Chemical transducers Group:
Hybrid photonics

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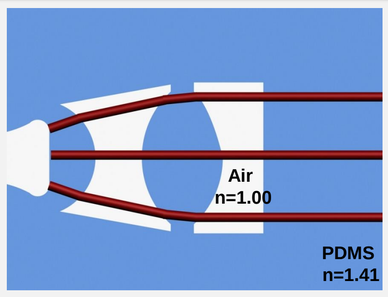
Research interests

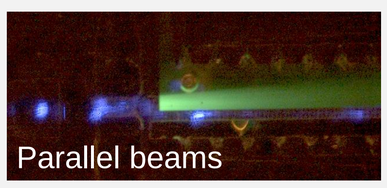
The hybrid photonics team is highly multidisciplinary, combining aspects of physics, chemistry and biology. It has the following research main streams:

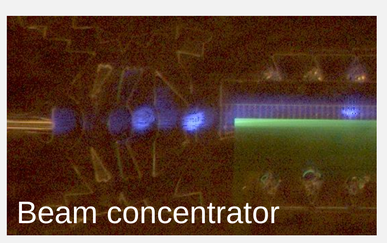
- Development of **polymer-based micro-optics/photonics elements**, such as light emitters, wavelength-selective filters, microlenses or air mirrors.
- Integration of the polymer-based micro-optics/photonics elements with microfluidics, obtaining true **photonic lab-on-a-chip (PhLoC)** suitable for fluorescence, absorbance and/or scattering. Enhancement of the PhLoC performance by selective biofunctionalization. They have been applied to real-time screening and monitoring of microorganisms.
- **Soft-MOEMS**. Exploiting the low Young's modulus of polymeric materials, it has been implemented intensity-based polymer micro-optoelectromechanical systems for applications comprising displacement or acceleration.

Micro-optics/Photonics

Microlenses

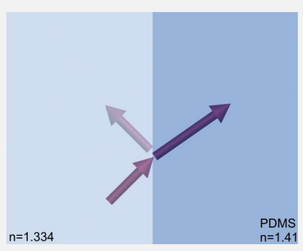


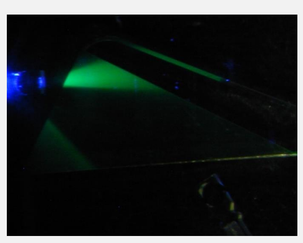




Micromirrors

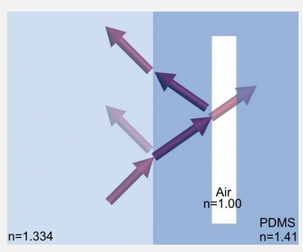
No Mirror





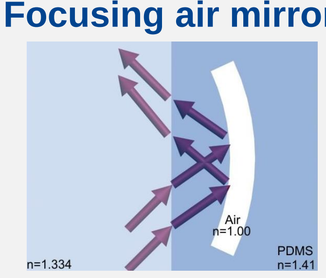
- ✗ Divergence not corrected.
- ✗ Light not focused.
- ✗ Poor reflection at the interface.

Flat air mirror



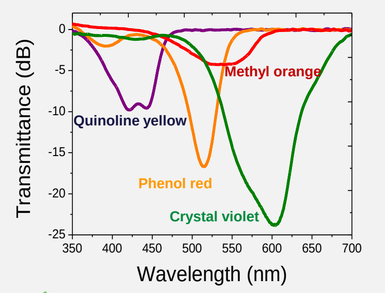
- ✗ Divergence not corrected.
- ✗ Light not focused.
- ✓ Efficient for managing the flow of light.

Focusing air mirror



- ✓ Divergence partially corrected.
- ✓ Light partially focused.
- ✓ Allows multiple internal reflection (MIR).

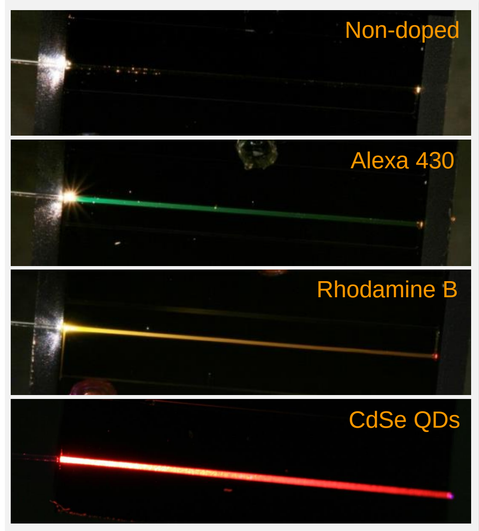
Polymer absorbance microfilters



- ✓ Large stop-band rejection.
- ✓ Zero pass-band attenuation.
- ✓ Available in xerogel and UV-curable polymers.

E. Carregal-Romero et al. Opt. Exp. 20(21), 2012

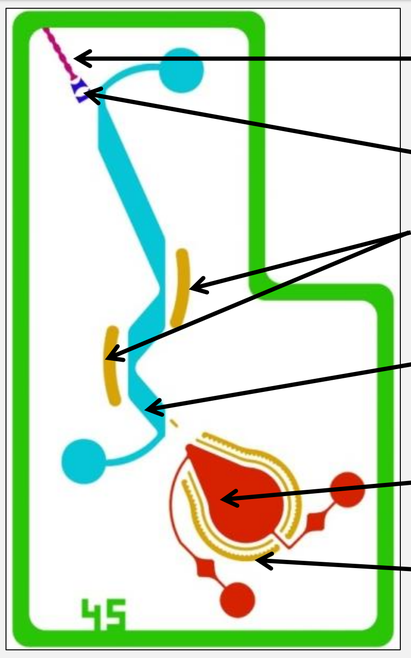
Xerogel solid-state light emitters



- ✓ Xerogel suitable to be functionalized either with fluorophores or NP.
- ✓ Homogeneous dispersion, without phase segregation
- ✓ Easy-to-pattern using soft lithography

A. Llobera et al. Opt. Exp.19(6), 2011
E. Carregal-Romero et al. ACS Appl Mater Inter 4(9), 2012

(Bio) Photonic lab-on-a-chip (PhLoC)

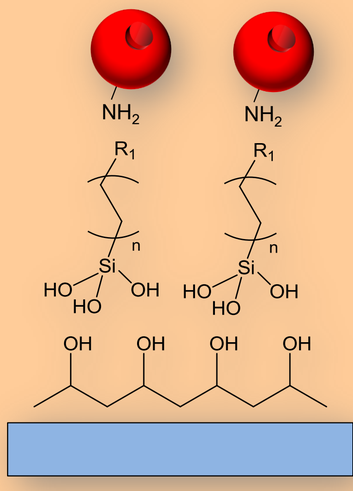


- Self-alignment microchannel
- Microlens
- Focusing air mirrors
- Multiple internal reflection system (MIR)
- Xerogel SSLE
- Auxiliary air micromirrors

A. Llobera,et al Lab. Chip. 7, 2007

- ✓ SSLE, air mirrors, microlenses, self-alignment microchannels and microfluidics integrated using single mask technology.
- ✓ Large tolerances against excitation-SSLE misalignment (> 50 µm).
- ✓ Biofunctionalized with enzymes

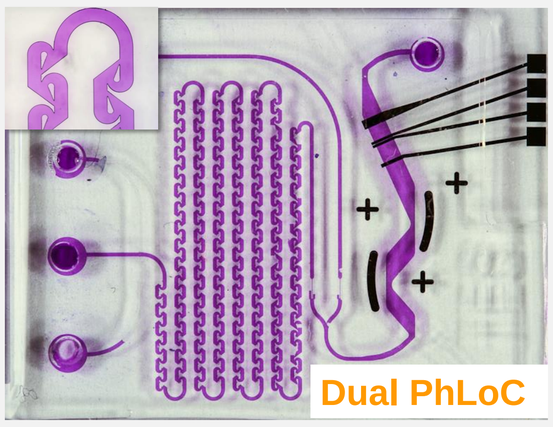
Biofunctionalization



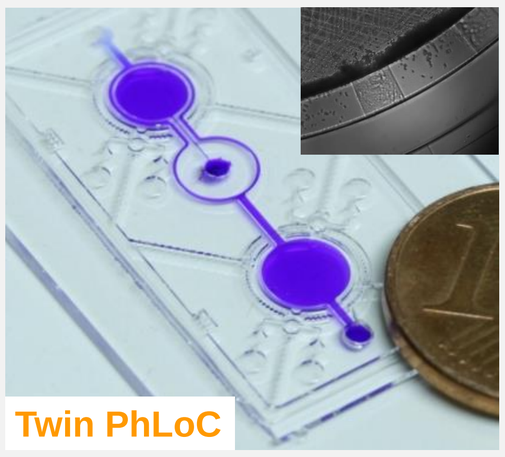
- Covalent attachment to primary amine moieties of the biomolecule
- Silanization (R1 = aldehyde, epoxy, amine, thiocyanite)
- Introduction of hydroxyl groups (linear polymers)
- Hydrophobic polymer substrate (PDMS, PC, PMMA)

✓ Wet chemical process for the introduction of functional groups on the PhLoC walls. No instrumentation required

B. Ibarlucea et al. Analyst 136(17), 2011



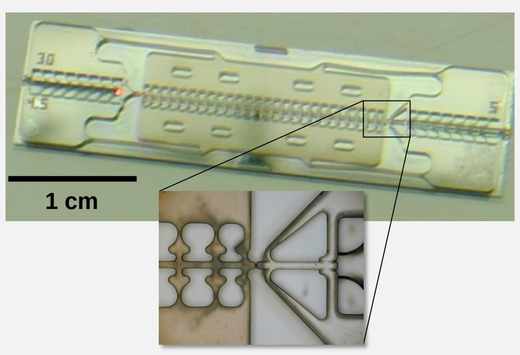
- ✓ Dual optical/electrochemical detection without crosstalk.
- ✓ Two mask technology.
- ✓ Monolithically integrated with a biofunctionalized tesla mixer and two unidirectional valves.



- ✓ Twin chambers for cell retention/proliferation and monitoring of cell metabolism.
- ✓ Monolithic integration of micro-optics with 3 µm high size-exclusion microfilters, suitable for trapping cells.
- ✓ Size separation between *Saccharomyces cerevisiae* and *Escherichia coli*. Vascular smooth muscle cells (VSMC) efficiently trapped in the incubation chamber where they proliferate with a classical spindle-shaped morphology.

Soft Micro-optoelectromechanical systems

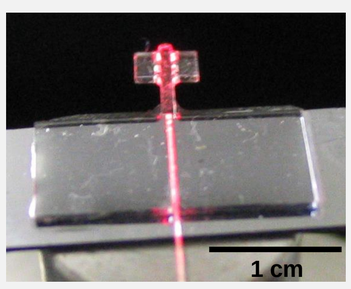
SU-8 Optical accelerometer



- ✓ Based on intensity modulation.
- ✓ Air mirrors to integrate the sensing waveguide onto the seismic mass.
- ✓ The quad beam structrure assures the flat displacement of the seismic mass.
- ✓ Two mask technology.
- ✓ High sensitivity (> 13 dB/g).

A. Llobera et al. J. Microelectromech. Syst. 16(1), 2007

PDMS optical cantilever



- ✓ Based on intensity modulation.
- ✓ Use of air mirrors onto the sensing mass. Cantilever used as waveguide ended in a microlens.
- ✓ The cantilever structrure assures high sensitivity.
- ✓ Single mask technology.
- ✓ Suitable to be (bio)functionalized.

A. Llobera et al. IEEE Photonic Tech.L. 21(2), 2009

Centro Nacional de Microelectrónica IMB

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LiPhos

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