NANO-PROBE INTERACTION WITH PHOTONIC CRYSTAL SLOW-LIGHT MODE

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Context

Resonant modes in 2D PC

- Band-edges slow Bloch modes (SBM) allow to increase the lifetime of photons (few ns)
- Cavity modes allow to confine photons in tiny volume (~ λ^3)

applied →

1. Biological sensors
2. Very low threshold devices
3. Quantum information
4. Manipulation of particles

Study the extension of Bloch modes
Self confined or intentionally confined

evaluate →

- Modal volume modification
- Group velocity

Investigate and Manipulate SBM

by →

1. Inverted microscope- mounted SNOM in transmission mode
2. Functionalized tip (nano-antenna)

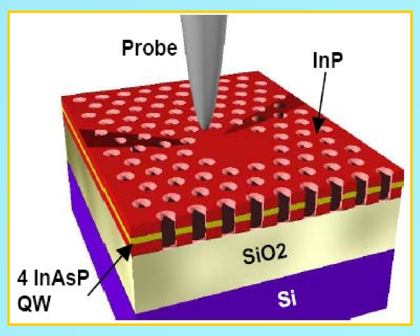
Feasibility of photon funneling?

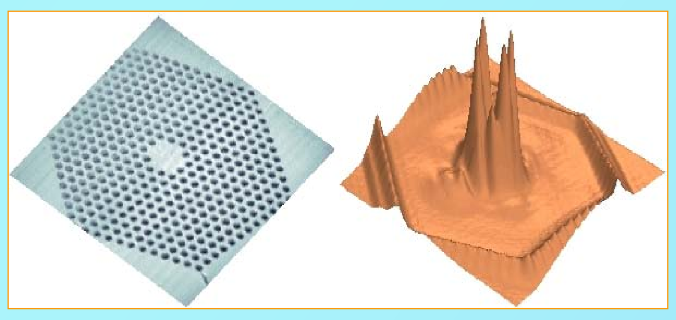
SNOM and 2D PC structures

- Spatial sensitivity beyond far-field technique
- Ability to probe the evanescent of tail of guided modes.

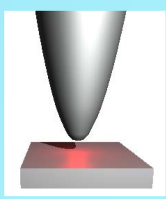
Optical characterization at a sub-wavelength scale
Validation of computational models

Hole radius : 130 nm
Period : 460 nm
λ~1550 nm





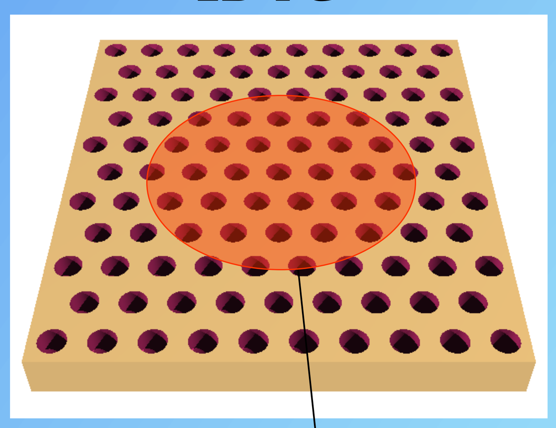
Interaction probe / electromagnetic field



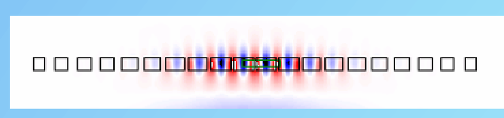
- Low index (n_{probe}~air) : passive tool
- High index (n_{probe}~semiconductor substrate) : active tool

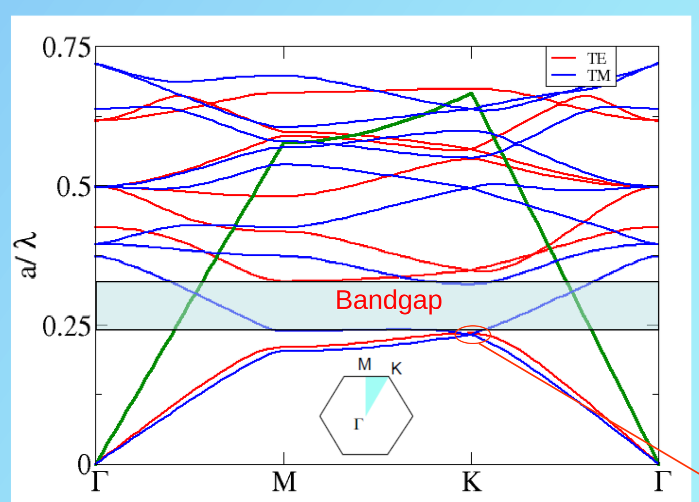
Design

Perfect triangular lattice 2D-PC



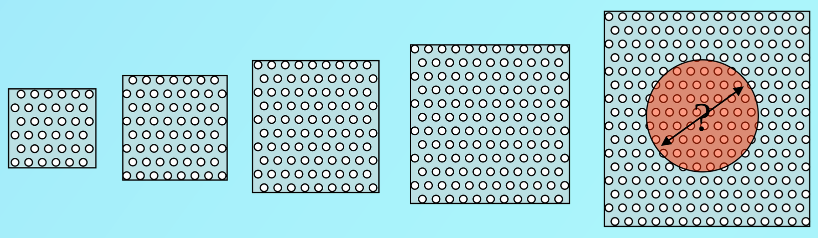
Mode extension ?





Band structure computed with MPB

(Steven G. Johnson)



Investigation of the extension of modes vs:
- Structure size
- Excitation spot size

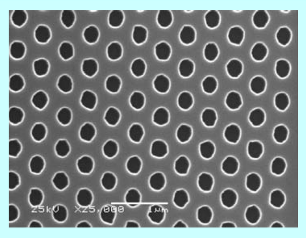
Valence band edge at K point

Sample fabrication

1. Deposite 90nm of SiO_2

2. Spin coating 100nm PMMA

3. E-beam lithography and Development



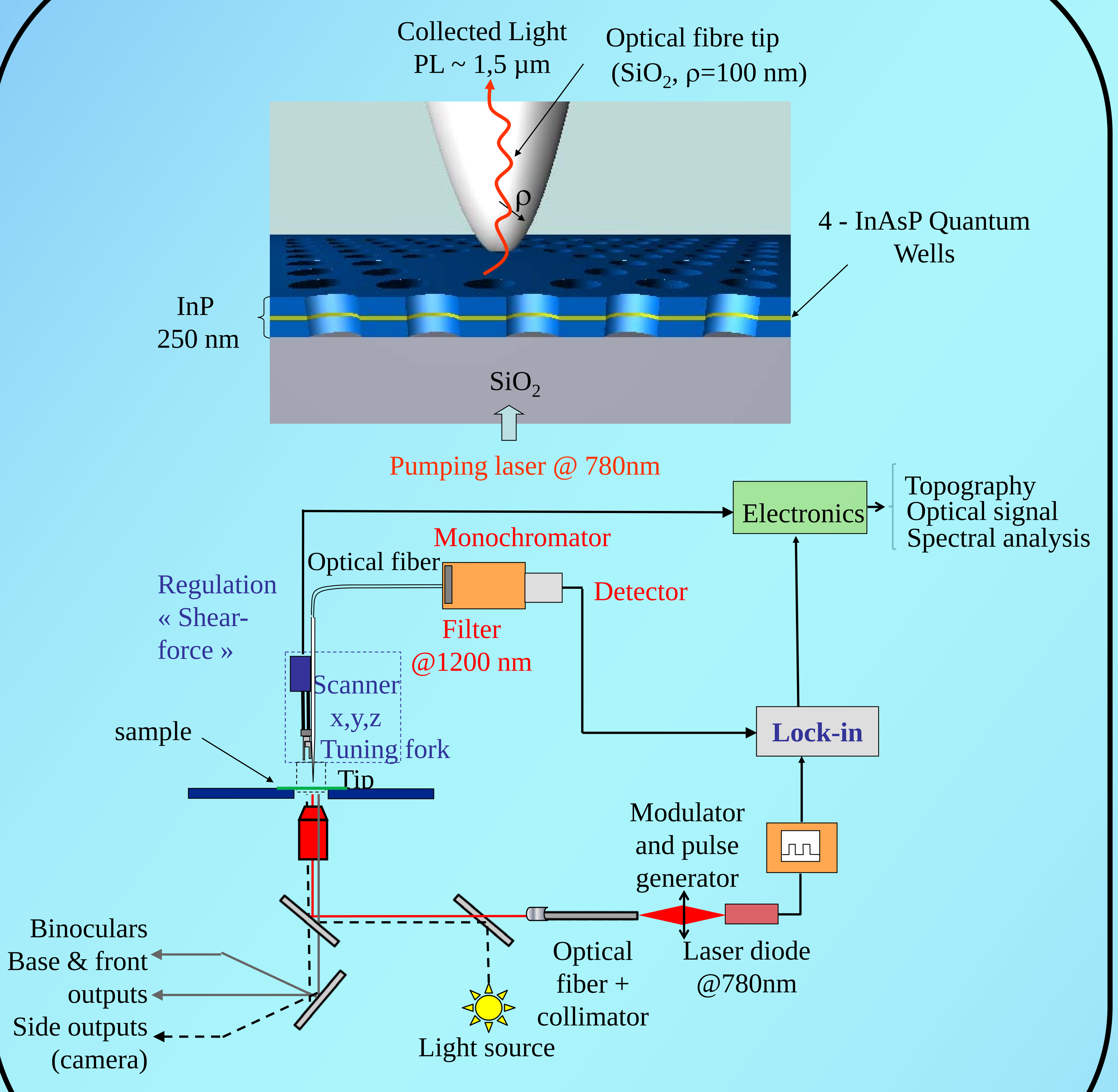
SEM image of a completed triangular lattice PC (a = 460nm, r = 100nm)

4. Transfer patterns into the hard mask

5. Transfer mask into InAsP

6. Remove the remaining resist

Experimentation



The Axio observer inverted microscope-based set-up was built in scope of the NanoEc program

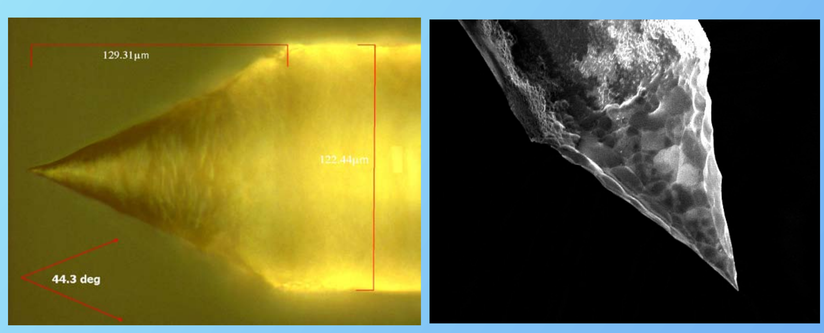
Tip fabrication

The desirable properties of near-field optical probe:
- High brightness (large opening angle)
- Well-defined circular aperture
- A high optical damage threshold

(T. Yatsuia, M. Kourogi, and M. Ohtsu, Appl. Phys. Lett. 73, 2090 (1998).

Low dielectric probes are silica probes fabricated by chemical tube etching in which volume ratio V of NH_4F in mixture NH_4F-HF-H_2O is controlled to obtain the expected opening angle (X:1:1, X=1-6).

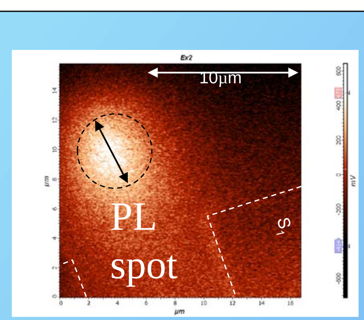
(T.Pangaribuan et al., Jpn.J.Appl.Phys.31 (1992).



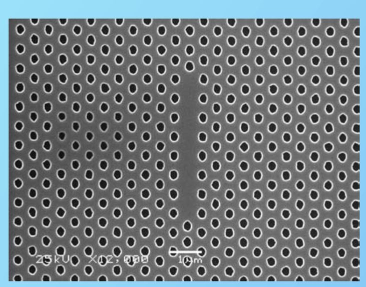
Optical (left) and SEM (right) images of a completed silica tip with opening angle of 44.3^0 approximately

Preliminary Results

Before investigating Bloch modes, our set-up is being tested using CL-7 structures on transparent silica host substrate as they have already been studied in previous works by Gaëlle Le Gac.

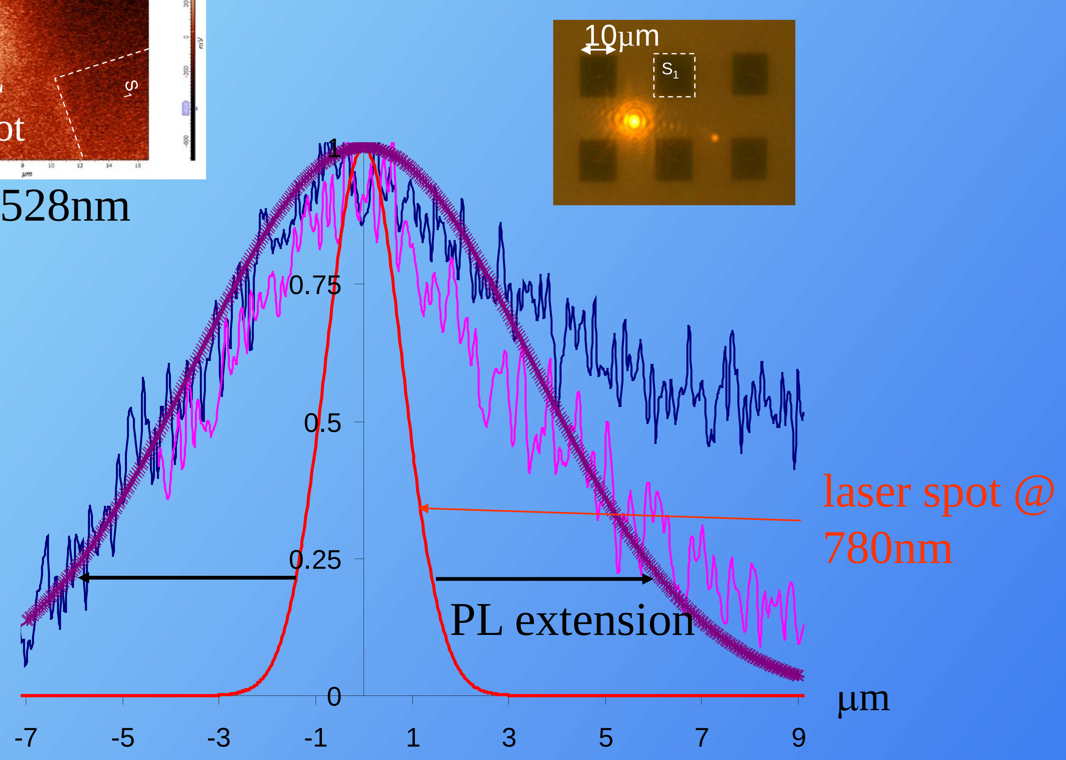


@ 1528nm



SEM image of CL-7 inside a triangular 2D PC (a = 460nm, r = 100nm)

Controlling the excitation spot size



Perspectives

1. The Bloch mode structures have been designed and will be fabricated soon at INL
2. For the next step, we will measure the mode extension on the resulted 2D PC sample.
3. For the future works, we will characterize the interaction between Bloch modes and nano-antenna which is placed
   a) on the structures,
   b) on the tip (in collaboration with FEMTO-ST)

Acknowledgement

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