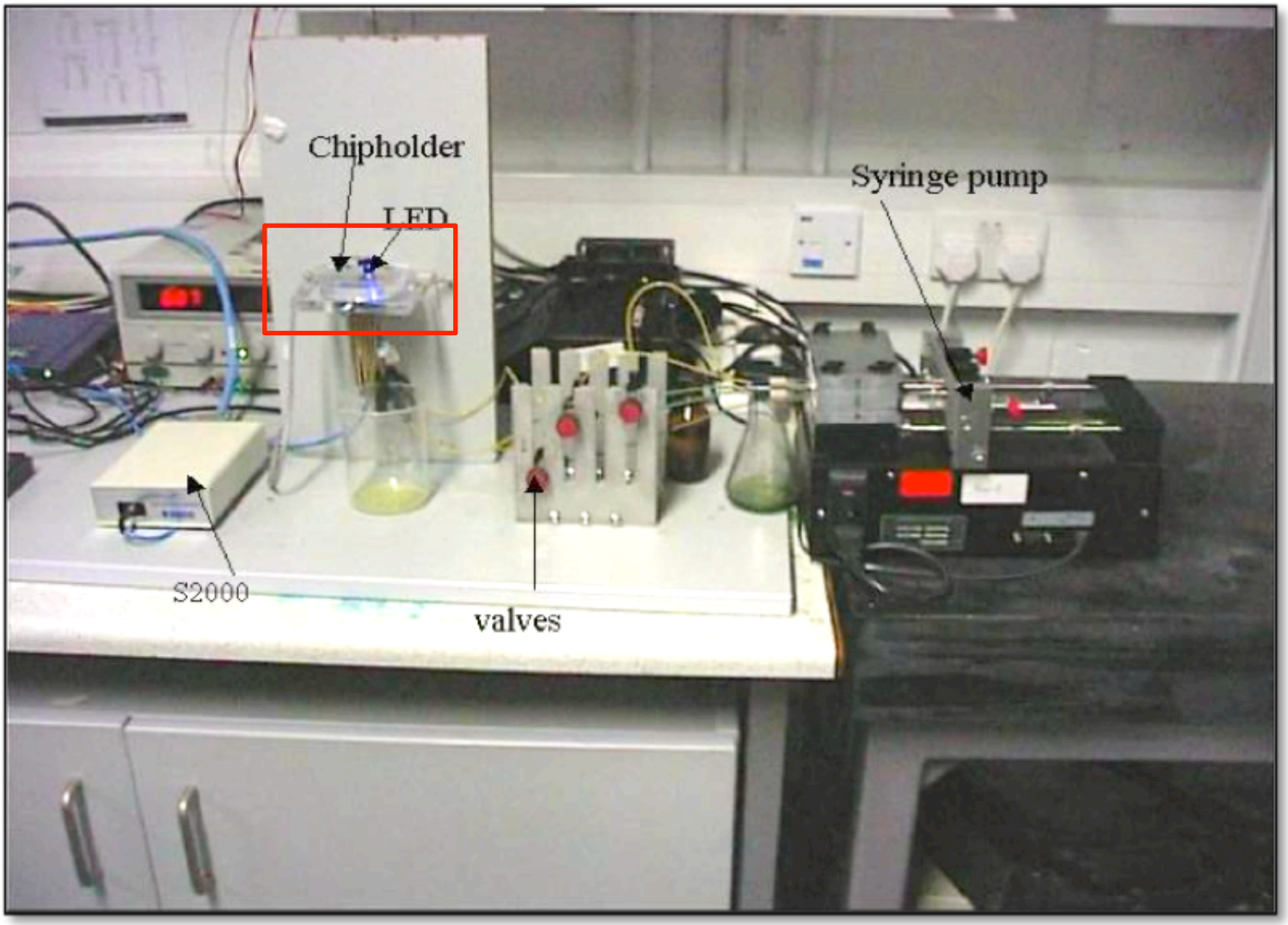
Larisa Florea, Aishling Dunne, Wayne Francis,
Alexandru Tudor, Dermot Diamond

Cetraro, 14-15 September 2016

MPNS COST Action 1205

Advances in Optofluidics: Integration of Optical Control and Photonics with Microfluidics

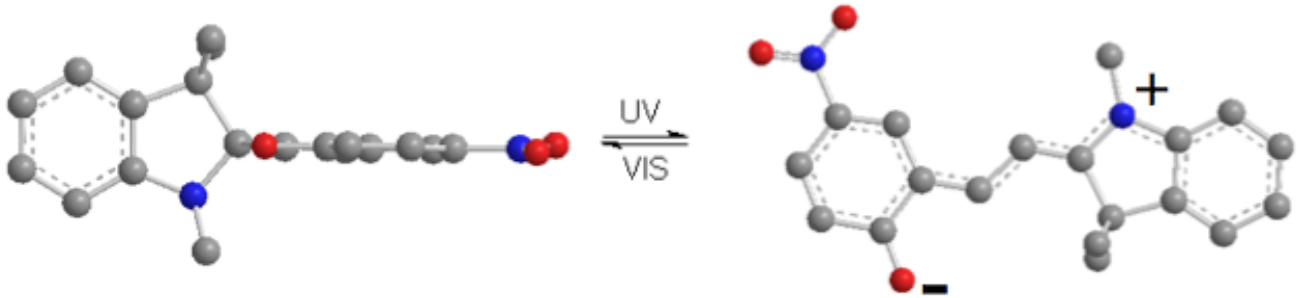
cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY



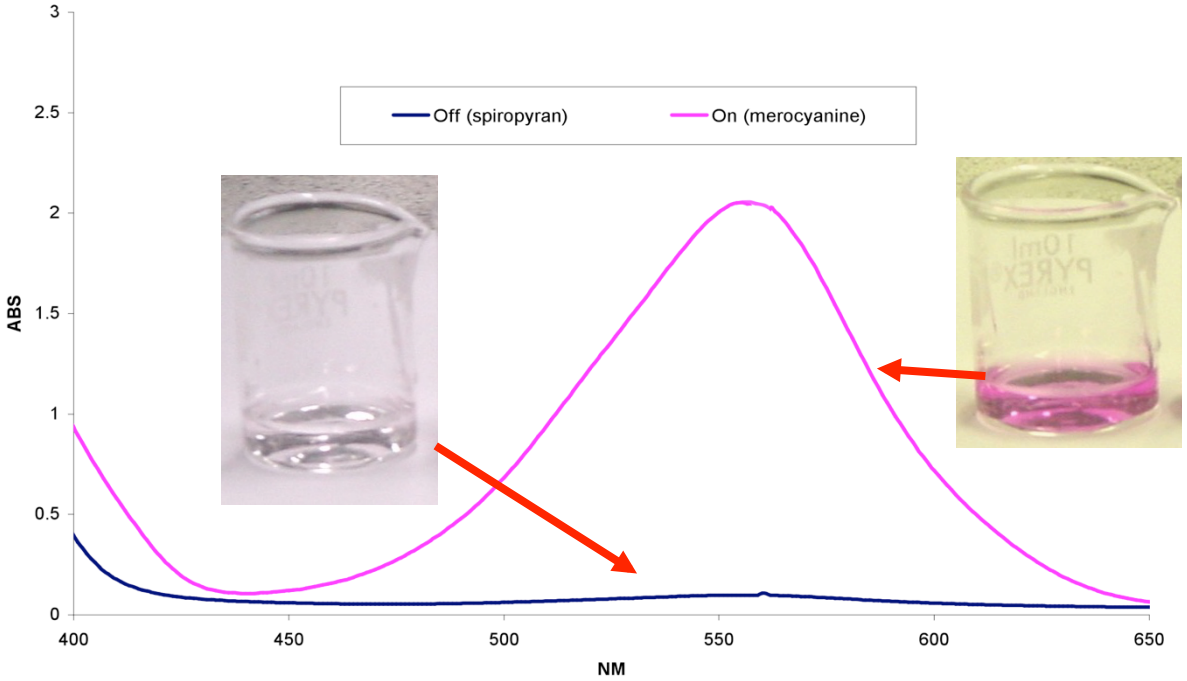
Chemical Sensing using an Integrated uFluidic System based on Colorimetrics: A Comparative Kinetic Study of the Bertholet Reaction for Ammonia Determination in Microfluidic and Spectrophotometric Systems, A Daridon, M Sequiera, G. Pennarun-Thomas, J Lichtenberg, E Verpoorte, D Diamond and NF de Rooij, Sensors and Actuators B, 76/1-3, (2001) 235-243.

Historic background

Spiropyran

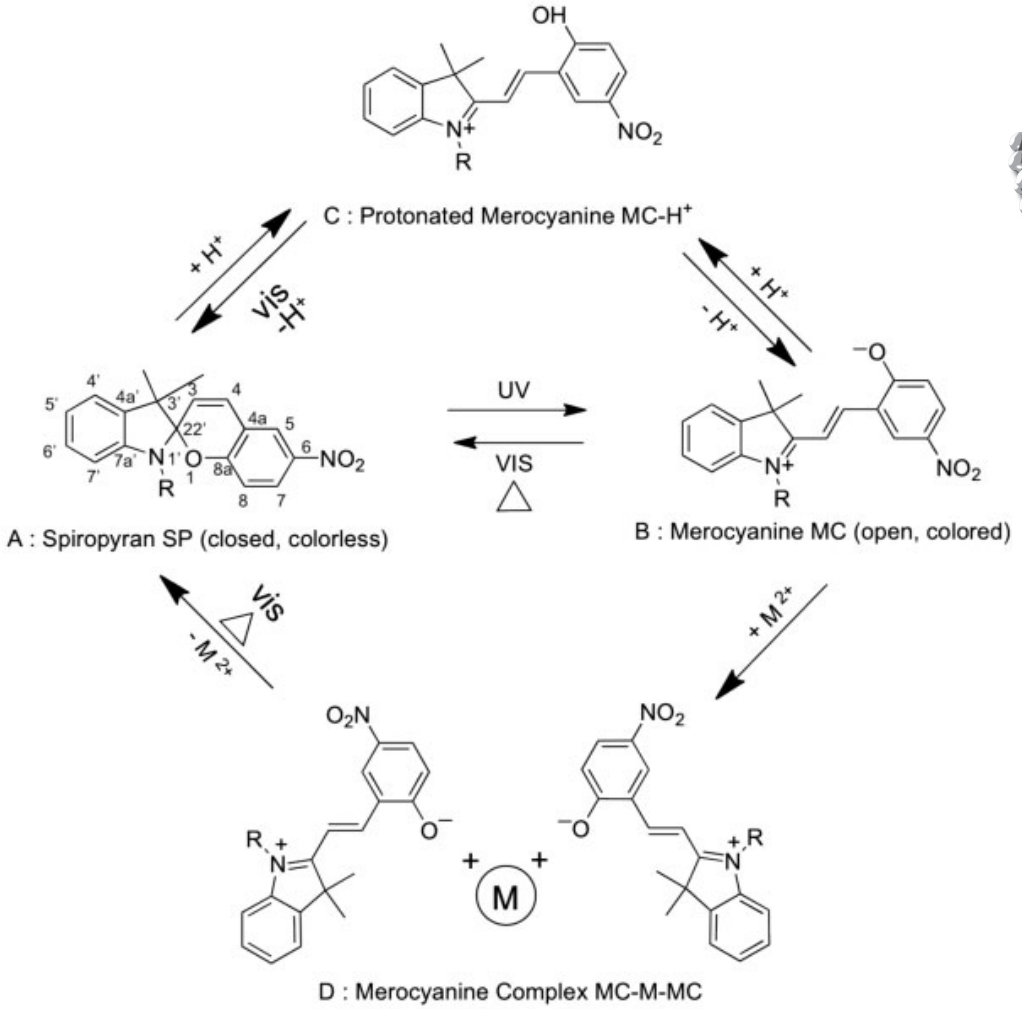


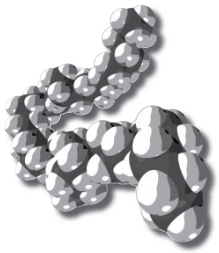
A : Spiropyran SP (closed, colorless) **B : Merocyanine MC (open, colored)**



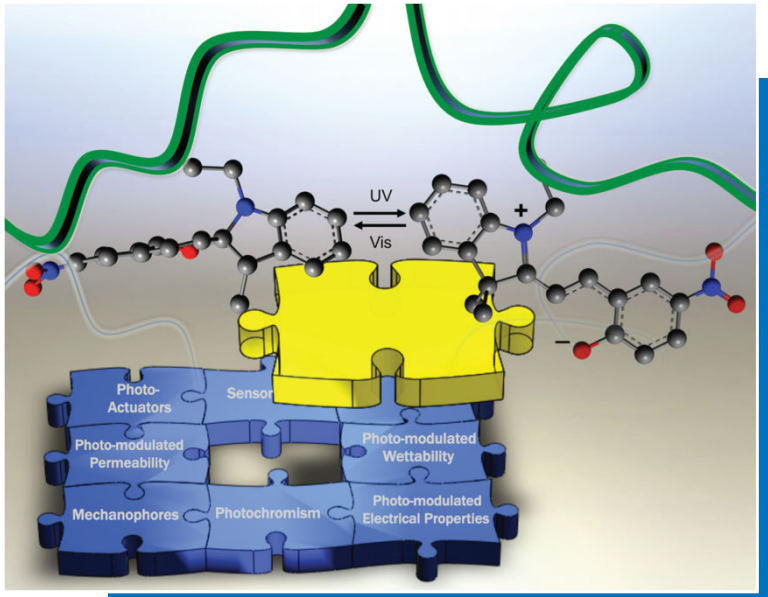
Spiropyran

ISSN 1438-7492 · MMENFA 297 (12) 1129–1236 (2012) · Vol. 297 · No. 12 · December 2012 D 51047





Macromolecular Materials and Engineering



Special Issue:
Advances in Actively Moving Polymers

Guest-edited by Andreas Lendlein

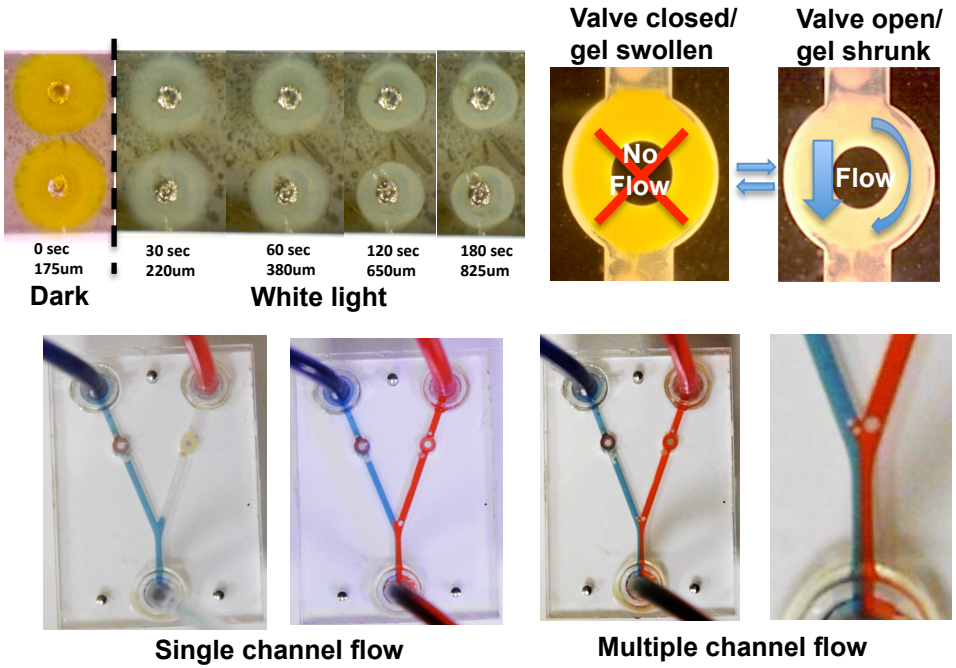
12/2012

WILEY-VCH

L. Florea, D. Diamond and F. Benito-Lopez, ***Macromolecular Materials and Engineering***, 2012, 297, 1148-1159.

Photo-switchable actuators

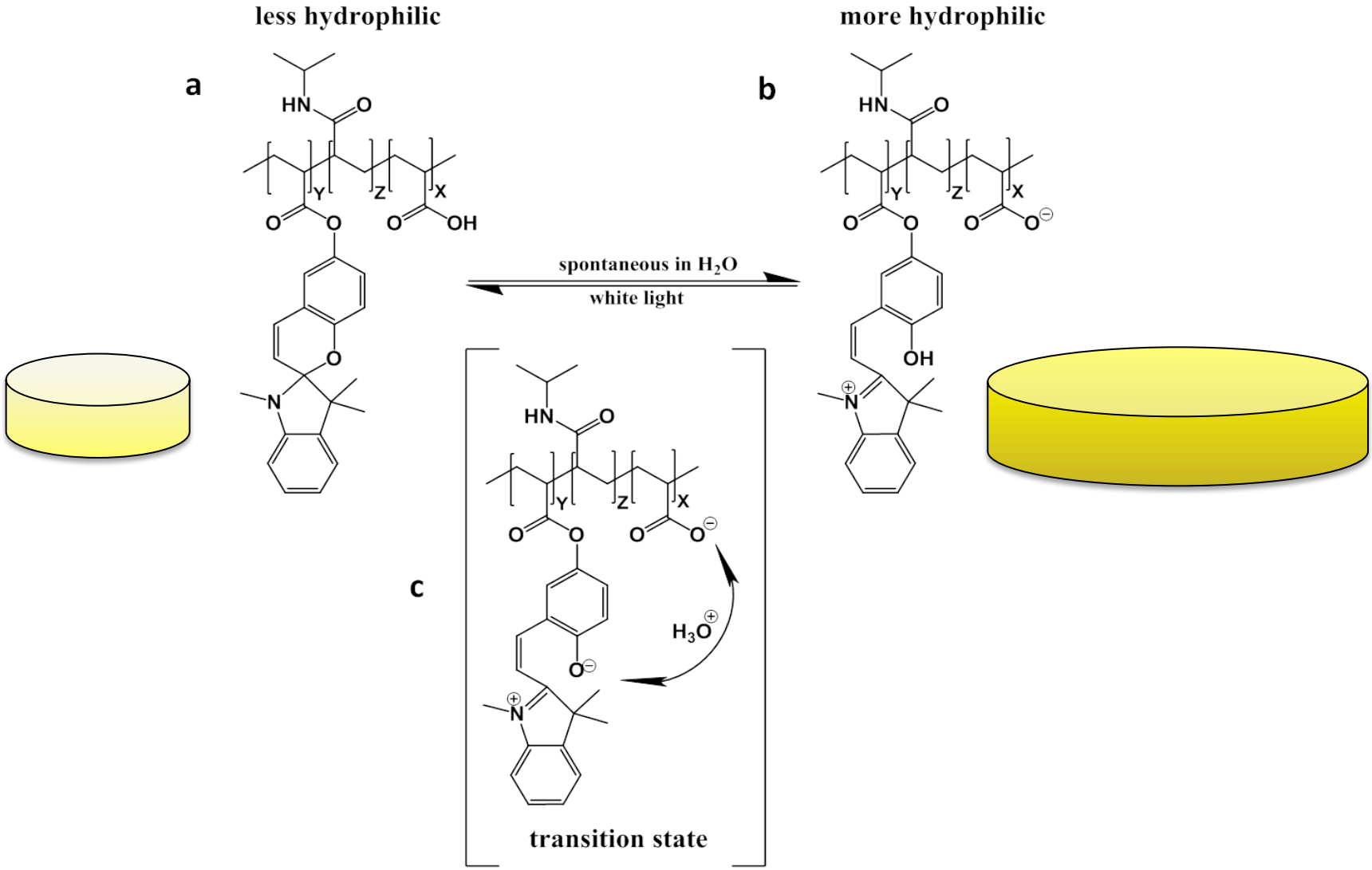
- ON/OFF flow modulation
- photo-control of flow in microfluidic devices



Light actuated polymer valves for fluid control

Dunne, A., Delaney, C., **Florea, L. Diamond, D.**, 2016. RSC Advances, 6(86), 83296.

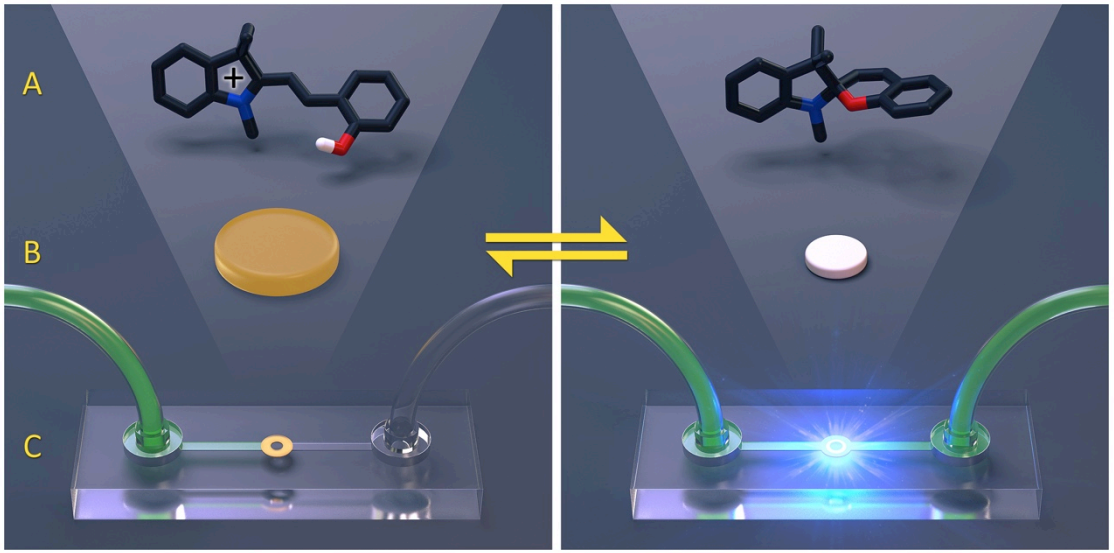
Self-protonating hydrogels

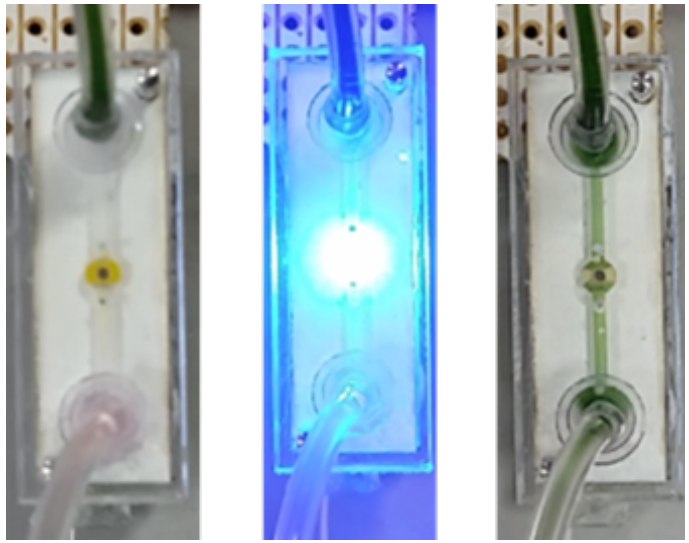


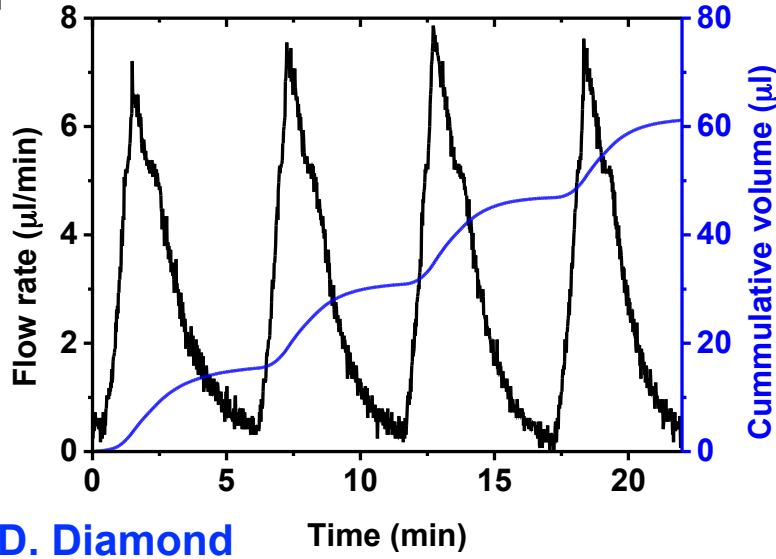
B. Ziolkowski, L. Florea, J. Theobald, F. Benito-Lopez and D. Diamond, *Soft Matter*, 2013, 9, 8754-8760.

Reversible Photo-Switching of Flow

With Albert Schenning and Dirk Broer, TU Eindhoven







Above: scheme showing switching process protonated MC-H^+ photoswitched to SP triggering p(NIPAAM-*co*-AA-*co*-SP) gel contraction and opening of the channel.

Right, Top: Photos of the valve in operation before (flow OFF) and after (flow ON) one minute of blue light irradiation.

Right, Bottom: Flowrate and cumulative volume measurements showing repeated opening and closing of microvalve: 1 min blue light irradiation opens valve followed by ~5.5 min thermal relaxation to close.

J. ter Schiphorst, S. Coleman, J.E. Stumpel, A. Ben Azouz, **D. Diamond** and A. P. H. J. Schenning, Chem. Mater., 27 (2015) 5925−5931.

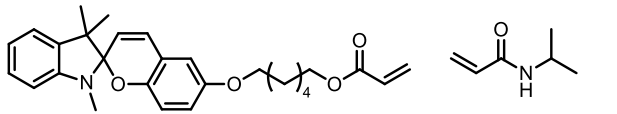
Photo-actuated surfaces

ACS APPLIED MATERIALS & INTERFACES
Research Article
www.acsami.org

ACS applied materials & interfaces, 6 (2014) 7268-7274

Photoswitchable Ratchet Surface Topographies Based on Self-Protonating Spiropyran–NIPAAM Hydrogels

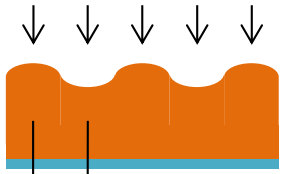
Jelle E. Stumpel,[†] Bartosz Ziółkowski,[‡] Larisa Florea,[‡] Dermot Diamond,[‡] Dirk J. Broer,*[,†,§] and Albertus P. H. J. Schenning*[,†,§]

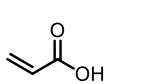


SPA, 1 mol%

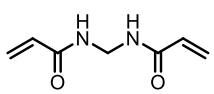
NIPAAM, 91-92 mol%

a)

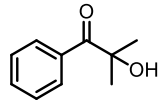




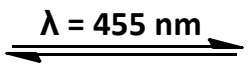
acrylic acid, 5 mol%

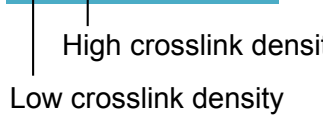


MBIS, 1-2 mol%



Darocur 1173, 1 mol%





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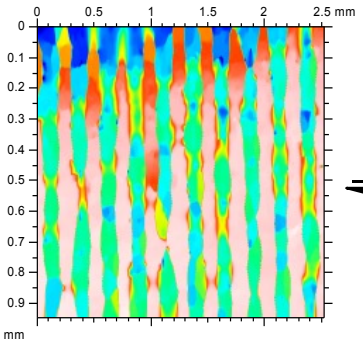
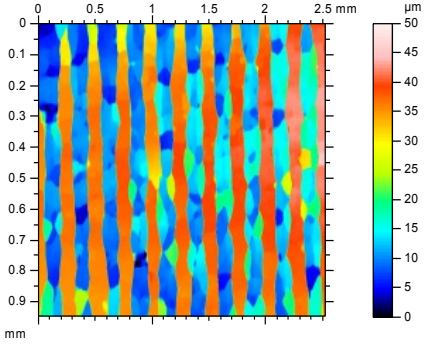
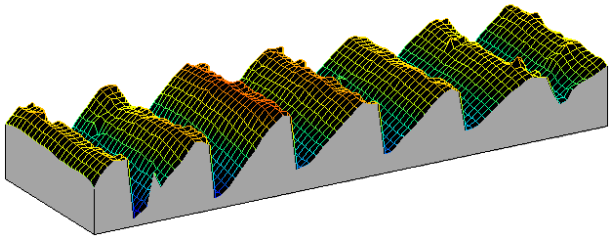




a)



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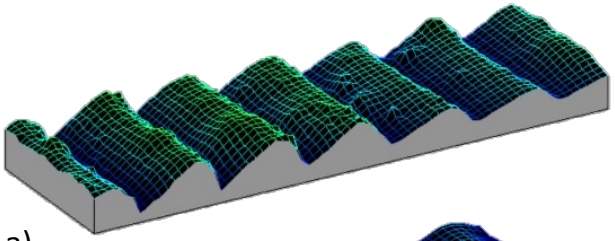

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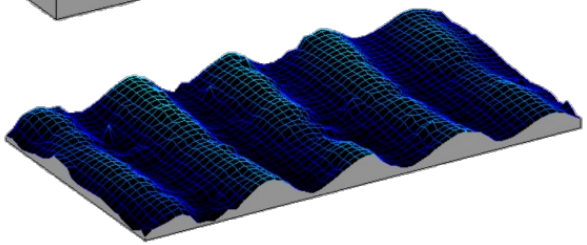

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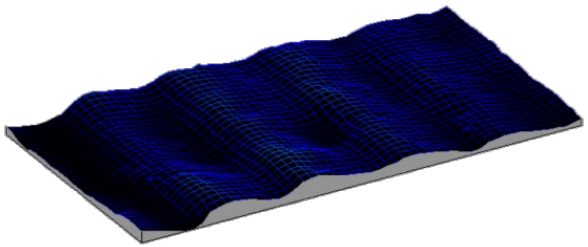
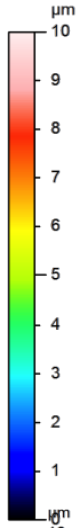




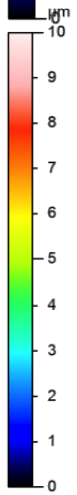


Photo-generated micro-channels

On-demand microfluidic control by micropatterned light irradiation of a photoresponsive hydrogel sheet

Shinji Sugiura, András Szilágyi, Kimio Sumaru,* Koji Hattori, Toshiyuki Takagi, Genovéva Filipcsei, Miklos Zrınyi and Toshiyuki Kanamori

Lab Chip, 2009, 9, 196–198

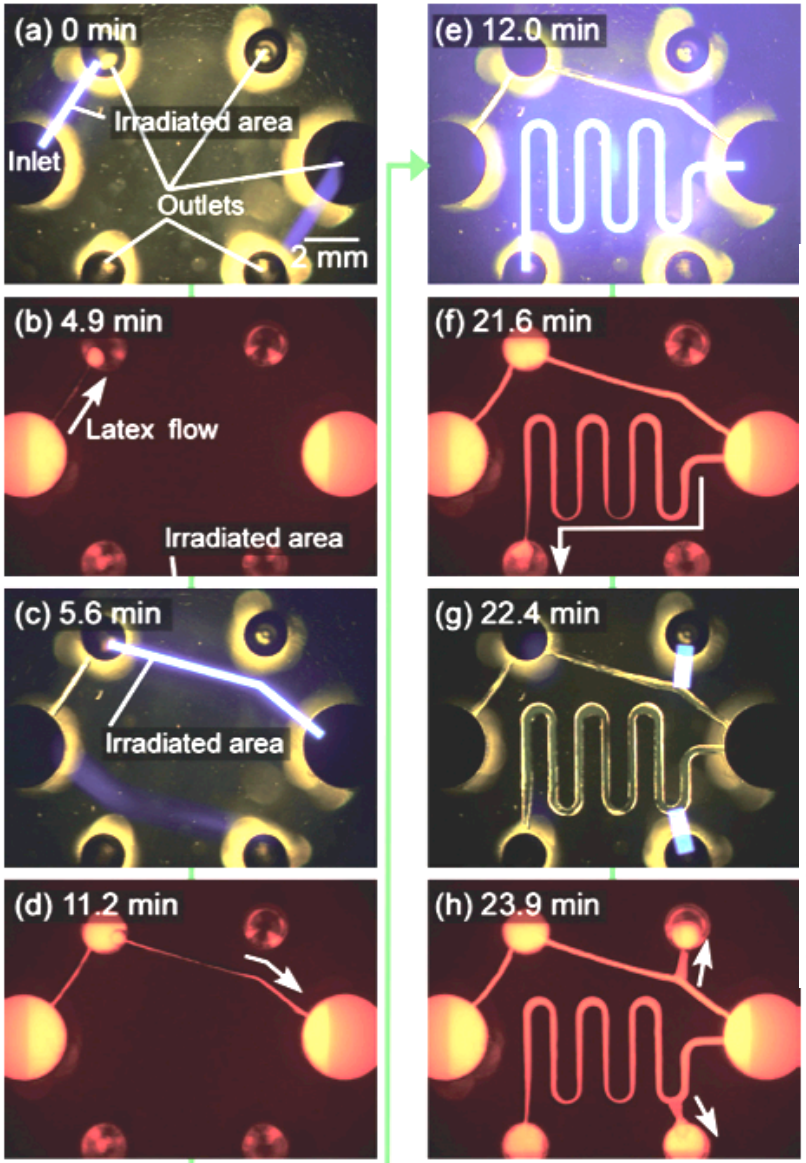


Fig. 2 On-demand formation of microchannels with arbitrary pathways in the universal microfluidic system by micropatterned light irradiation. White arrows indicate the flow direction of a fluorescently labeled latex bead suspension. (a) Microchannel formation by micropatterned light irradiation of the pSPNIPAAm hydrogel sheet. (b) Latex bead suspension flow through the microchannel after irradiation. Flow of the red colored latex bead suspension from the inlet to the upper-left-side outlet is slightly visible. (c)–(h) Three consecutive sequences of micropatterned light irradiation and microchannel formation.

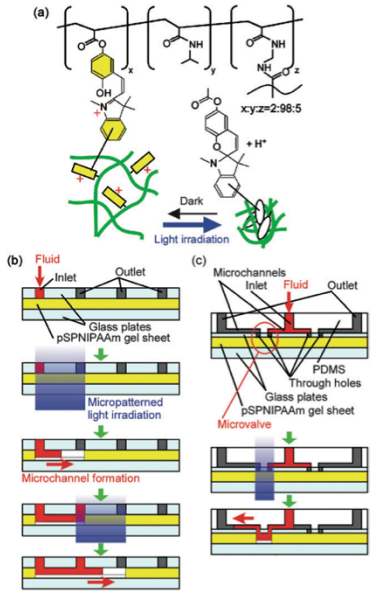
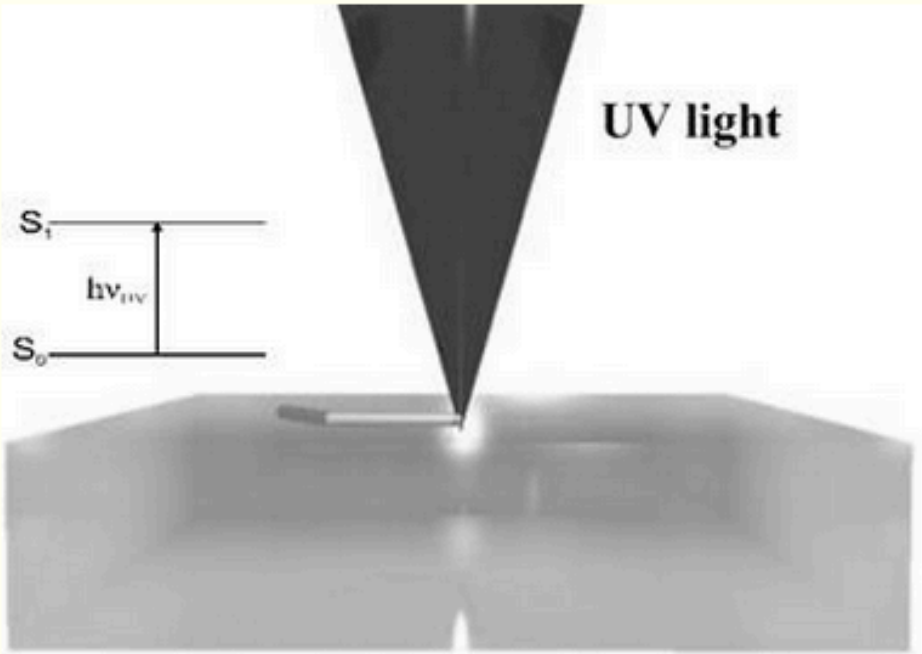


Fig. 1 Schematics of pSPNIPAAm hydrogel and of two types of microfluidic systems for on-chip fluid control by micropatterned light irradiation. (a) Chemical structure and a schematic of the photoinduced shrinkage of pSPNIPAAm hydrogel. (b) Universal microfluidic system for on-demand formation of arbitrary microchannels by micropatterned light irradiation. (c) PDMS microchannel network equipped with microvalves for independent and parallel flow control in microchannels by micropatterned light irradiation.

3D Fabrication Tools

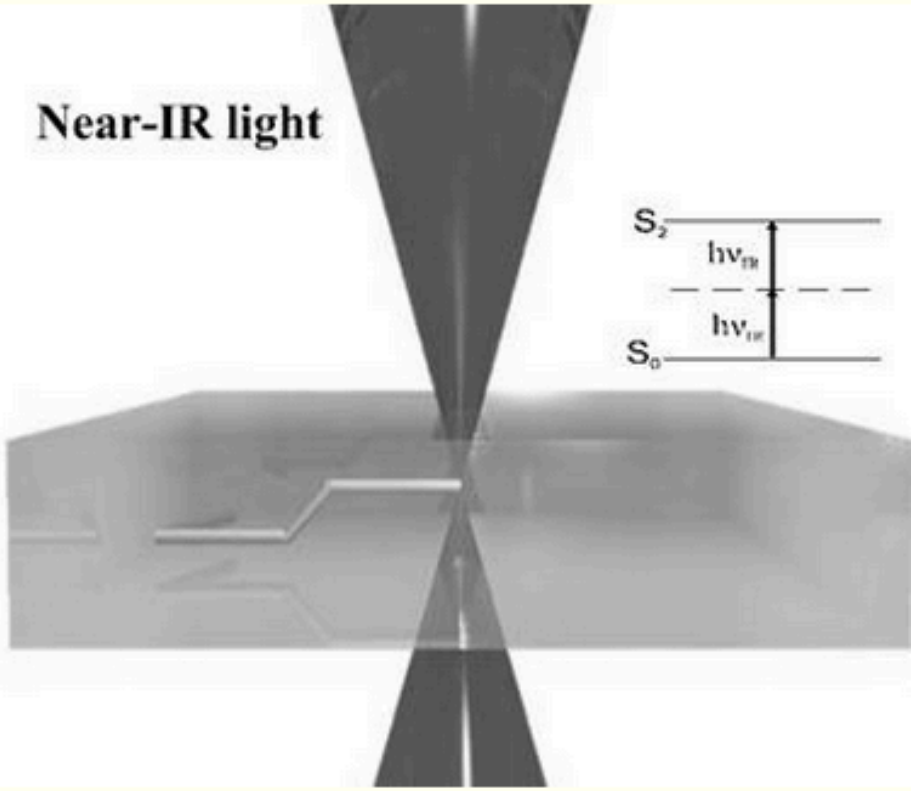
Background

Stereolithography



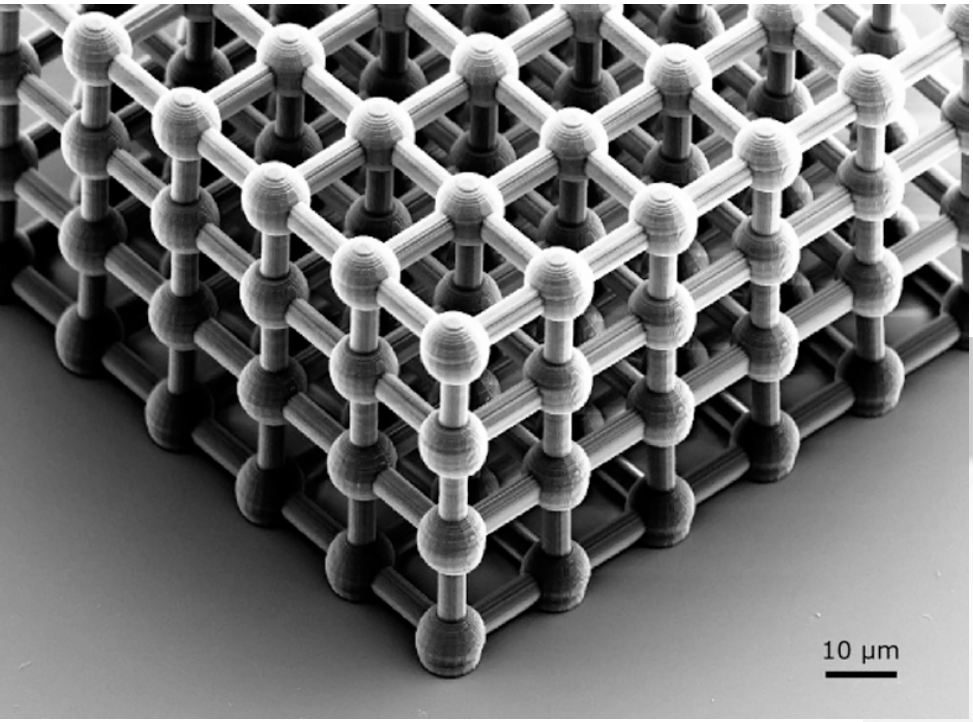
- Single photon absorption
- 2D patterns

Two-photon polymerisation



- Two photon absorption
- 3D structures

Background



http://www.nanoscribe.de/

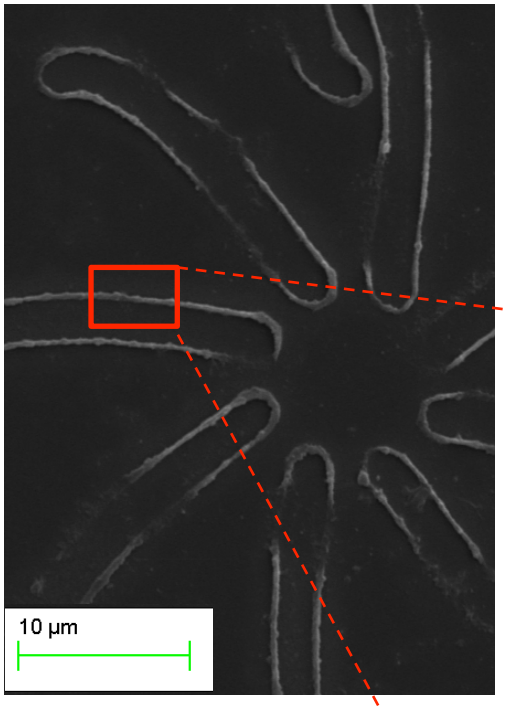
The Exciting Potential of Stimuli-responsive Materials and Biomimetic Microfluidics

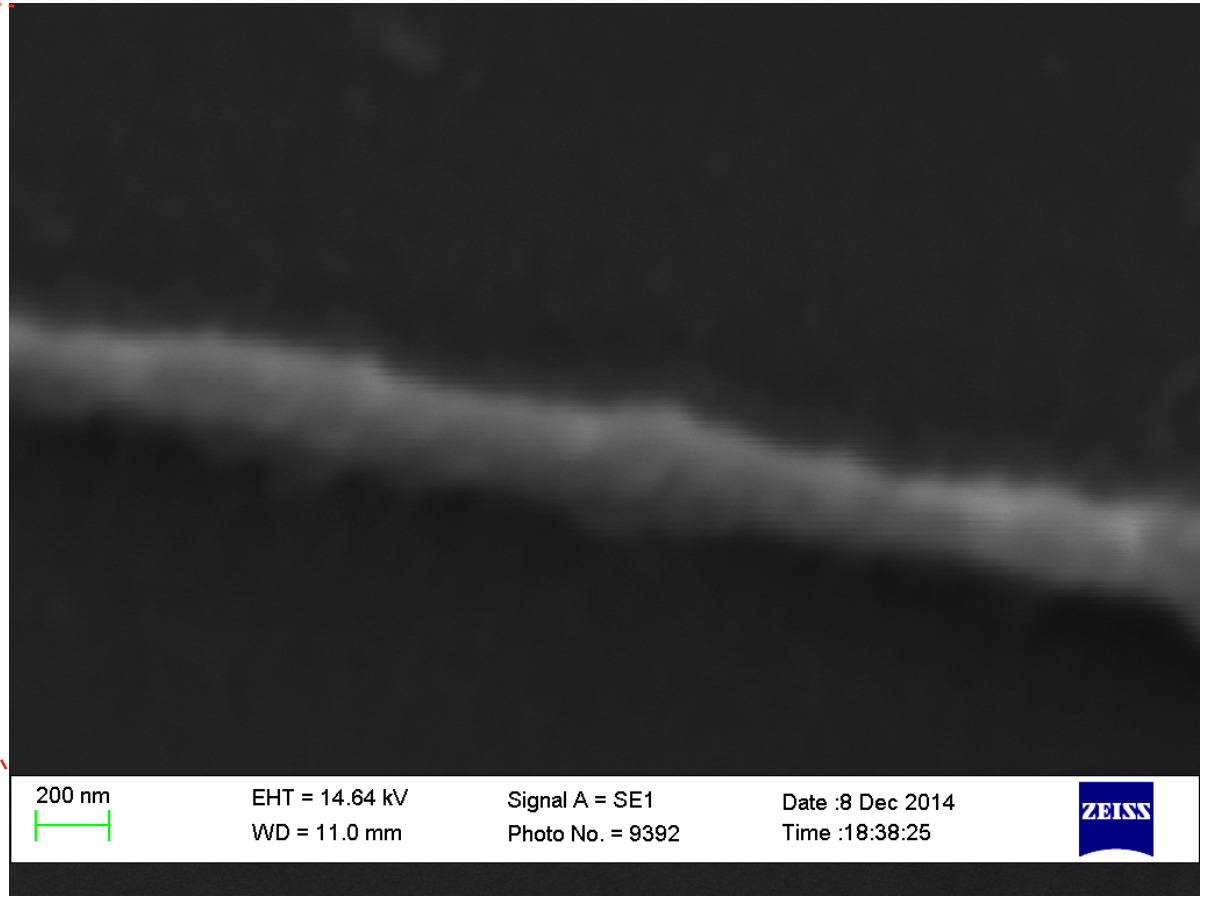
Larisa Florea[1], Vincenzo Curto[2], Alexander J. Thompson[2], Guang-Zhong Yang[2], and Dermot Diamond[1]*

[1]Insight Centre for Data Analytics, NCSR, Dublin City University

[2]The Hamlyn Centre for Robotic Surgery, Imperial College London, London, SW7 2AZ

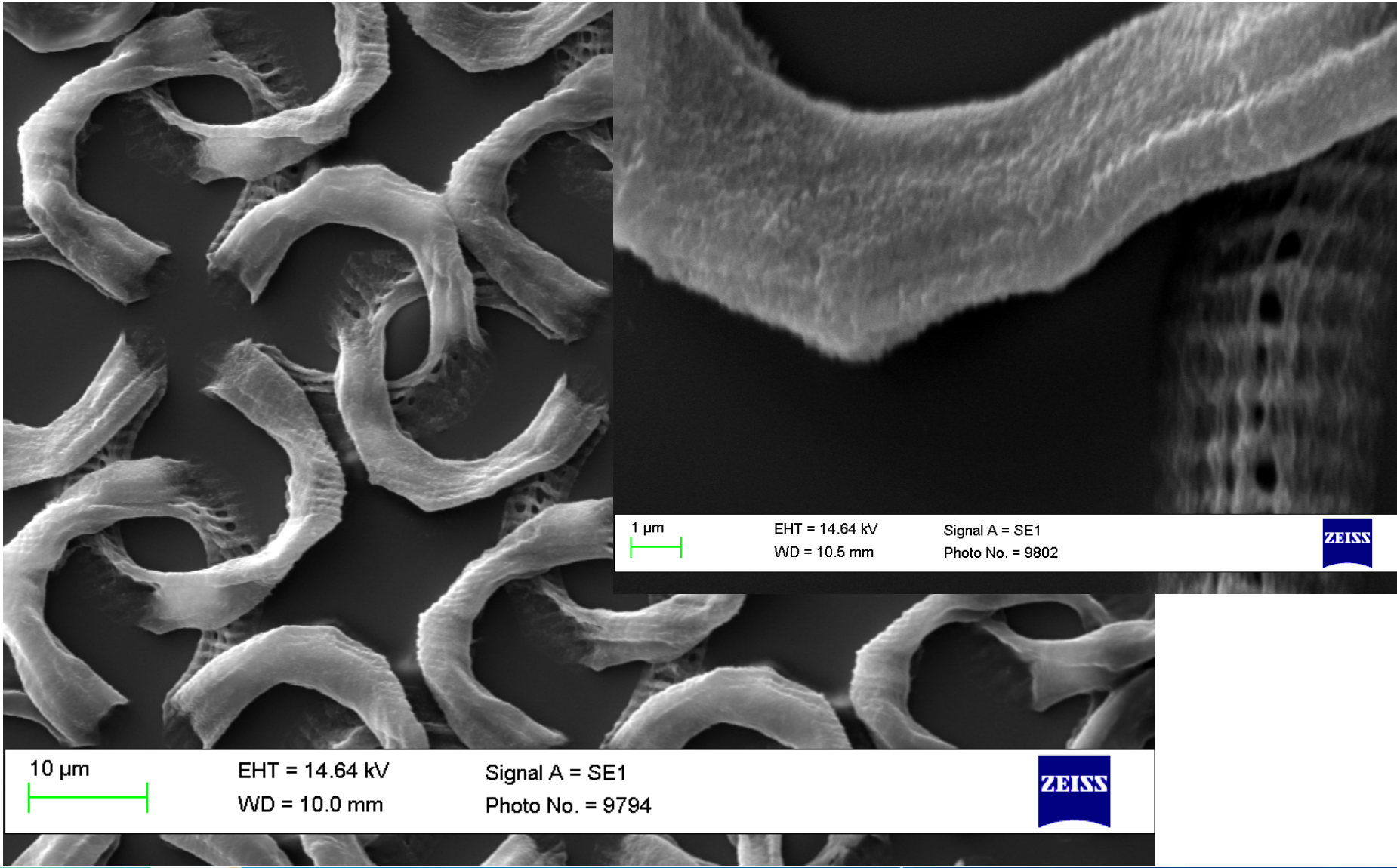
Euronanoforum, Riga, Latvia, June 2015





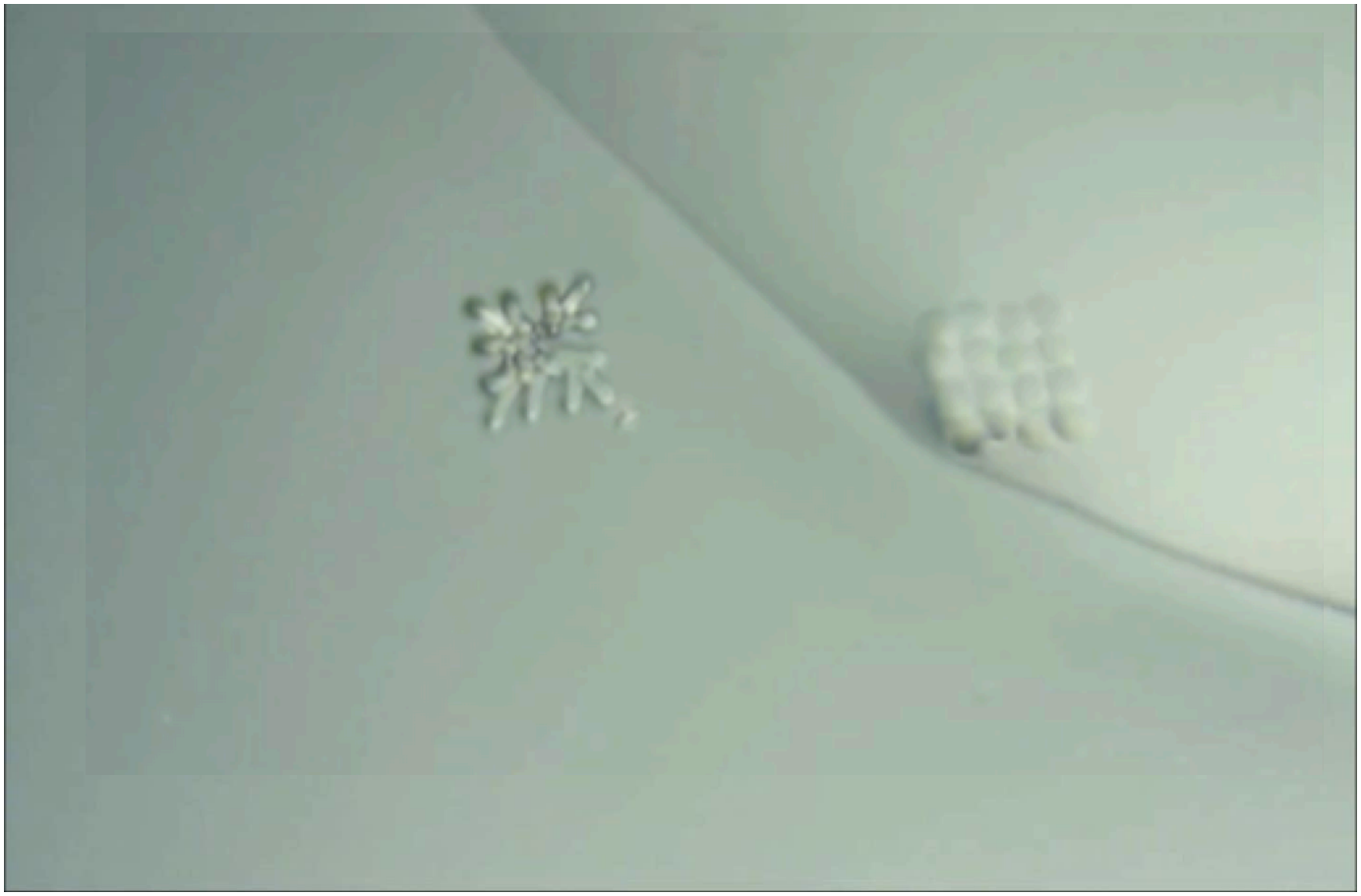
Creating 3D soft gel structures with a line resolution of ca. 200 nm

Interlocking Structures



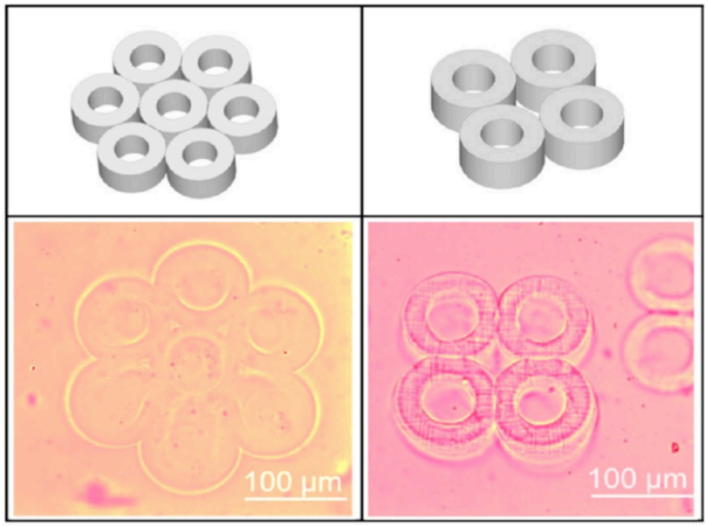
2-Photon 3D Printed Microstructured Hydrogels

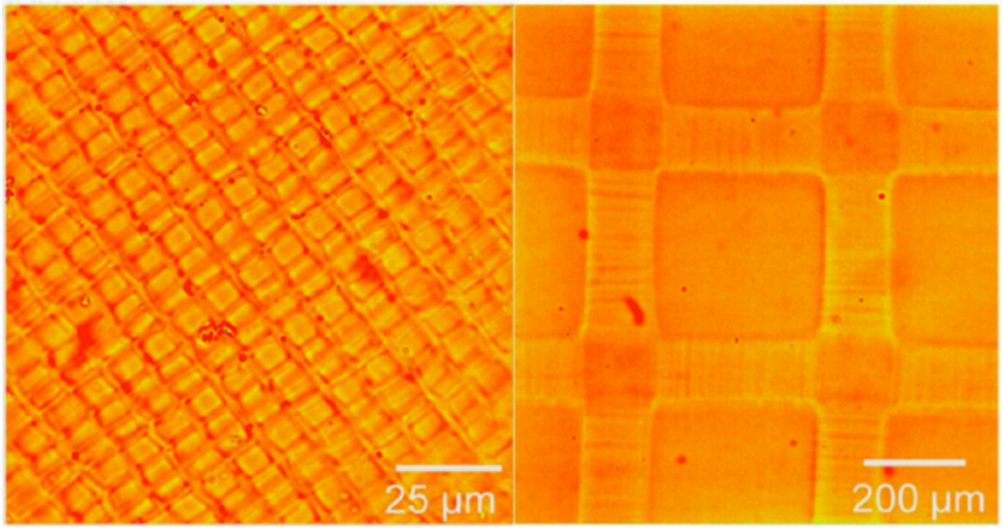
Comparative dehydration of Hydrogels Arrays



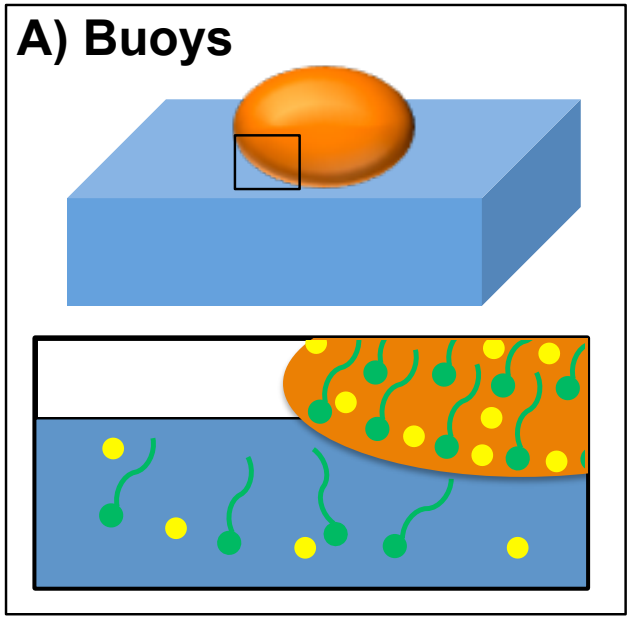
Two-Photon polymerization for microfabrication of 3D scaffolds for tissue engineering application

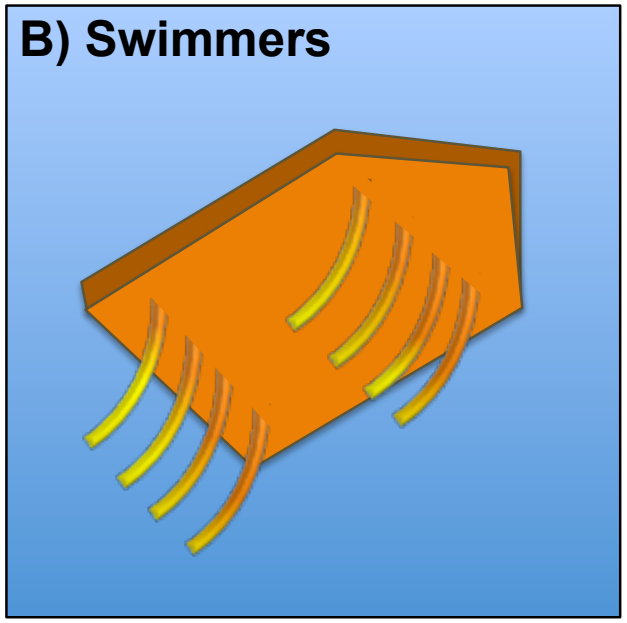
- T. Weib et al., Eng. Life Sci. 2009, 9, No. 5, 384–390.
- Kufelt et al., Biomacromolecules 2014, 15, 650−659.
- etc.

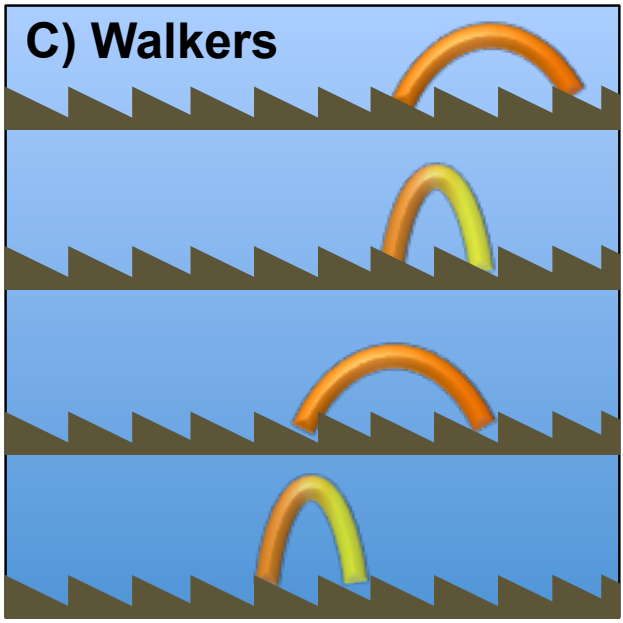


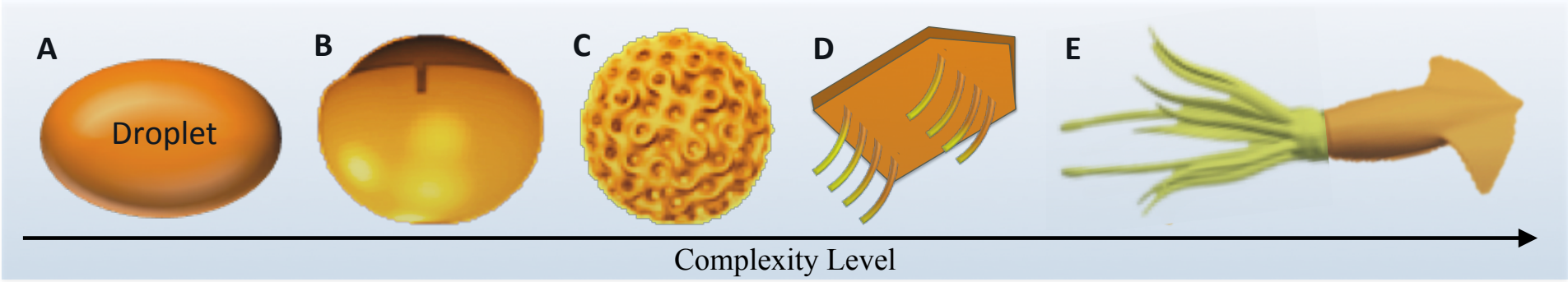


Microscopic images of 2PP-manufactured hyaluronic acid (HAGM) scaffold geometries:
(a) one-layered ring-like structures according to the applied CAD models;
(b) grid structures with different pore sizes (7, 114, and 325 µm)



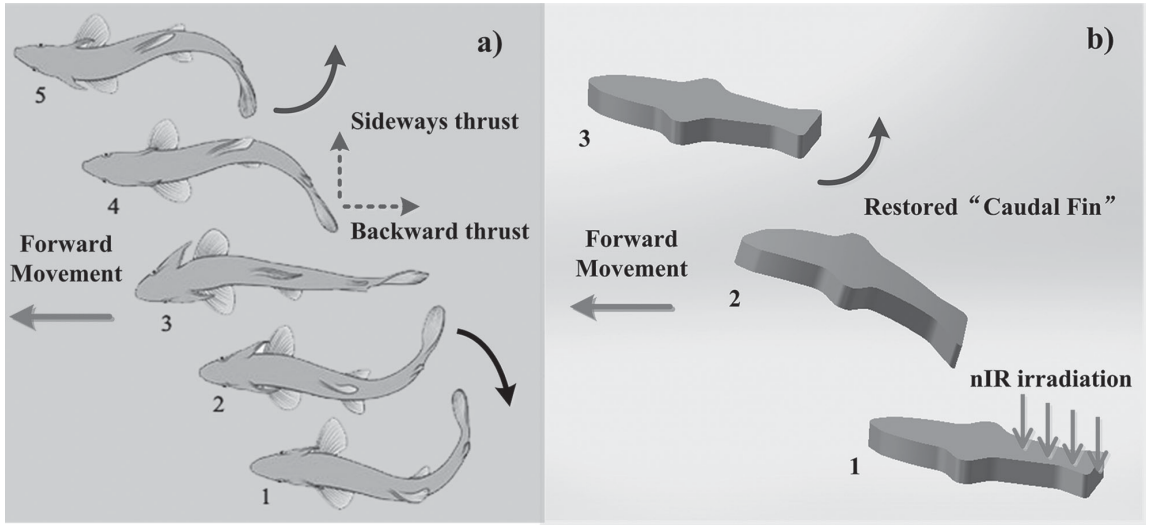


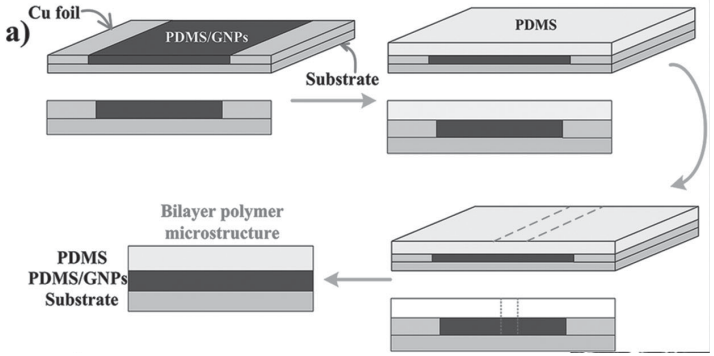


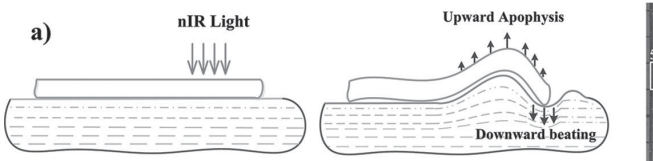


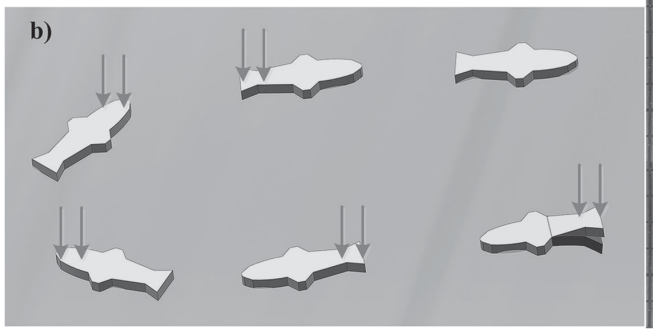
Examples of autonomous and biomimetic microstructures.

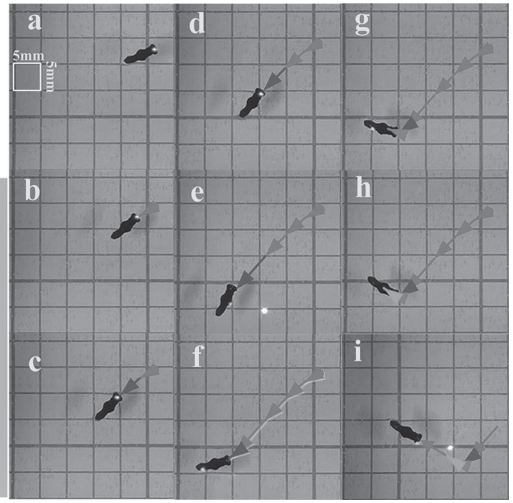
Photoresponsive Biomimetic Swimmers

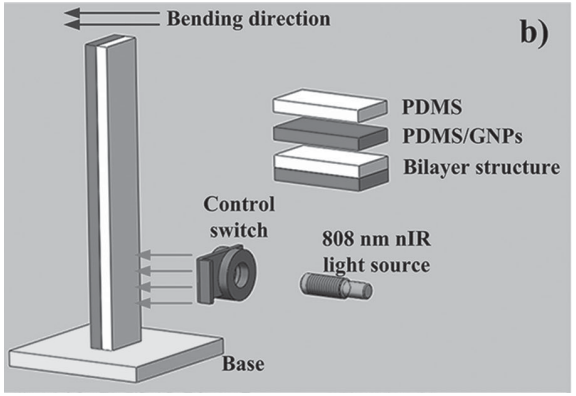


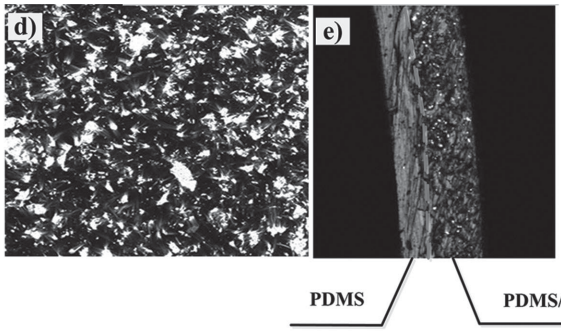






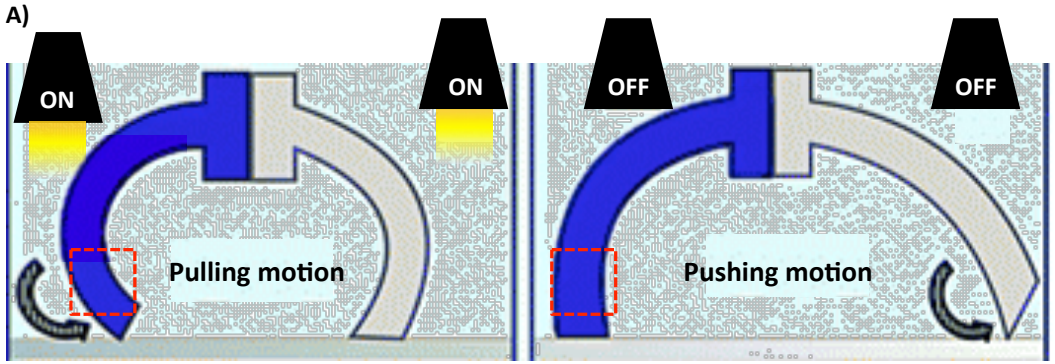




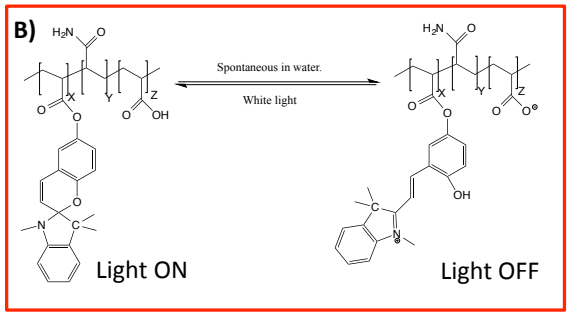


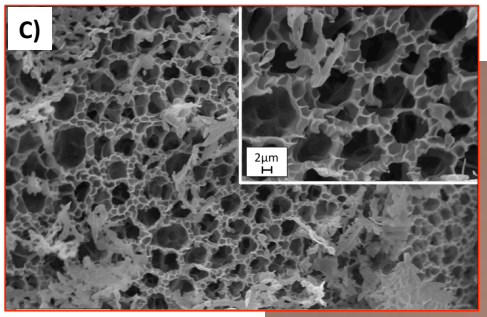
Jiang et al., Adv. Funct. Mater. 2014, *24*, 7598–7604.

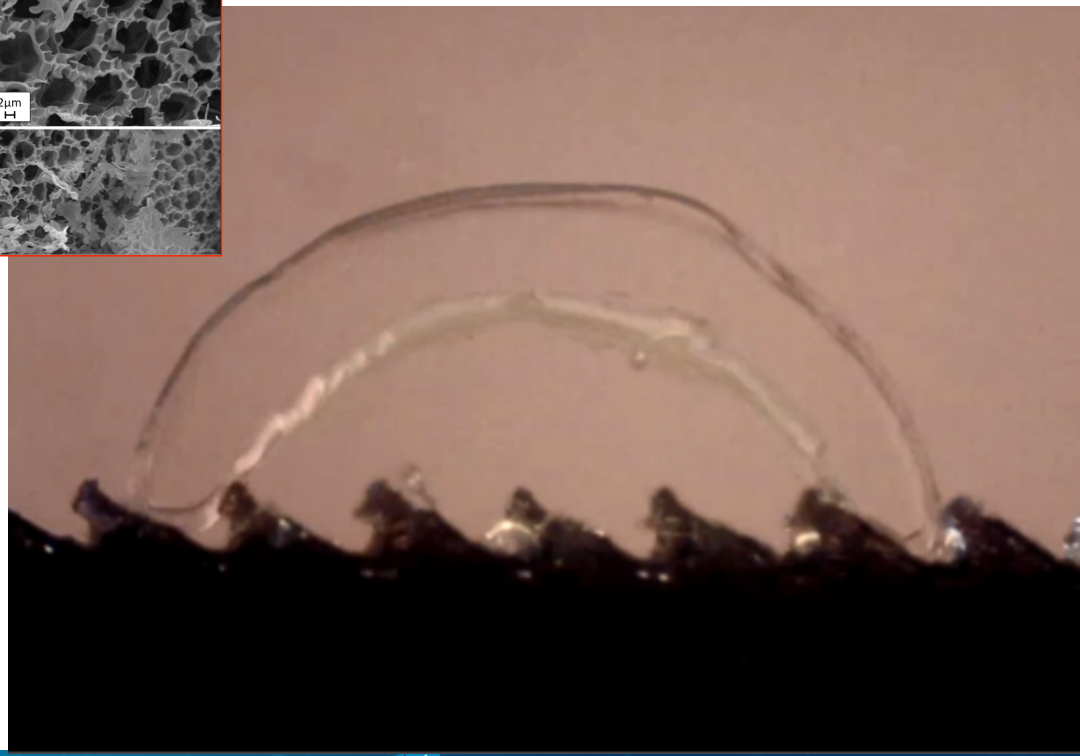
Photoresponsive Soft Hydrogels

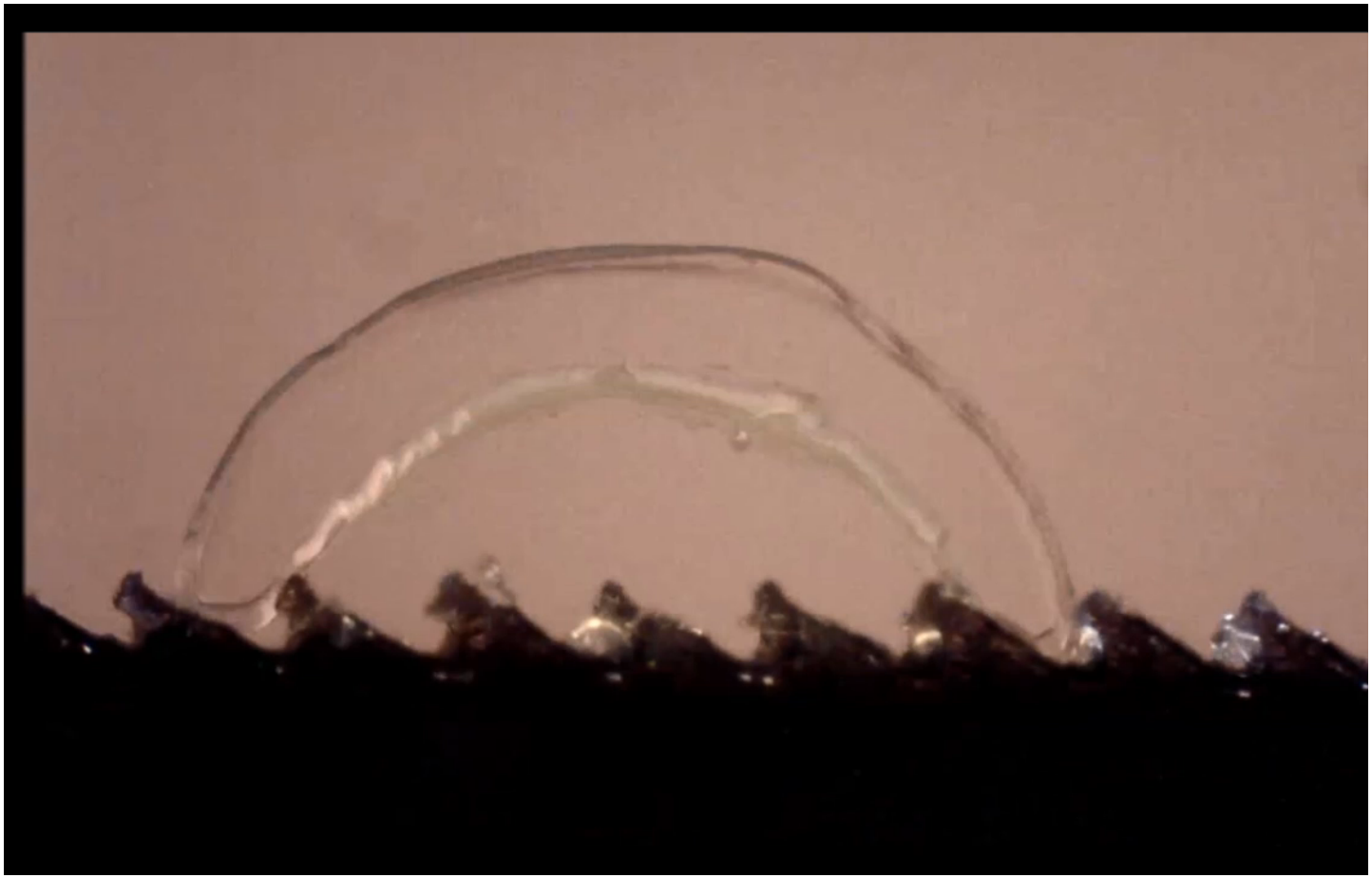


Walking towards the light









Conclusions

- **Advanced functional materials coupled with effective fabrication techniques is the key for the progress of analytical flow systems of the future.**

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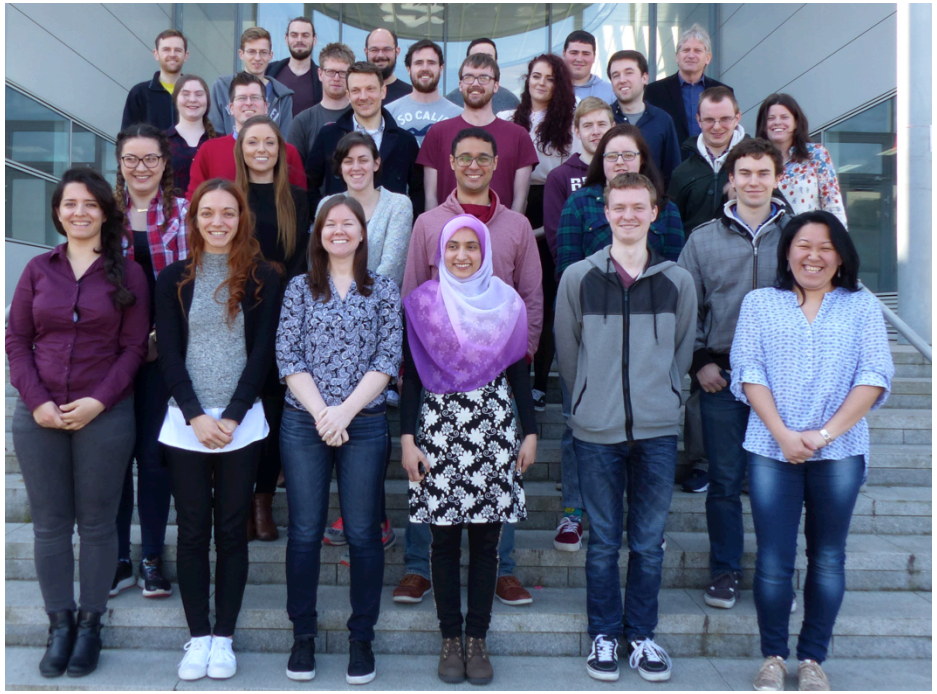

Thank you!

General Conference and MC/WG Meeting

Wednesday 14 September 2016 - Cetraro (CS), ITALY - September 14-15, 2016