Light absorption and emission in symmetry broken heterogeneous metasurfaces

C. Seassal, H-S. Nguyen, R. Mermet-Lyaudoz, E. Drouard, C. Chevalier, J.L. Leclercq, S. Cueff, F. Dubois, L. Berguiga, X. Letartre, P. Viktorovitch

INL, Institut des Nanotechnologies de Lyon, UMR 5270
CNRS-Université de Lyon, Ecole Centrale de Lyon, INSA-Lyon, France

In collaboration with :

Emmanuelle Deleporte et al, ENS Saclay
Eric Puzenat, Chantal Guillard et al, IRCELYON
Yves Jourlin, Nicolas Crespo-Monteiro et al, Lab.HC, Saint-Etienne

Lyon Institute of Nanotechnology – INL

Campus Lyon Ouest

~200 people

Joint research unit with:
CNRS, INSA, ECL, UCBL, CPE
2 locations

LyonTech La Doua

Key facilities, incl. material facility

NANOLYON

Clean room facility, 600m²

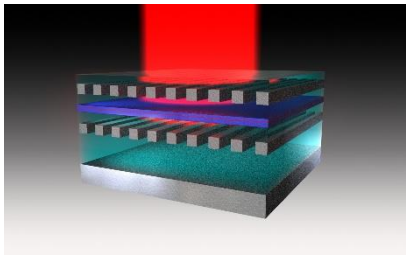
The i-Lum group at INL: Scientific approach

i-Lum: Light engineering and conversion

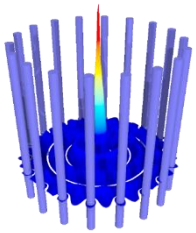
50 people, incl. 25 academics & CNRS scientists

Developing New photonic Concepts and related Technologies related to nanophotonics and optoelectronics, from UV to NIR

New concepts

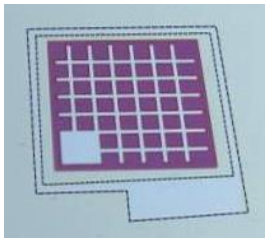


2.5D microlaser

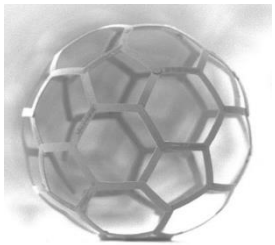


Photonic Cage

Original technologies

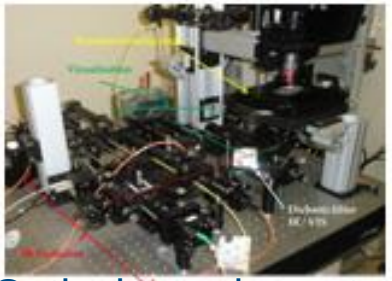


Photonised PV cell

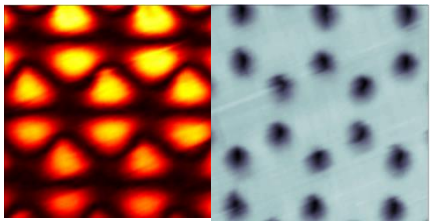


Optical origami

Optical studies



Optical trapping setup

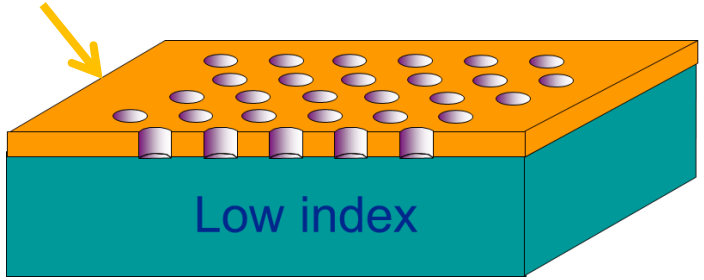


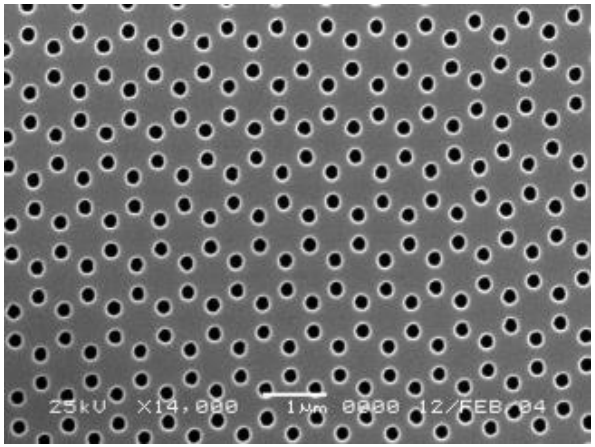
Near-Field map in a 2D PhC

Our key building block

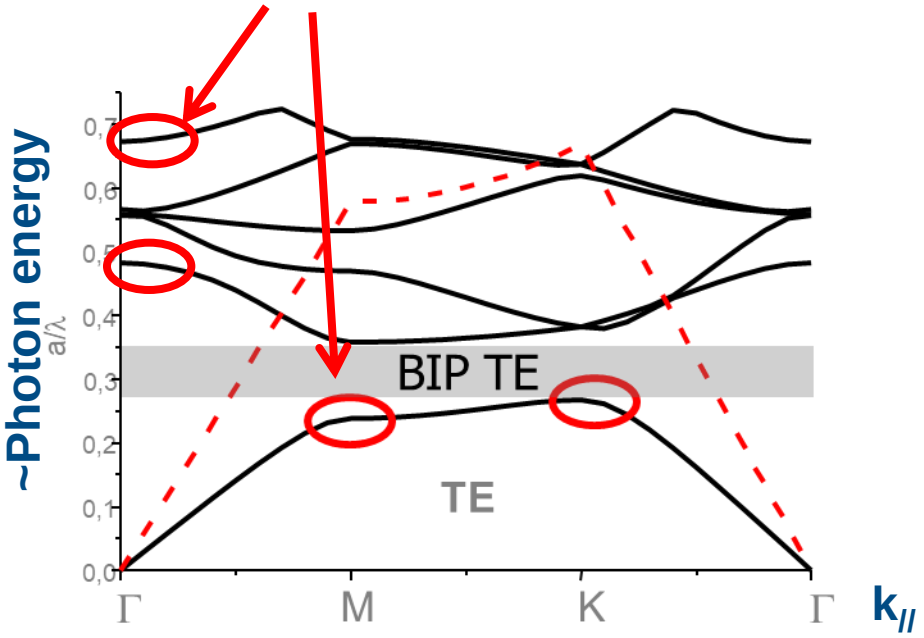
High refractive index contrast grating / 2D photonic crystals

High refractive index





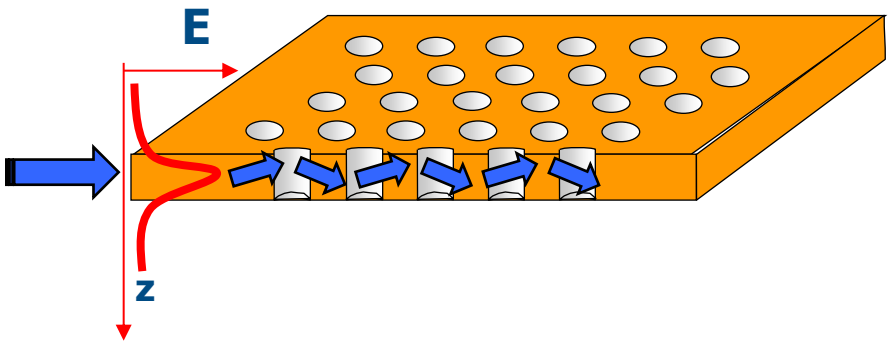
$v_G \rightarrow 0$, light confinement

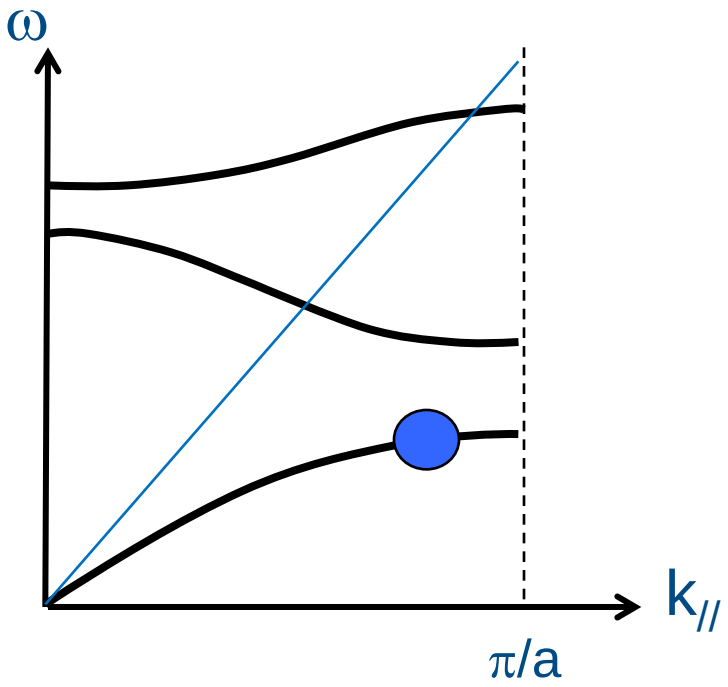


Photonic band structure

Photonic crystals, basic properties

1-Perfectly guided modes, no vertical losses

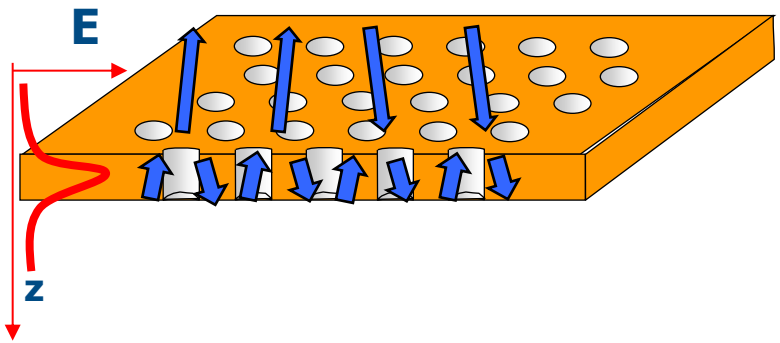


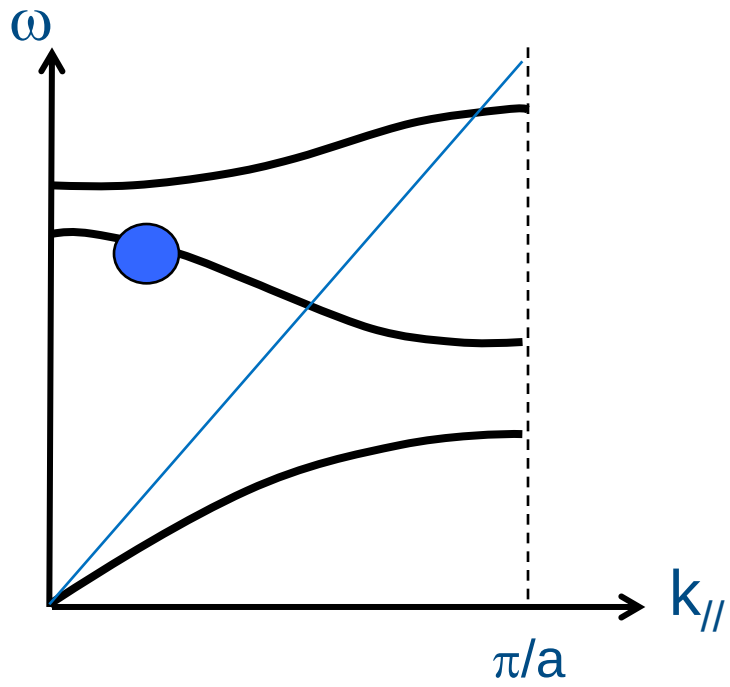


→Waveguided/integrated optics

Photonic crystals, basic properties

2-Leaky guided modes, vertically addressable

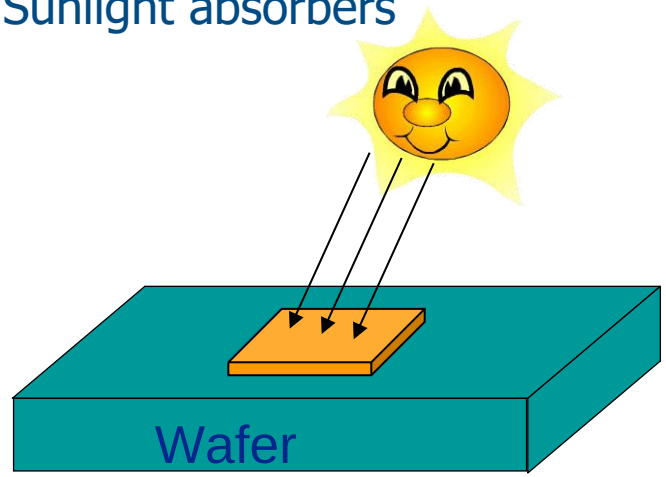




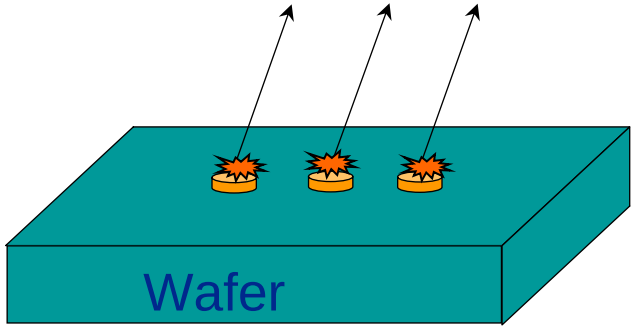
→Dedicated to the interaction with the radiative continuum

Focus on the “vertical operation”

Sunlight absorbers



Free space emiters

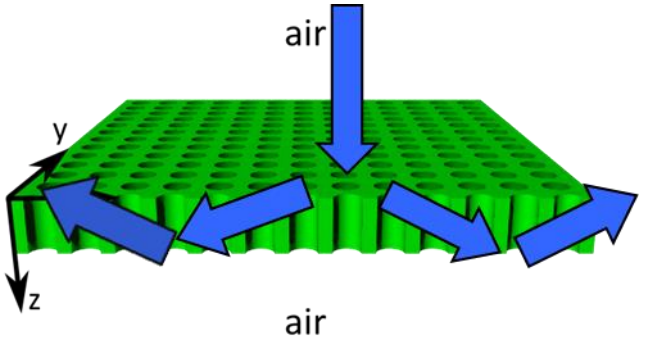


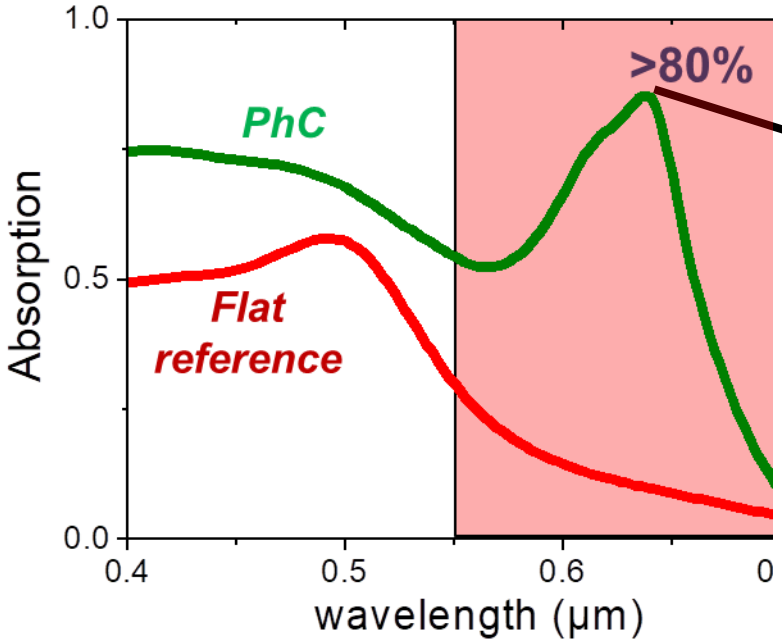
<u>Ultra-compact devices for</u>
→vertical light emission (lasers, …)
→sunlight conversion (solar cells, etc)

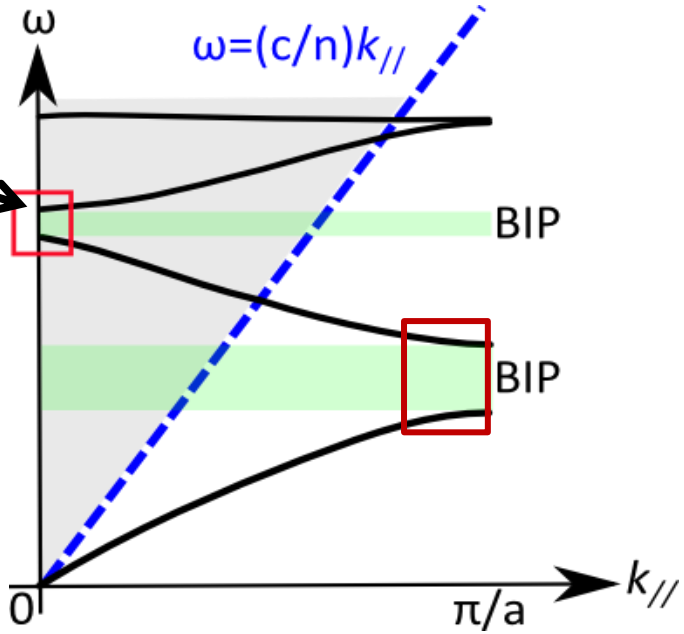
Photonic crystal absorbers

→Slow light, guided mode resonances

-Period a ~ λ/2
-Optimized D/a

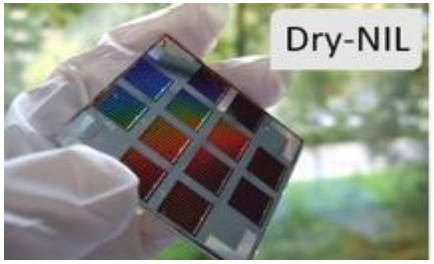


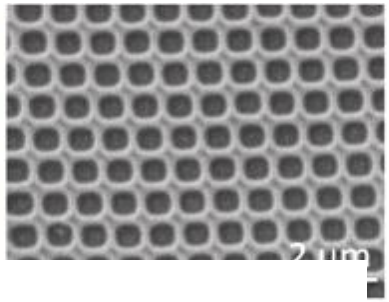


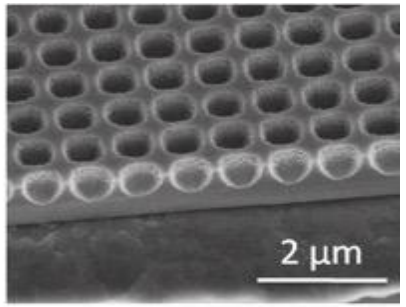


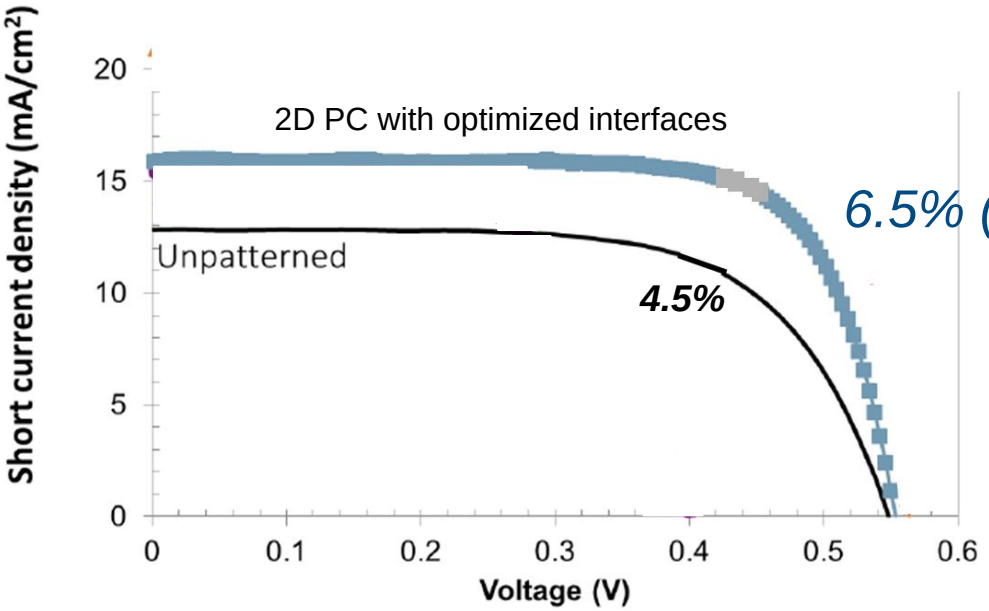
Photonic crystals and thin film solar cells

Solar cells, 1µm thick c-Si with periodic nanopatterns









6.5% (+45%) efficiency, 18mA/cm²

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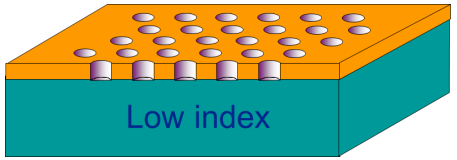
- *Strong Jsc increase due to photonic crystals*
- *Still room for improvement to reach simulated Jsc : parasitic absorption*

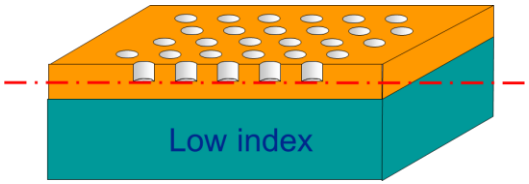
Outline

1. Introduction, INL, i-Lum group, our approach

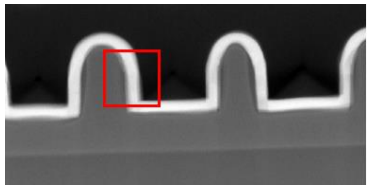


2. Vertical symmetry breaking

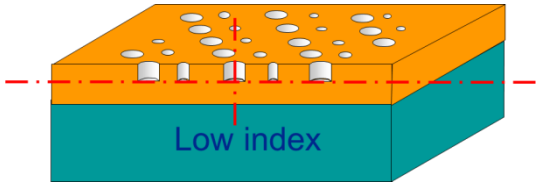
➔Generation of quasi-bound states in the continuum



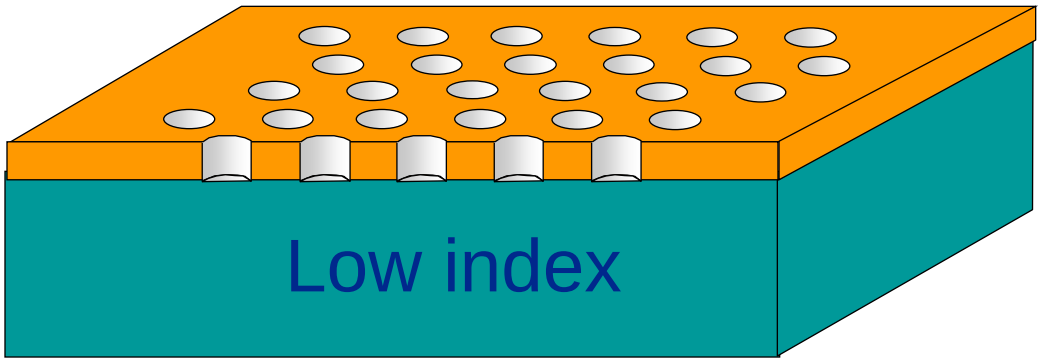
3. Towards photocatalysis using symmery broken metasurfaces



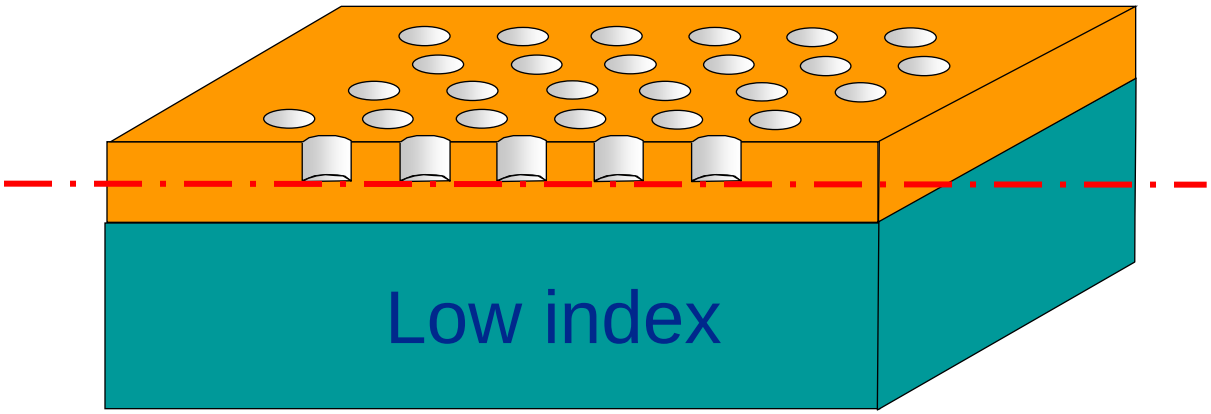
4. Conclusion and outlook



2-Vertical symmetry breaking



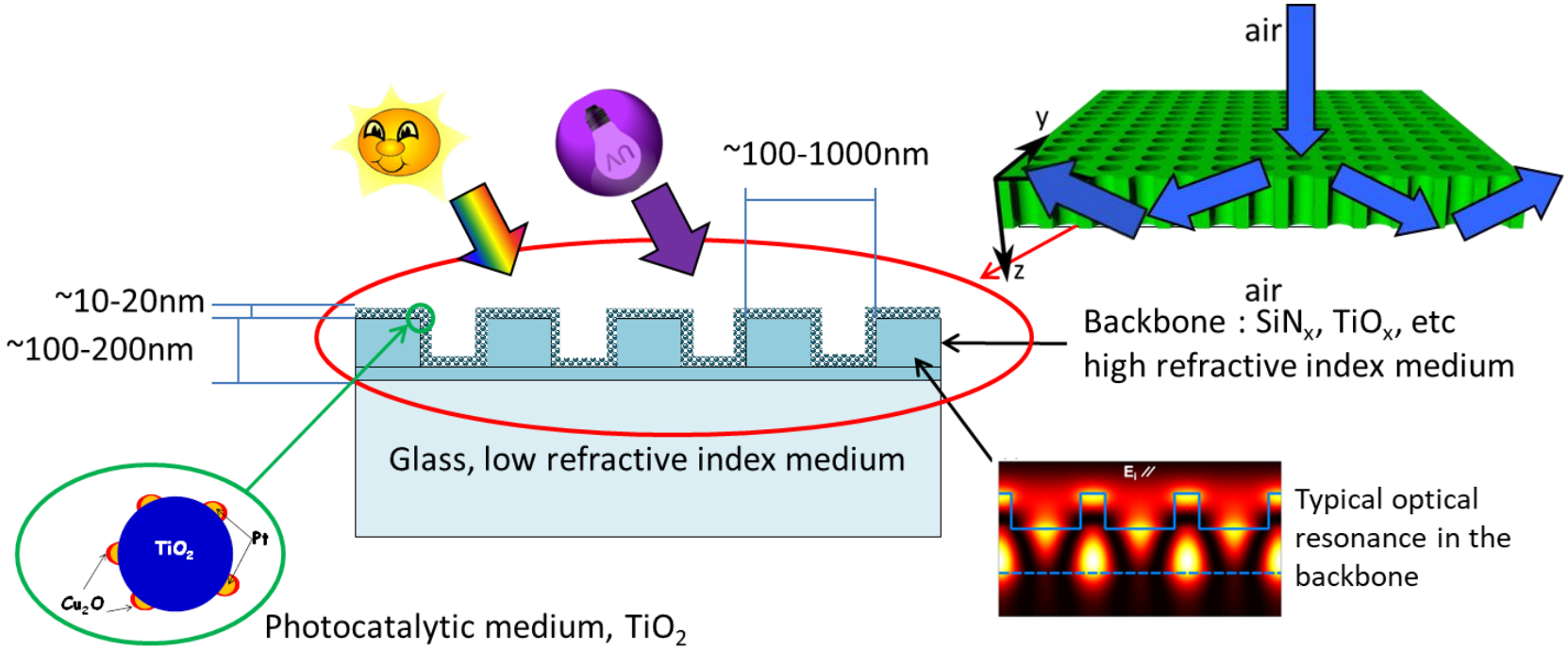
2-Vertical symmetry breaking



3-control of photocatalysis

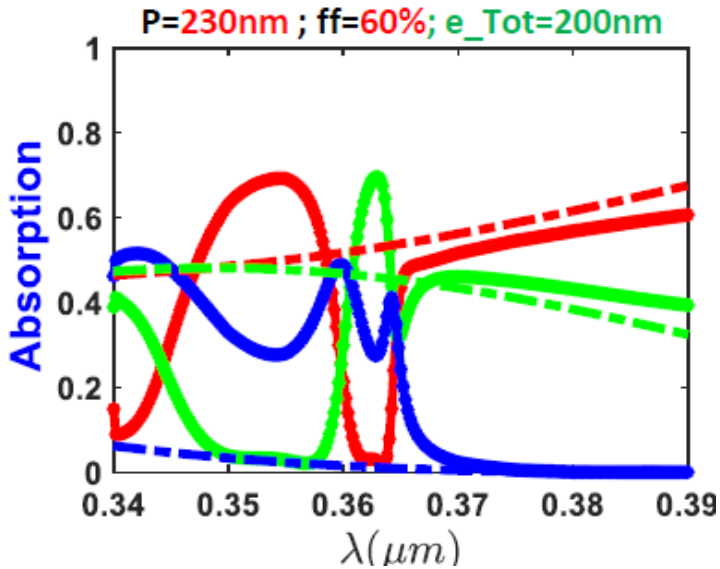
➢ *Photocatalytic medium integrated onto photonic nanostructures*

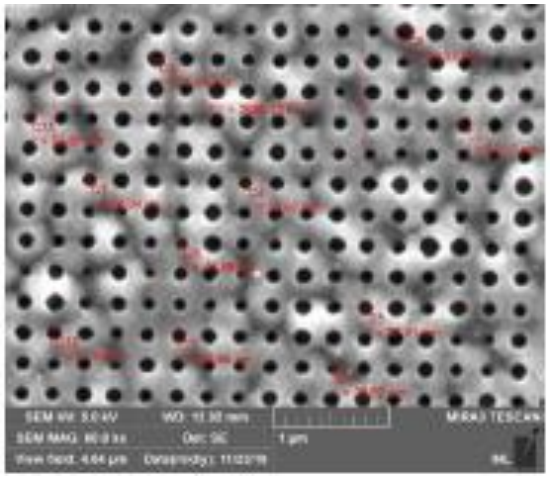
“IPPON” Scientific Breakthrough Projet, IDEXLyon



3-control of photocatalysis

- *Photocatalytic medium integrated onto photonic nanostructures photoniques:*





Conclusions, general comments

→Integrating a wide range of active materials

Including “PV”, “LED”, “Laser” media, but also photocatalysts. Organic, inorganic or hybrid.

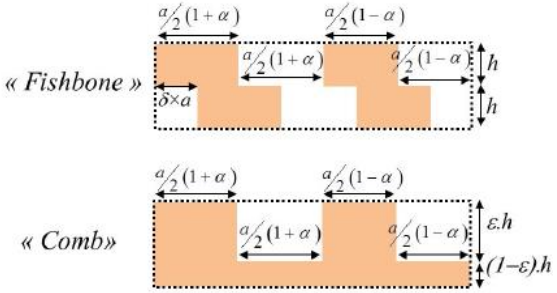
Achieving non-conventional regimes in nanopatterned hybrid perovskites: polaritonics

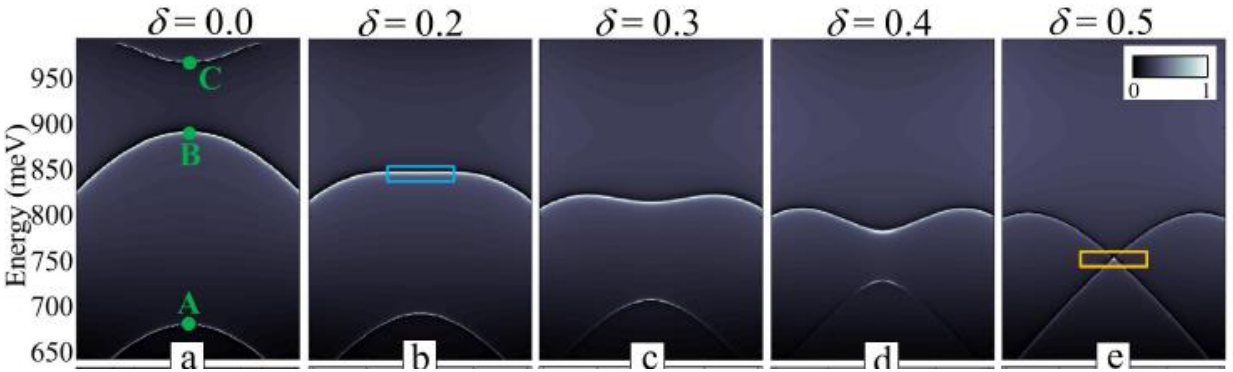
Conclusions, general comments

→Extended possibilities to generate on-demand dispersion characteristics

Through vertical **and lateral** symmetry breaking

Achieving ultra-flat bands, Dirac cones, M or W-shaped dispersions

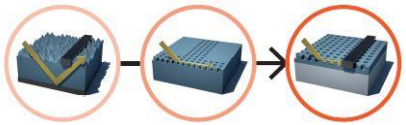




Acknowledgements

The NANOLYON technological team

EU program,



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