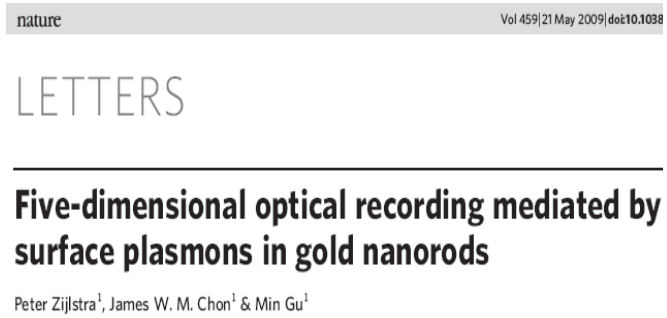
# Flagship C - Nanophotonique

Volet: PLASMONIQUE

# Motivations: why surface plasmons

- **Enhancement of surface phenomena (ex. *surface-enhanced Raman scattering*)**
- **Bio-detection applications – Surface-plasmon resonance detectors**

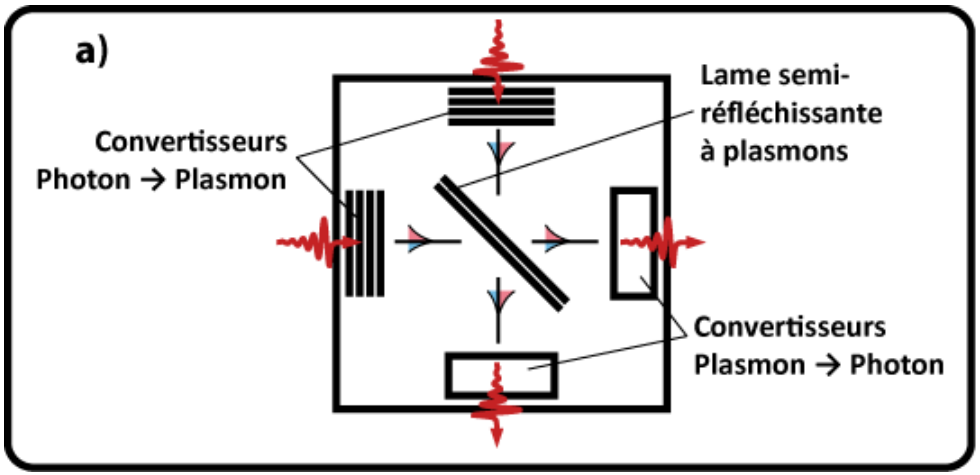
- **Localized plasmons: they endow glass with color!**
- **Medical applications (cancer therapy, for instance)**
- **Data-recording applications**

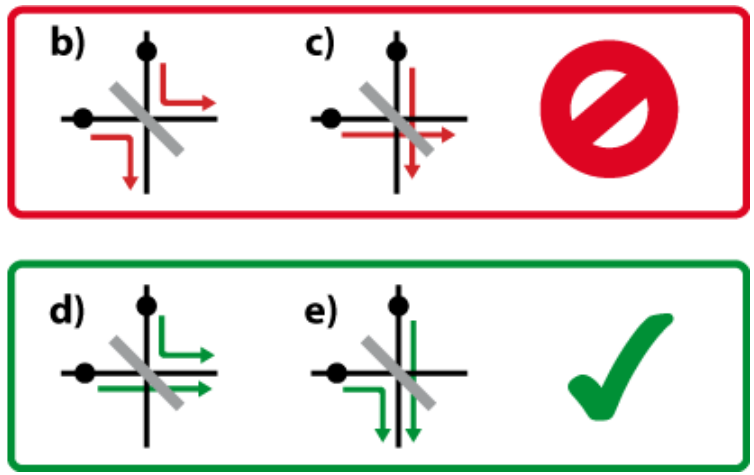



- **Compact, surface-plasmon based optical waveguides**

# Open questions: SP quantum optics

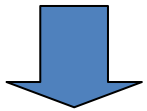
- **Can we convert single photons → single plasmons?**
- **A platform for surface-plasmon quantum optics?**
- **Ex.: surface-plasmon coalescence?**



# Open problems: losses

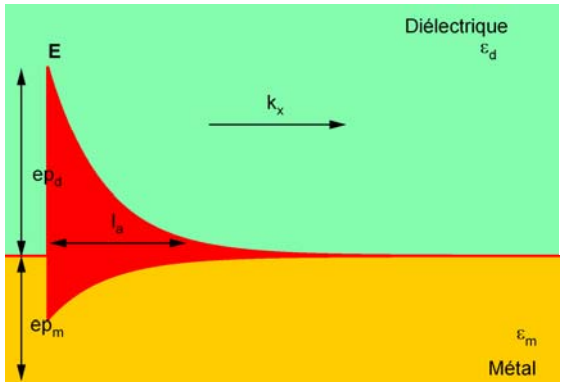
- **Ultrasmall light sources → Nanolasers**
- **Photovoltaics**
- **Metamaterials are essentially plasmonic structures!**
- **Sub-wavelength optical imaging**



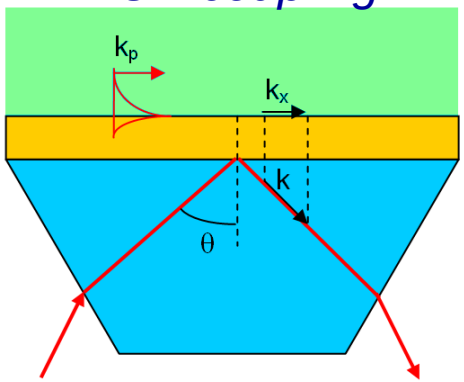
**All these applications need to cope with LOSSES**

**Surface-plasmon amplification**

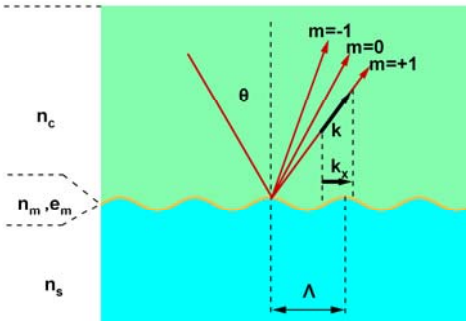
# Open *vistas*: enhanced light-matter interaction




*Prism coupling*

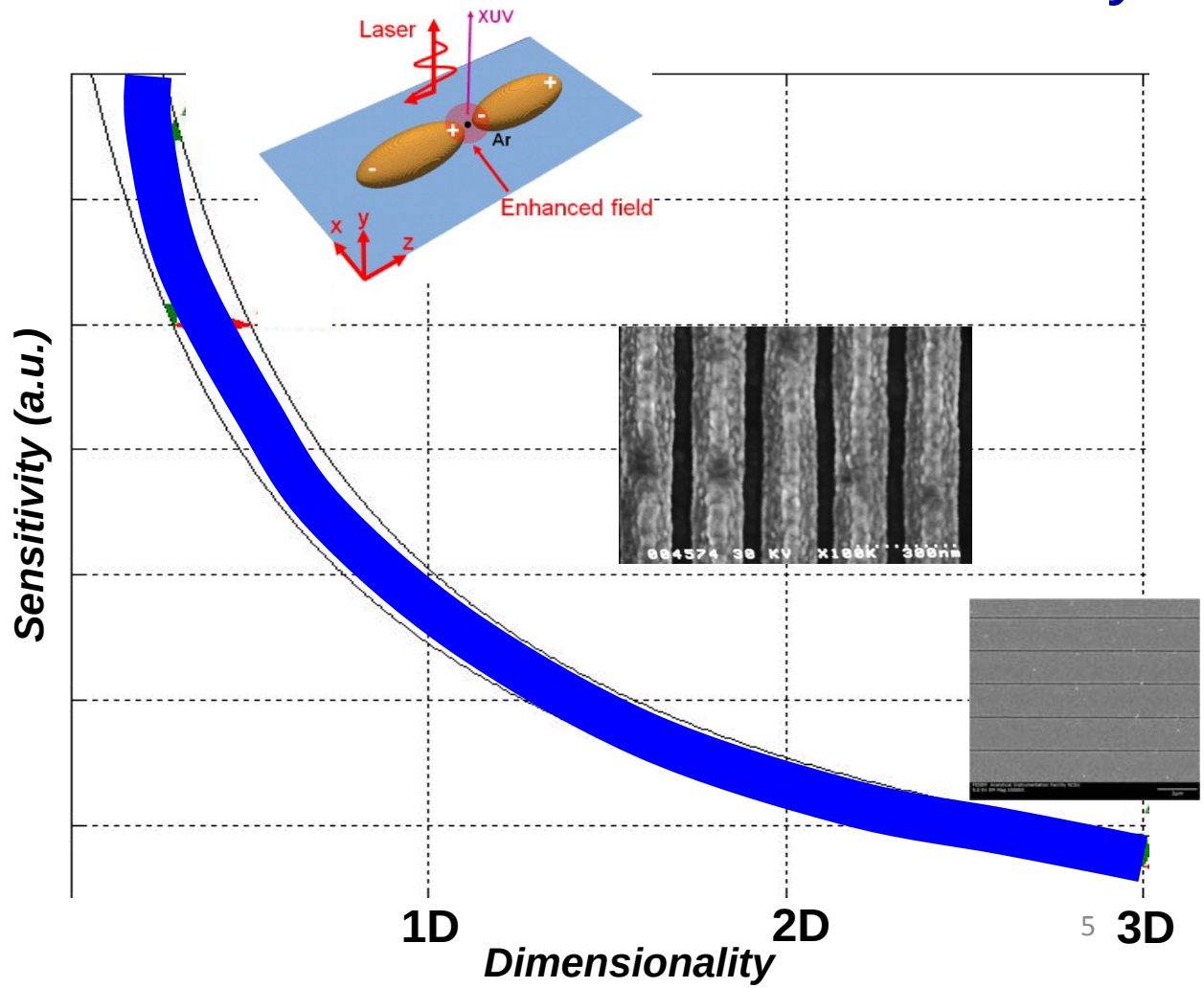



*Grating coupling*




## Sensitivity is enhanced

## DECREASING the dimensionality!

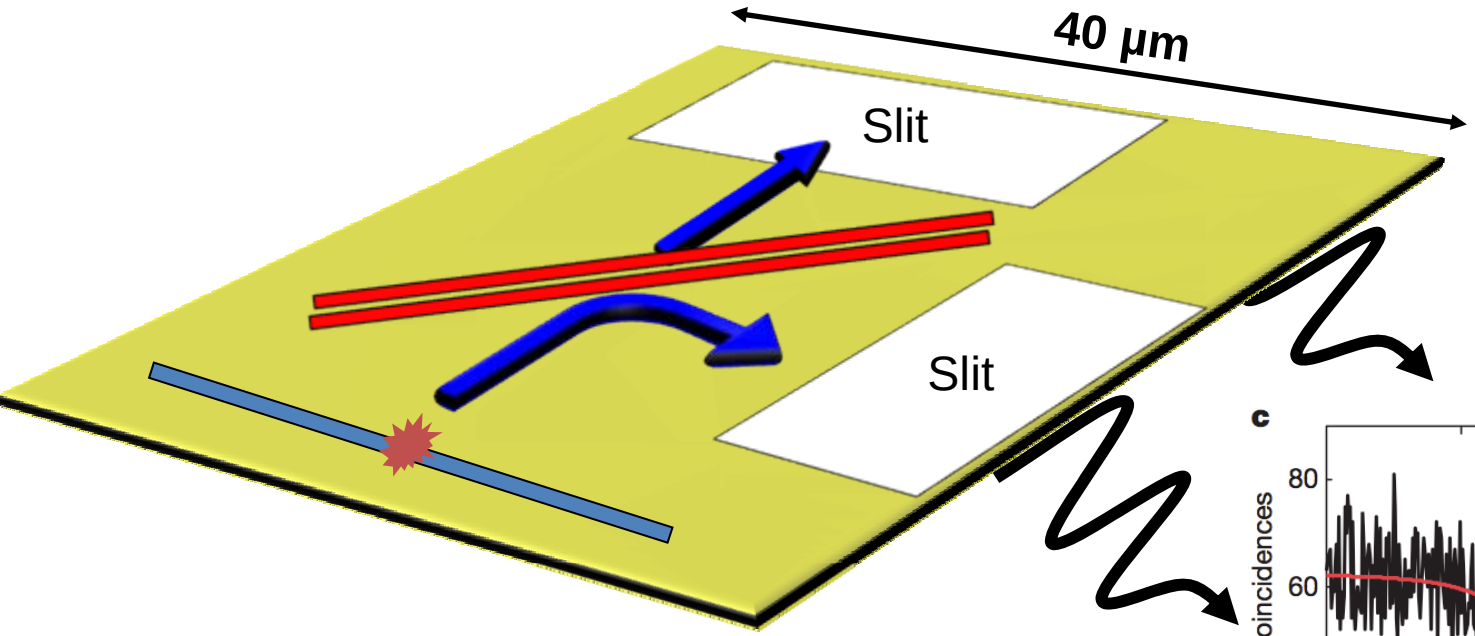


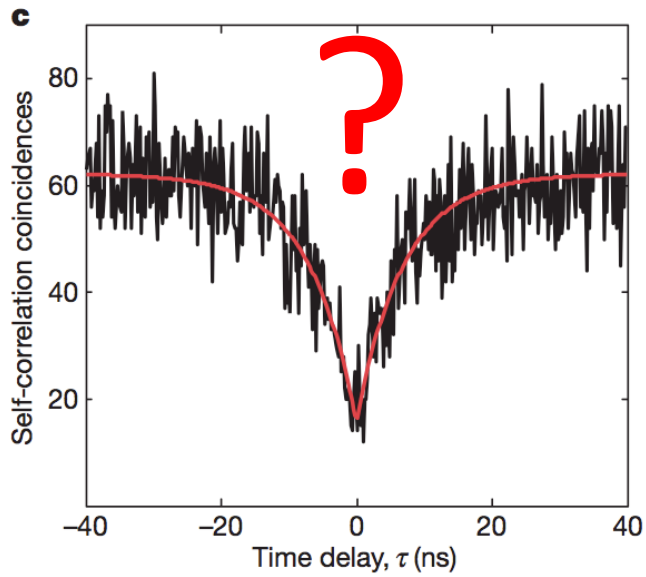
# Focus topics of the *plasmonics* action

***The guiding idea: providing answers to fundamental, long-term questions***

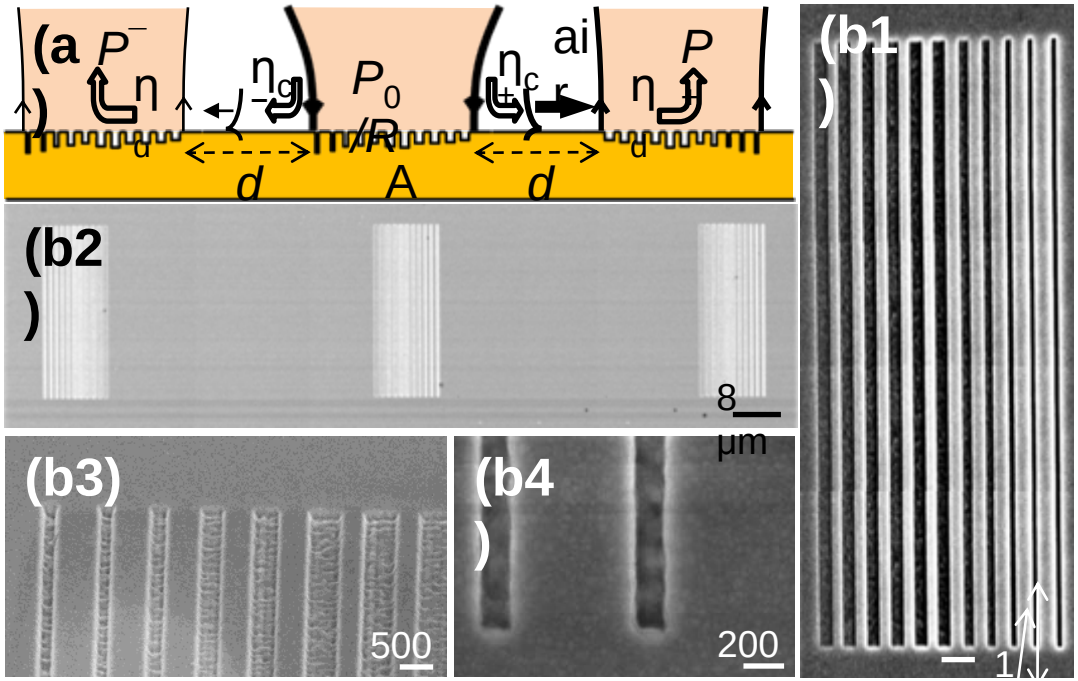
- ***Plasmon quantum-optics***
- ***Surface-plasmon generation and amplification***
- ***Plasmonic resonators***

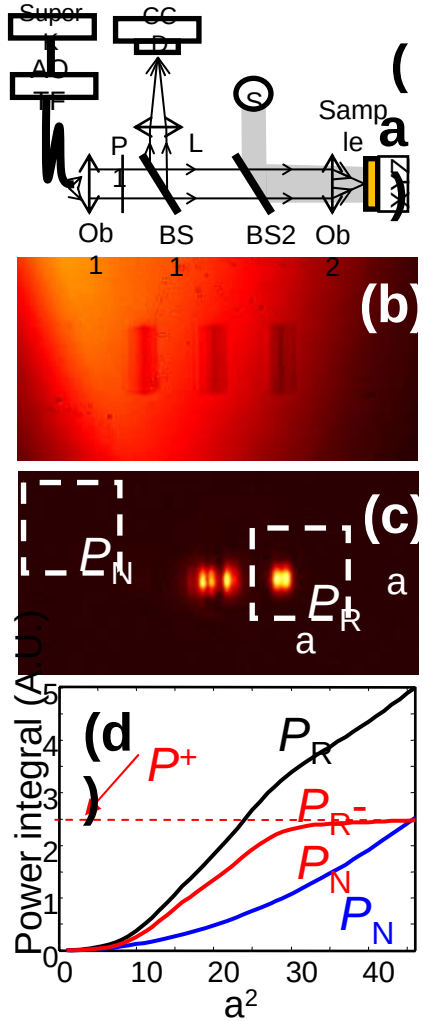
# Perspective: surface-plasmon anti-bunching



# Plasmonic components on a surface
## (IOGS-LPN-ISIS)



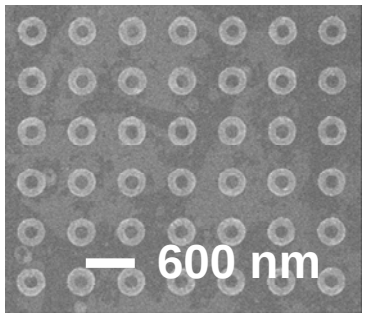



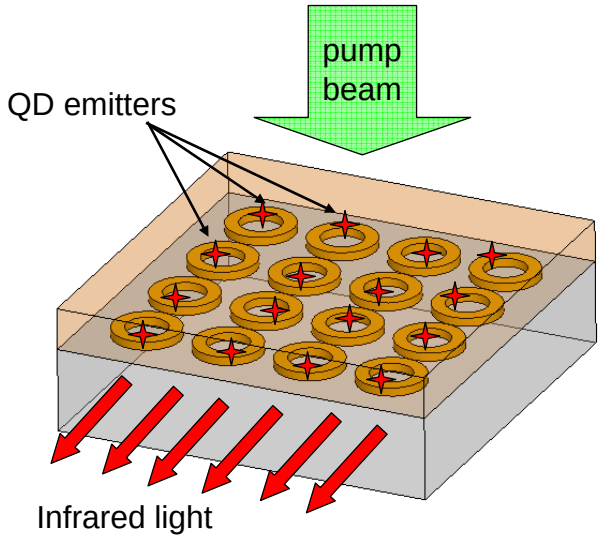

- ***Integrated components (mirrors, beam-splitters)***
- ***Dedicated setups for testing***

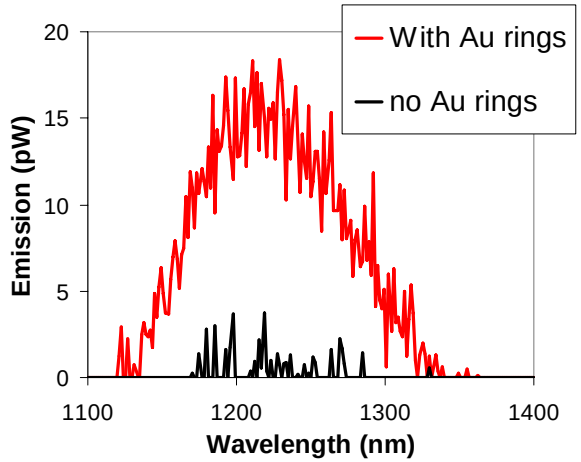
# Perspective: metamaterial-based nano-sources

***Metamaterials: artificial composites with electromagnetic properties not available in naturally occurring media.***

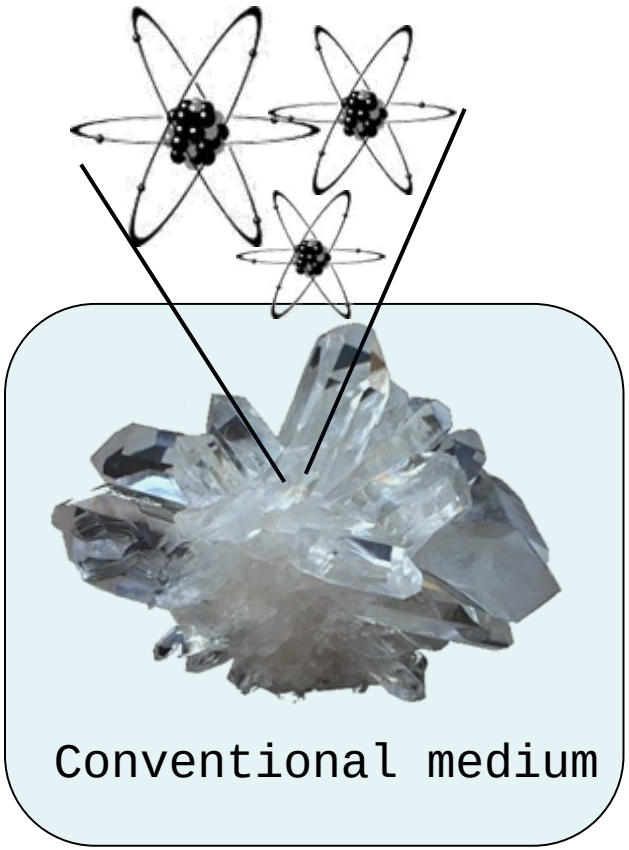
## *Unique opportunities to control the luminescence of nano-emitters*

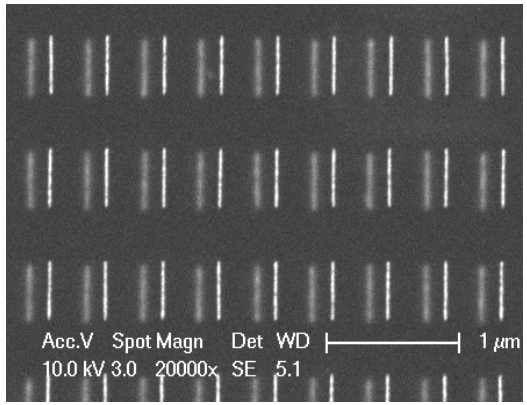


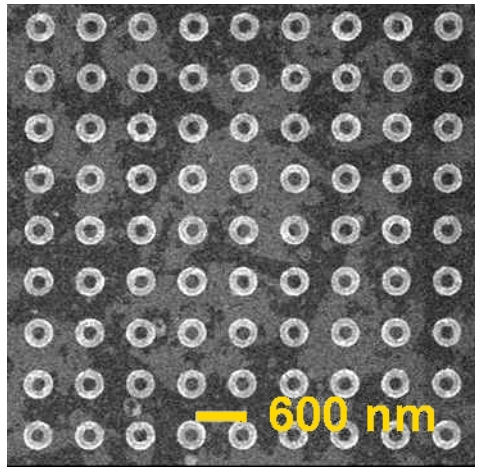



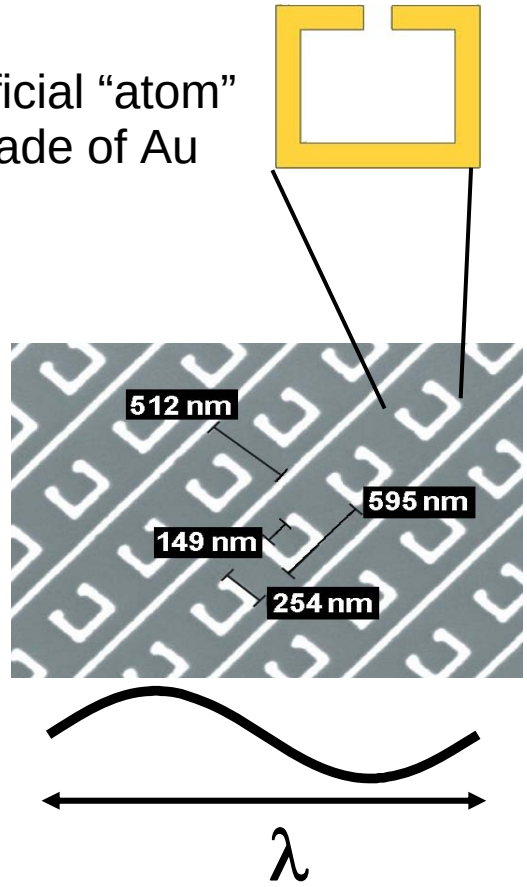
# Plasmonic Metamaterials nano-fabrication (IEF)



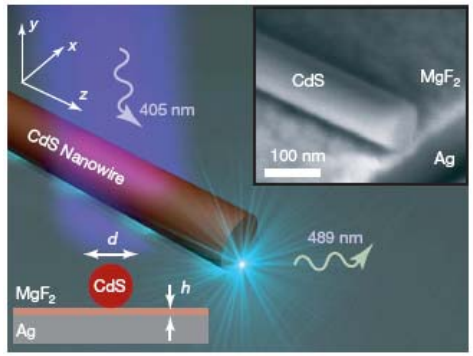




Artificial “atom” made of Au

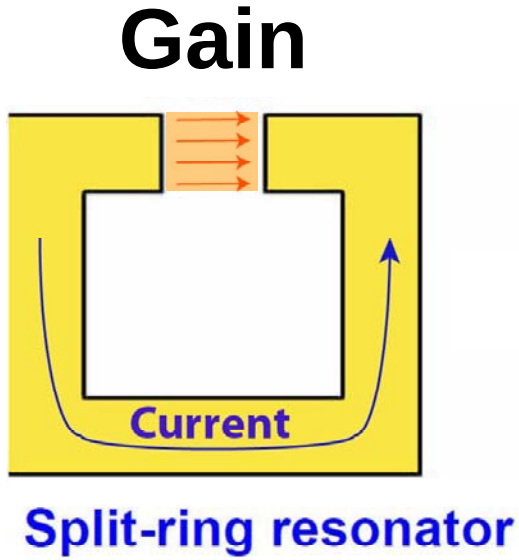


# Perspective: loss-compensation in plasmonic systems

- ***Waveguides: can we increase propagation lengths?***



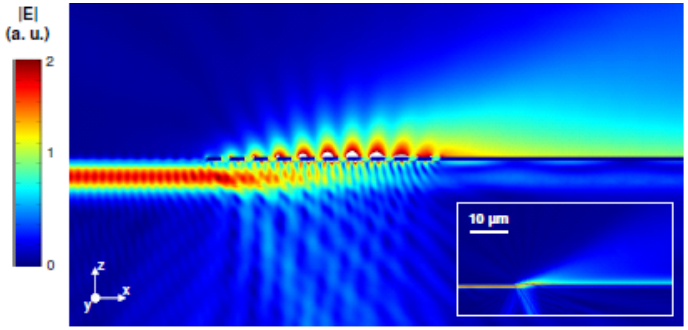

- ***Metamaterials: can we achieve transparency?***

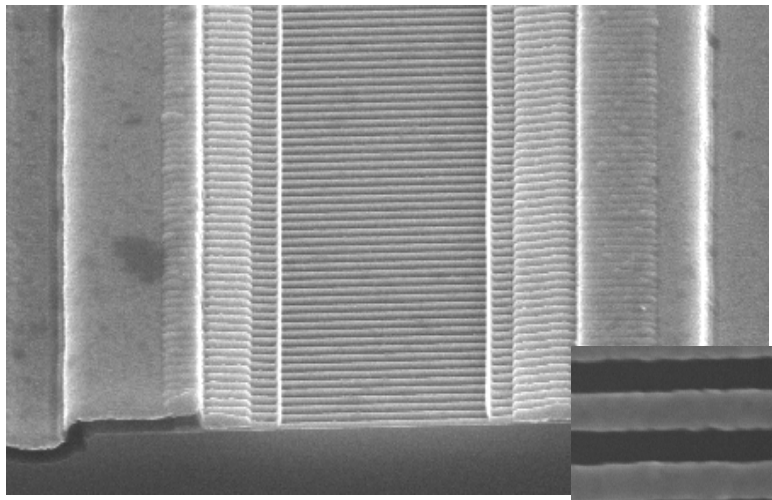


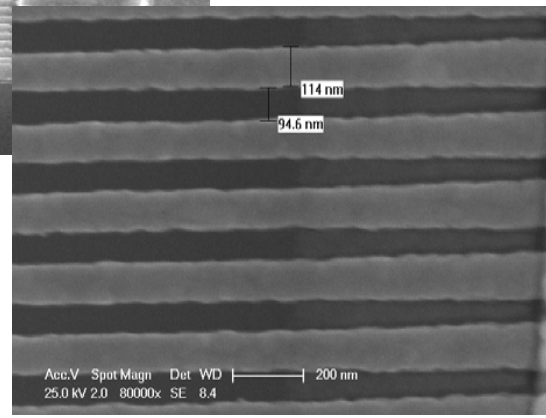

- ***Plasmonic resonators achieving high Q-factors***

# Endowing plasmons with gain (IEF/Thales/IOGS/CEA)

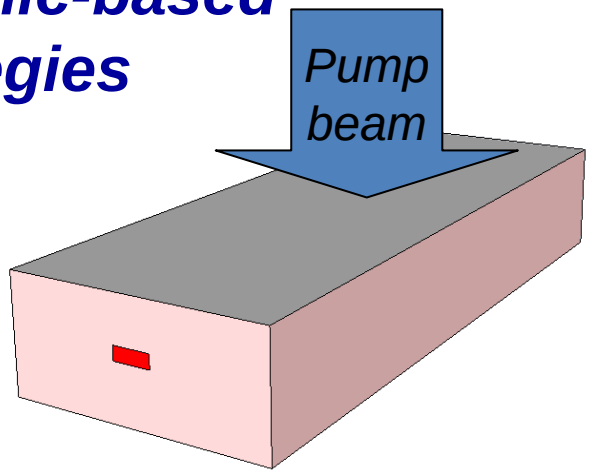
## *Semiconductor-based strategies (QWs, dots)*

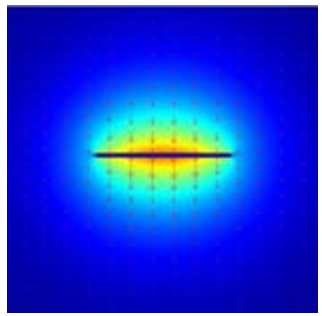





## *Organic-based strategies*

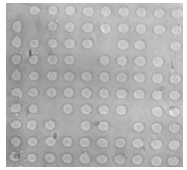


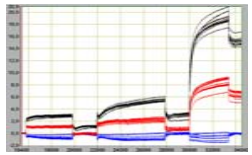
**Symmetric plasmonic waveguide embedded in gain-providing organic layer (carbon nanotubes, polymers, ecc…)**

# Perspective: multi-dimensional detection systems based on SP resonance imaging (IOGS)

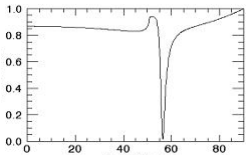
2D: spatial x, y



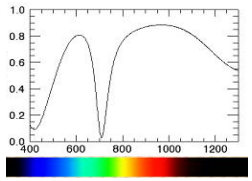
3D: time t



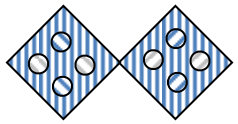
4D: angle of incidence θ

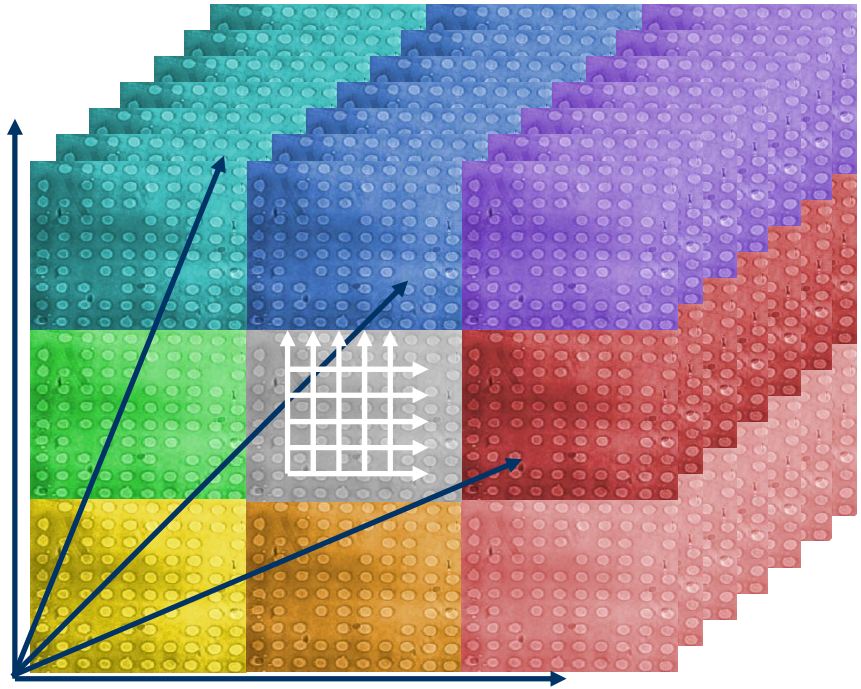



5D: spectral λ




6D: polarisation P

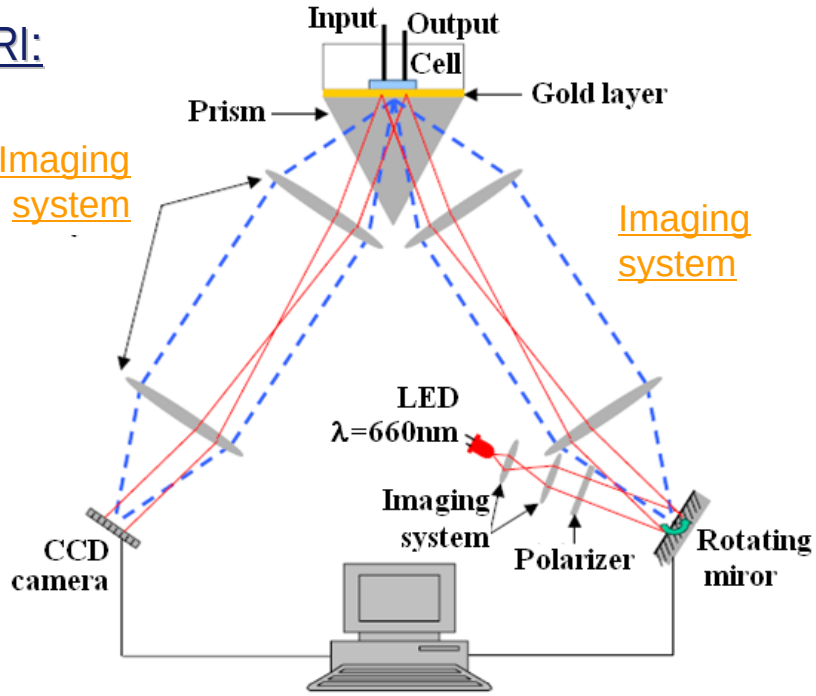


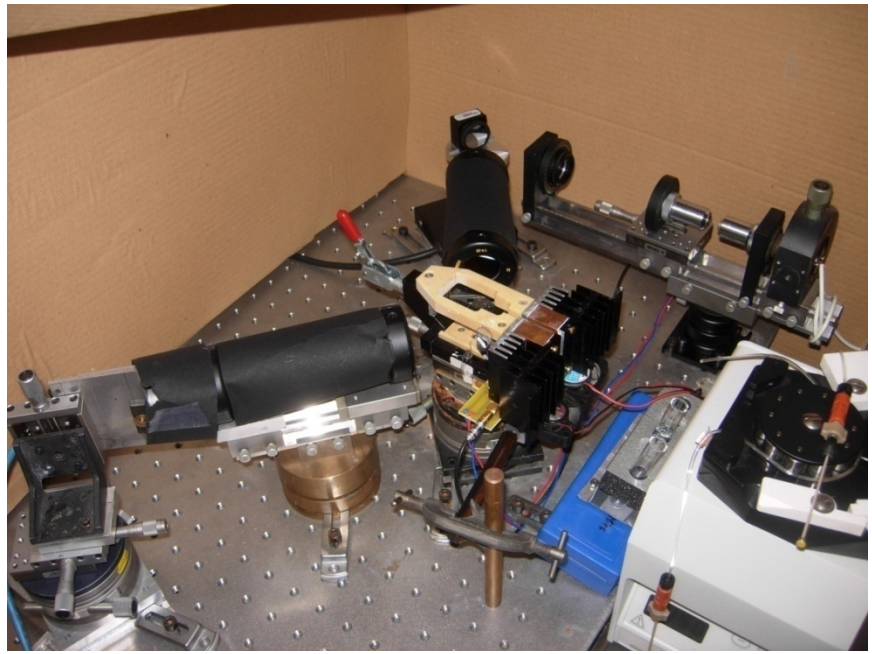


Each voxel of information : R (x, y, t, θ, λ, P)

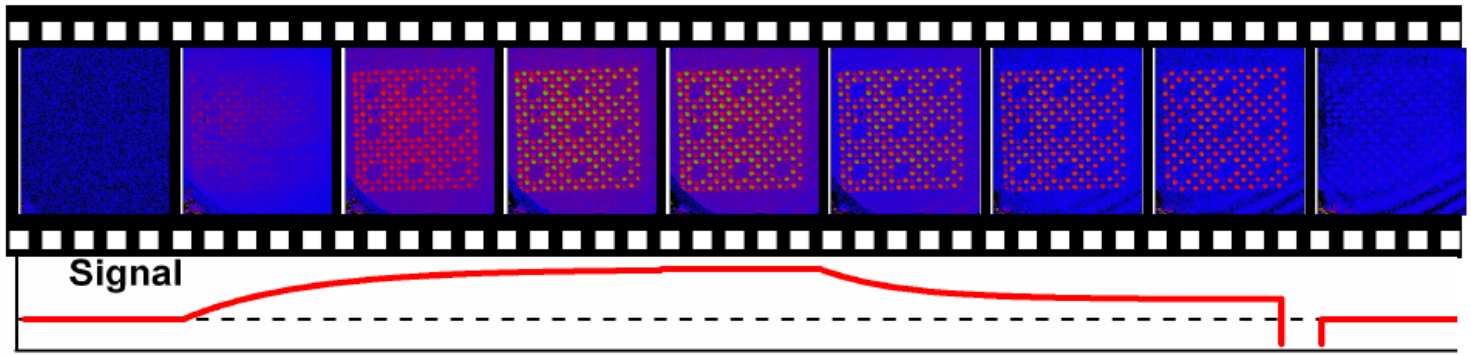
# Detection: imaging in SPR reflectivity mode

SPRI:



SPRI movie



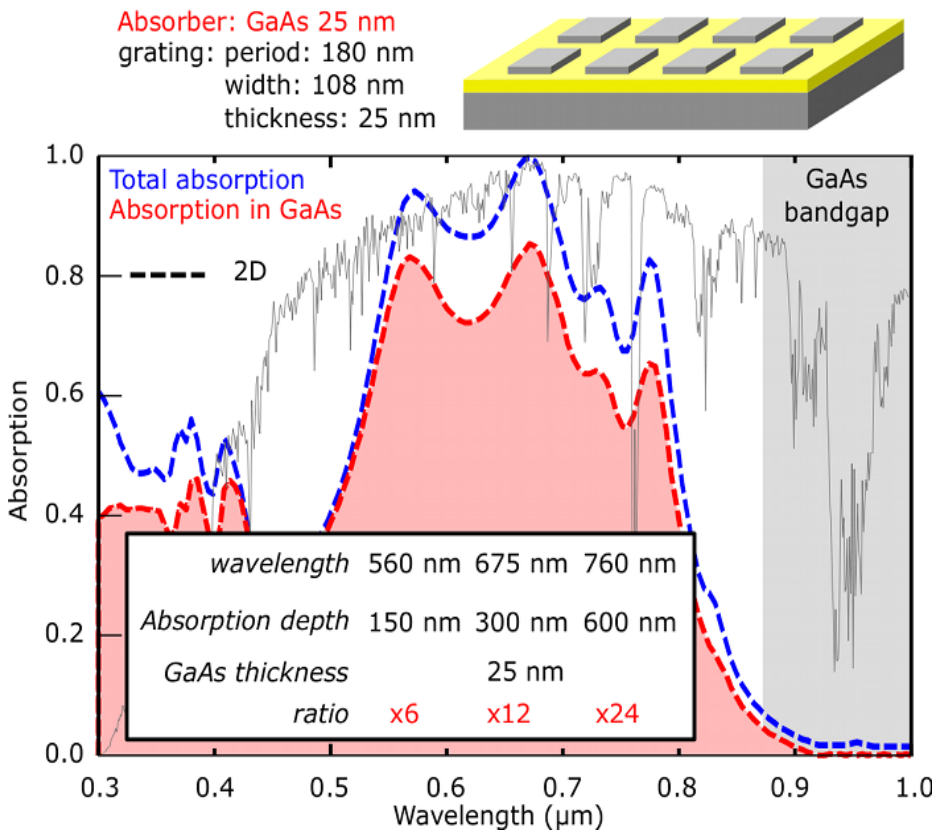

**+ data processing**

→ non conventional imaging optical set-up … R(x, y, t) at $\theta_0$ $\lambda_0$

# Perspective: broadband absorption in ultra-thin solar cells (LPN/IOGS/LPICM)

***Next generation solar cells require thinner absorbers.***

***plasmonic cavities: small volumes (but losses by metal absorption)***

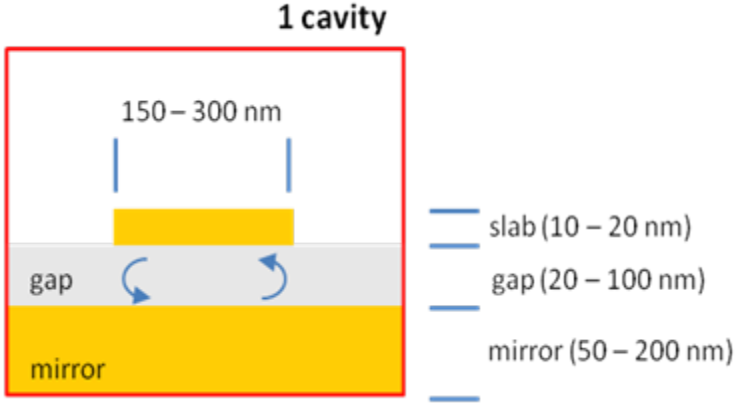


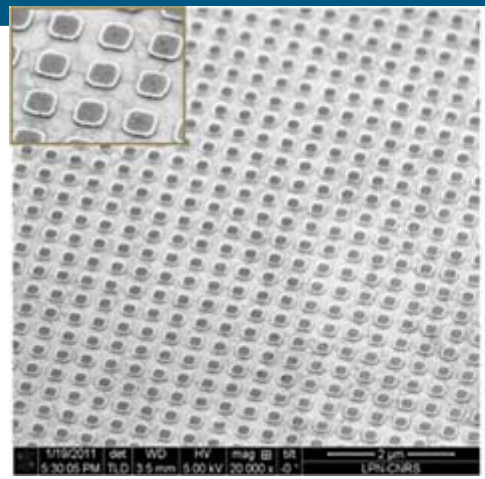

→ **breakthrough in the conception of ultra-thin solar cells**
→ **strong technological effort to achieve high-quality, ultra-thin solar cells**

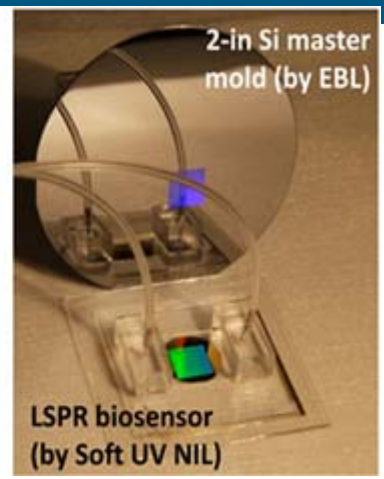
# Plasmonic nanocavities for perfect light absorption

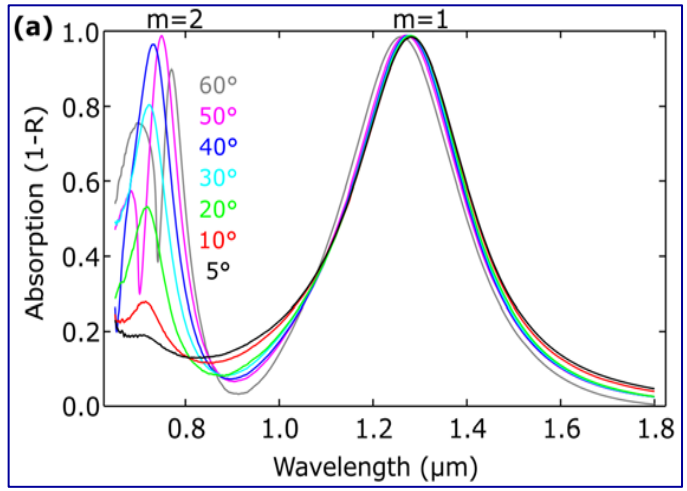
**$\lambda^3$/1000 plasmonic nanocavities**

**fabricated by nanoimprint (1 cm²)**






**Initial results:**

**→ perfect omnidirectional light absorption (1st order)**

**→ directional light absorption (2nd order mode)**

**→ state-of-the-art refractive index sensing**

# Milestones: demonstrations in 2 years

- ***Surface-plasmon anti-bunching***
- ***Electrical excitation of surface plasmons***
- ***Resonant absorption in photovoltaic applications***

# Milestones: demonstrations in 4 years

- ***Photovoltaic cells***
- ***Plasmonic ultra-sensitive detectors***
- ***Plasmonic lasers/amplifiers***