

Fotonica e spettroscopia ottica

- SPETTROSCOPIA
- the study of the interaction between matter and radiated energy. Historically, Spectroscopy originated through the study of visible light dispersed according to its wavelength.
- The concept was greatly expanded to comprise any interaction with radiative energy as a function of its wavelength or frequency.

Fotonica e spettroscopia ottica

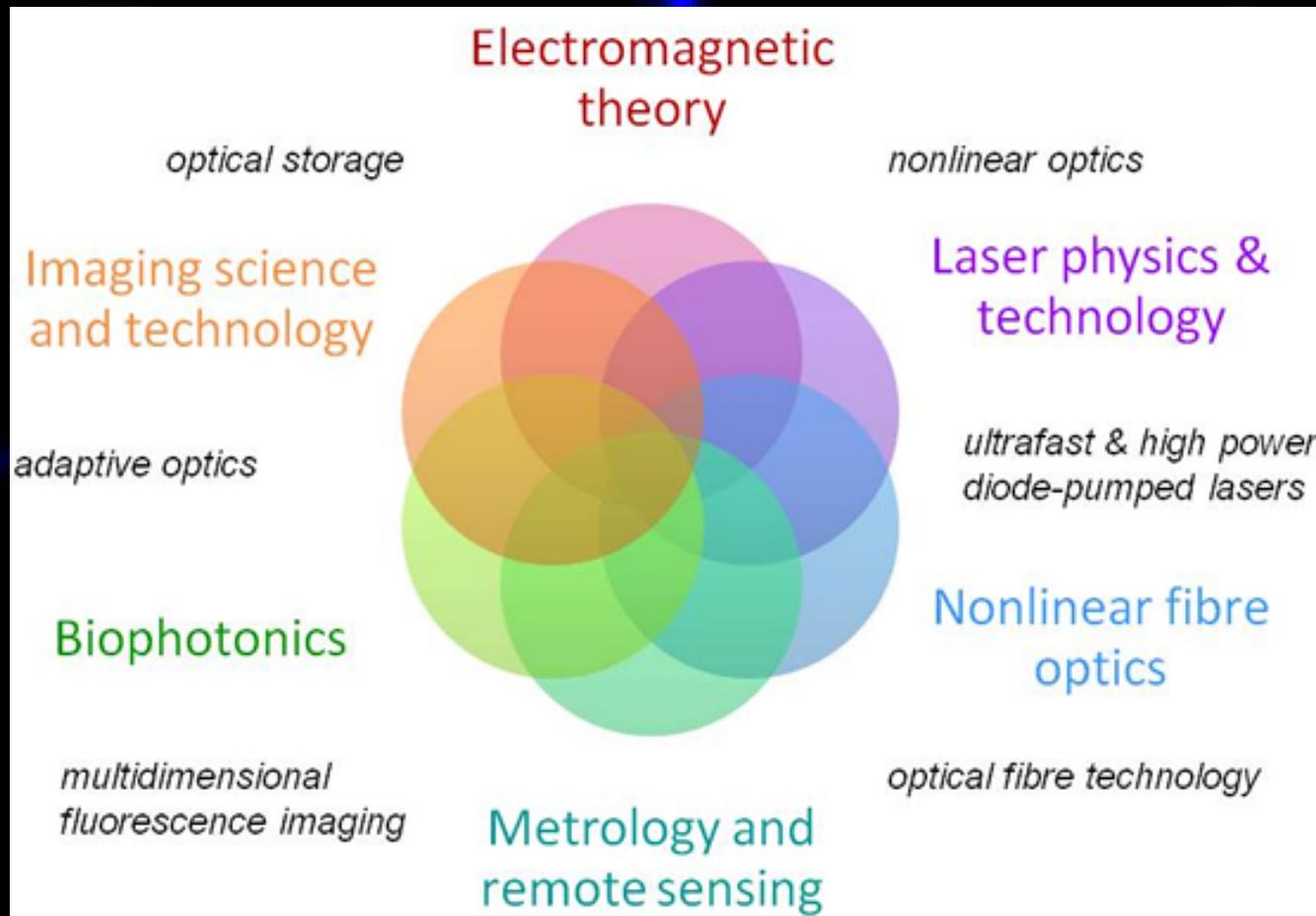
- FOTONICA
- The science of **photonics** includes the generation, emission, transmission, modulation, signal processing, switching, amplification, and detection/sensing of light.
- The term photonics thereby emphasizes that photons are neither particles nor waves — they have both particle and wave nature.

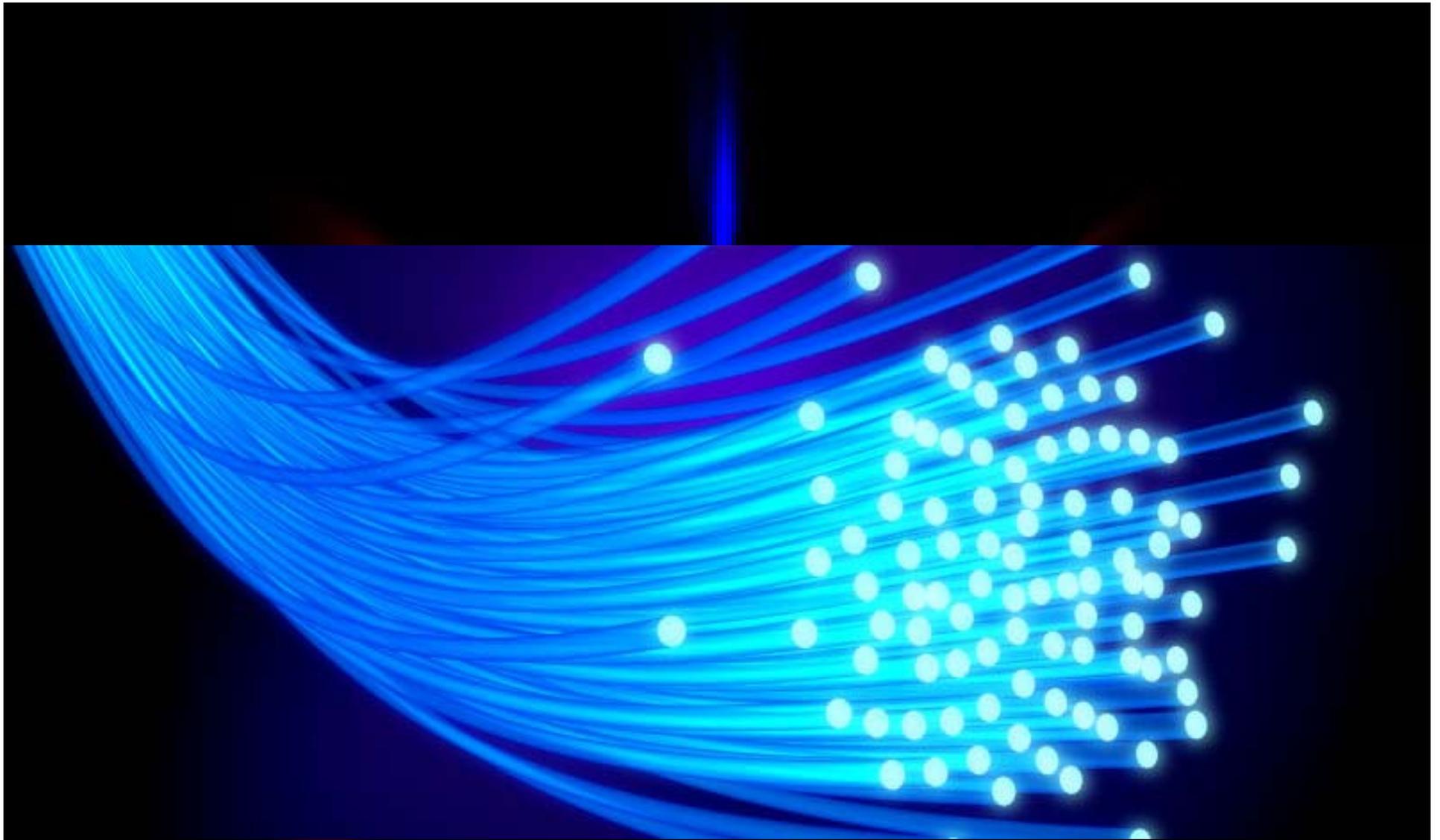
Fotonica e spettroscopia ottica si correla con

- PLASMONICA
- a **plasmon** is a quantum of plasma oscillation like a collective oscillation of the free electron gas density.
- Plasmonics takes advantage of the coupling of light to charges like electrons in metals, and allows breaking the diffraction limit for the localization of light into subwavelength dimensions enabling strong field enhancements.

Fotonica e spettroscopia ottica si correla con

- Photonics also relates to the emerging science of **quantum information** in those cases where it employs photonic methods.





Dipartimento di Fisica - Università degli Studi di Pavia
<http://fisica.unipv.it>

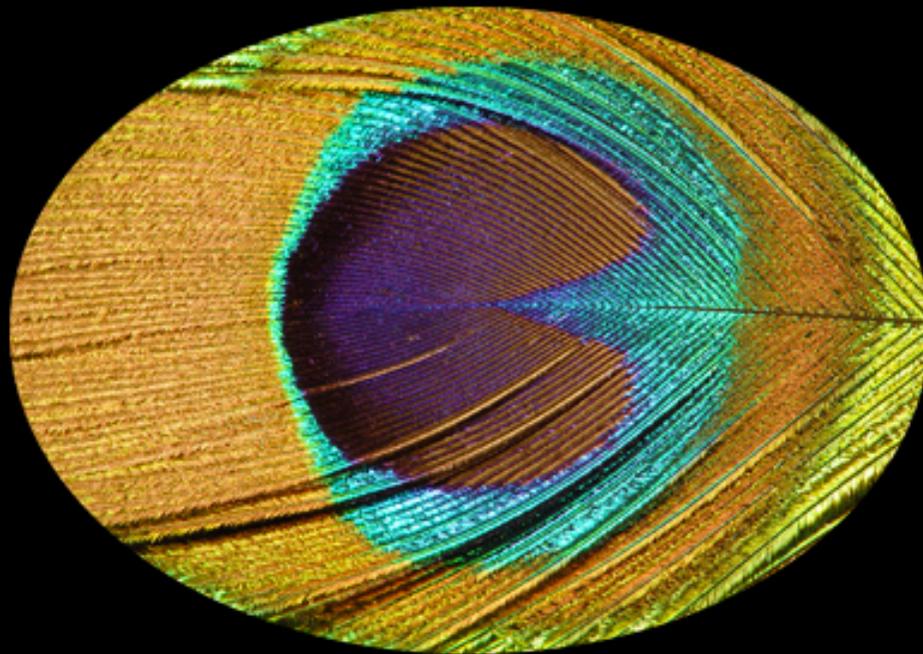
Natural Photonic Crystals



Chrysochroa vittata



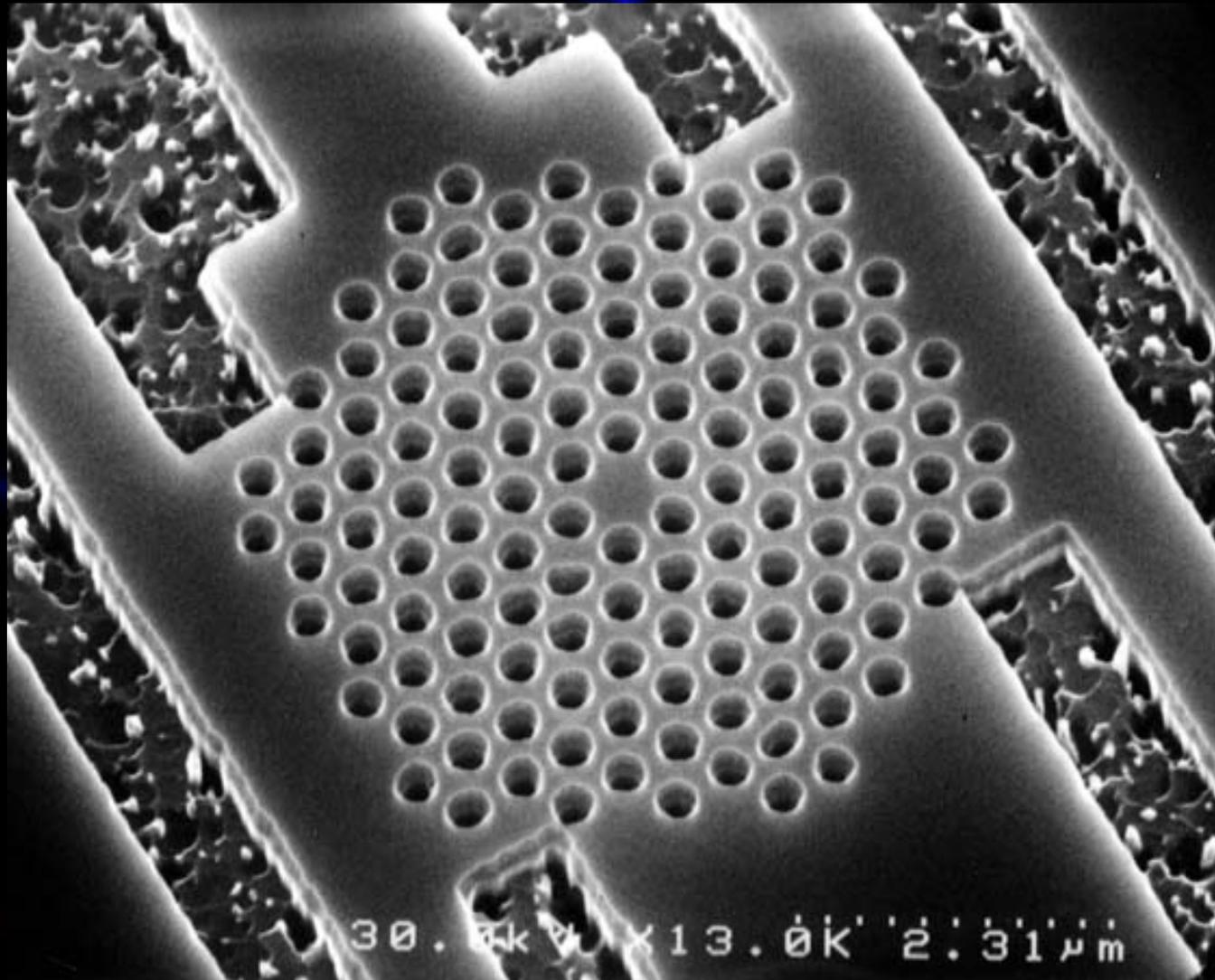
Morpho didius



Pavo cristatus (feather)



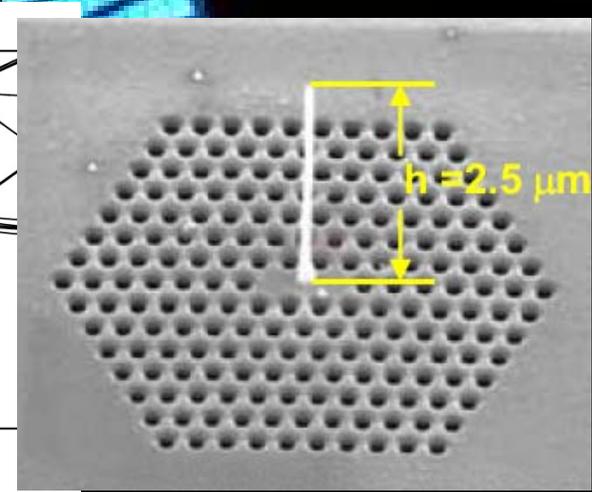
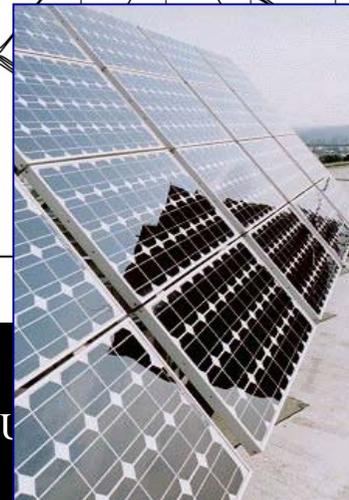
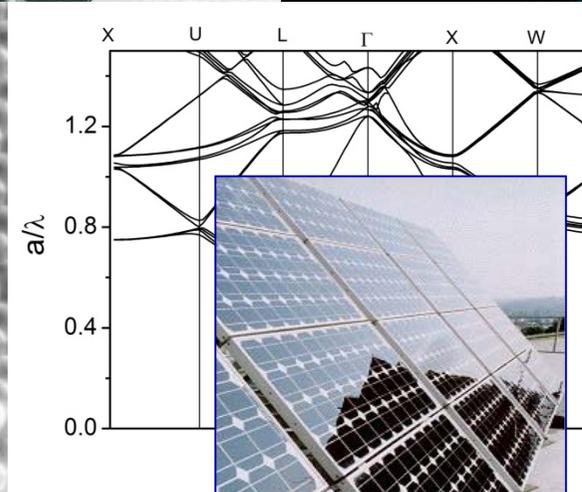
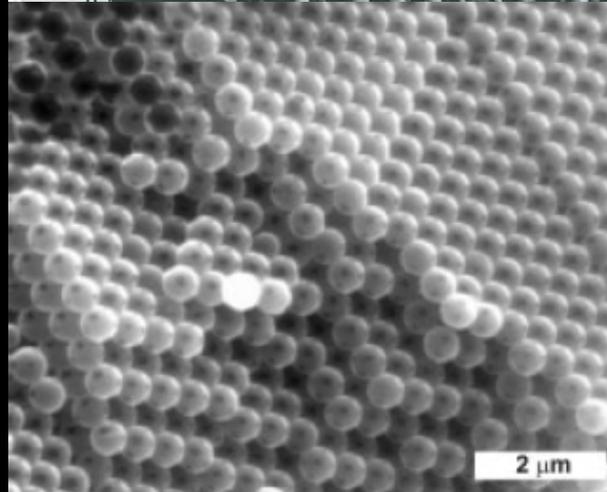
Chrysina resplendens



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Attività di ricerca nel Lab. di Spettroscopia Ottica

- ✓ **Caratterizzazione ottica di superstrutture di semiconduttori**
- ✓ **Materiali organici per optoelettronica**



Progetti in corso

- **MIUR FIRB Futuro in Ricerca 2012-2015**

"New challenges in molecular nanomagnetism: from spin dynamics to quantum information processing"

- **ENI S.p.A. research contract 2011-2014**

"Photonics for photovoltaics systems based on fluorescent concentrators".

- **EU FP7 Marie Curie ITN Network 2011-2014**

PROPHET - "Postgraduate Research in Photonics as an Enabling Technology"

- **Fondazione Cariplo 2010-2013**

"Nanophotonics for thin-film photovoltaics"

- **MIUR FIRB Futuro in Ricerca 2010-2013**

"Nonlinear and quantum optics in nanoscale photonic structures"

- **Fondazione Cariplo 2009-2011**

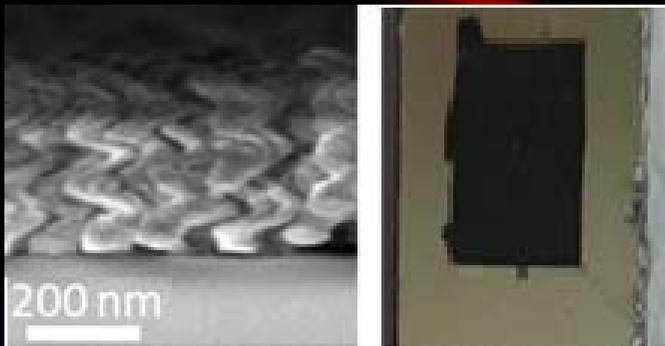
"PHOtonic ENhancement In Chemical Sensors: nanomaterials for optics"

- **Fondazione Alma Mater Ticinensis**

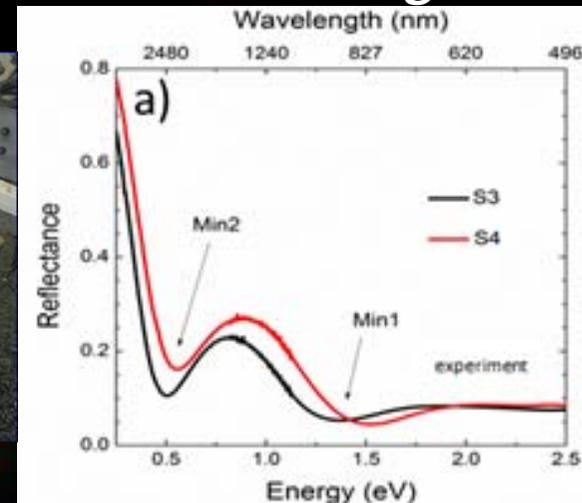
"Semiconductor devices for entangled photon pair generation"

Spettroscopia ottica di materiali nano strutturati

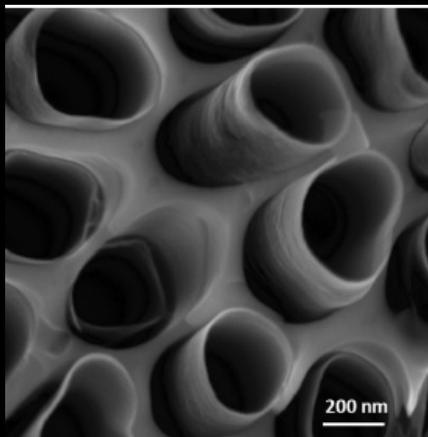
Studio di nano-oggetti metallici
(ad esempio:
nano-antenne di Nichel)



Tecnica sperimentale
Riflettività ottica risolta in angolo

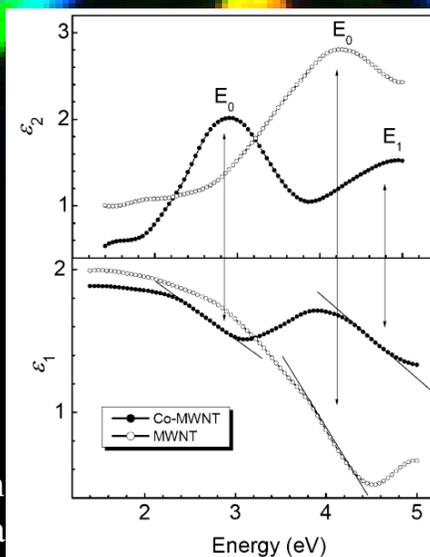


Studio di
Nano-tubi di carbonio



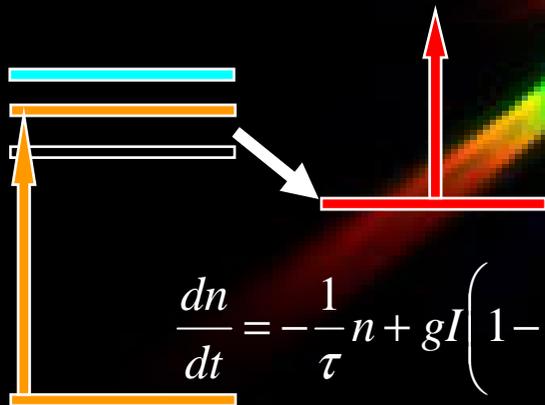
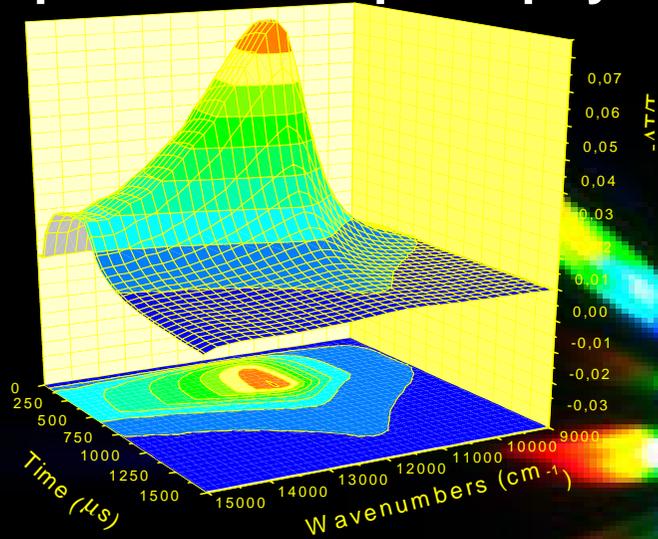
partimen
<http://fisica>

Tecnica sperimentale
Ellissometria spettroscopica



Polimeri conduttori

Triplets exciton photophysics

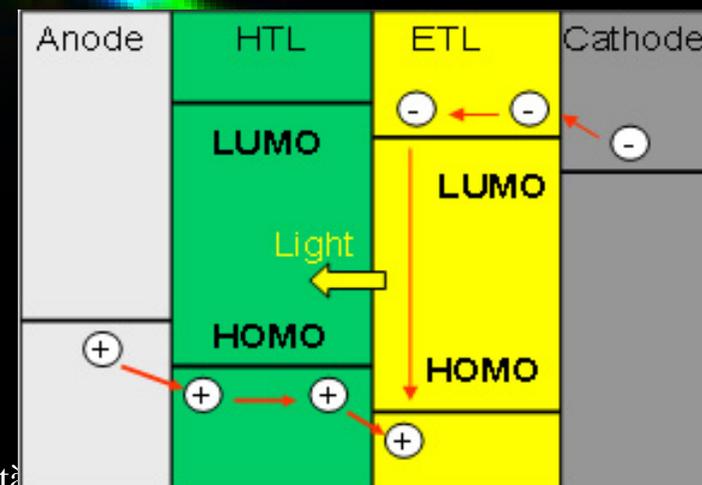


$$\frac{dn}{dt} = -\frac{1}{\tau}n + gI \left(1 - \frac{n}{n_0}\right)$$

Optical Spectroscopy Under Pressure



Organic solar cells

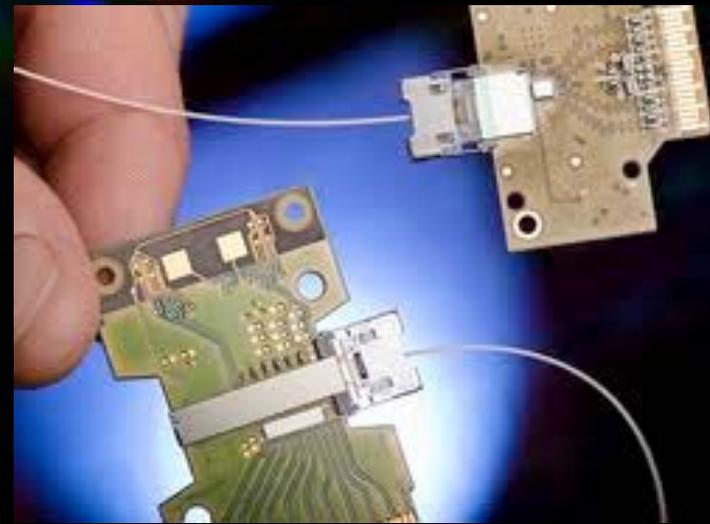
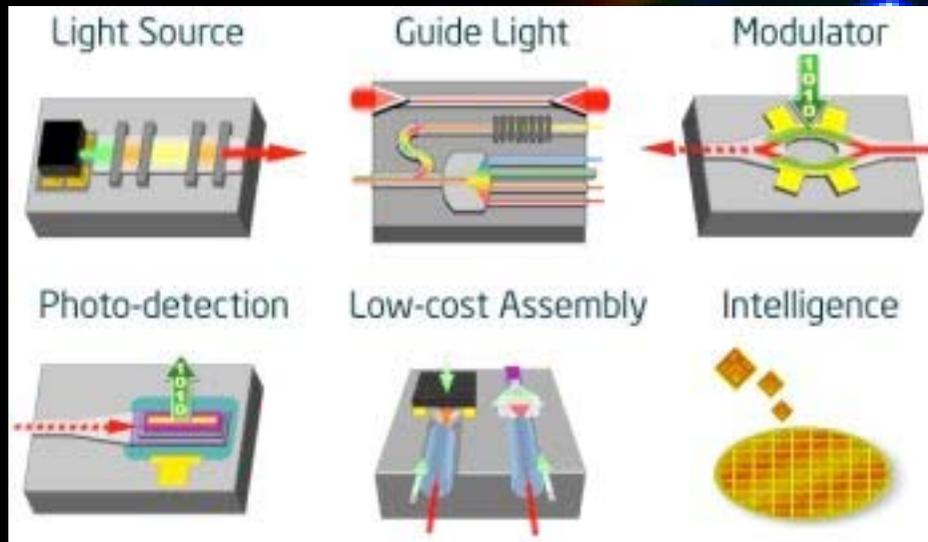


Silicon Photonics

Motivation: Information and Communication Technology (ICT) is still based on integrated electronic circuits, but increases in their power consumption and heat generation are now hampering further improvements in the speed and capacity of ICT and also hindering the realization of the 'Green Internet'

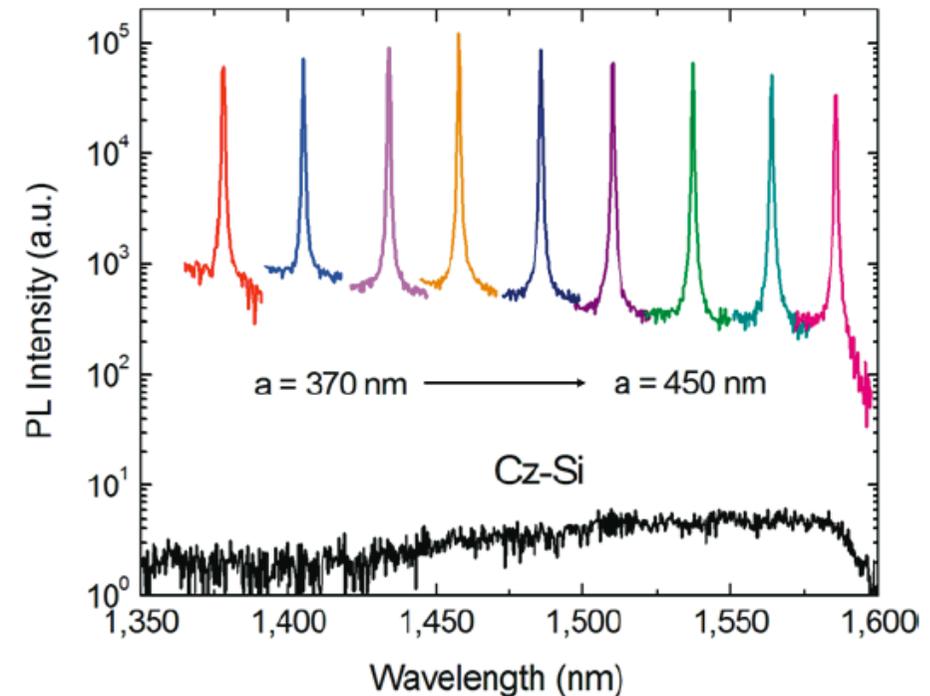
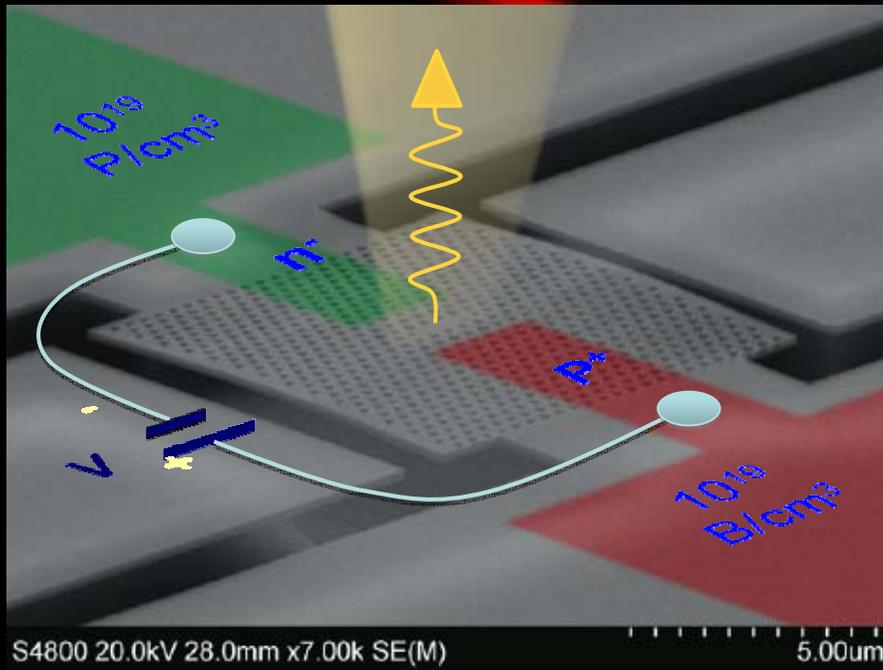
New approach: using light (photons) to move huge amounts of data at very high speeds with extremely low power over a thin optical fiber rather than using electrical signals over a copper cable

Moving data with silicon and light



Research: light emission in silicon

Use a photonic crystal (PhC) cavity to realize an **efficient** and **integrated** light source in silicon

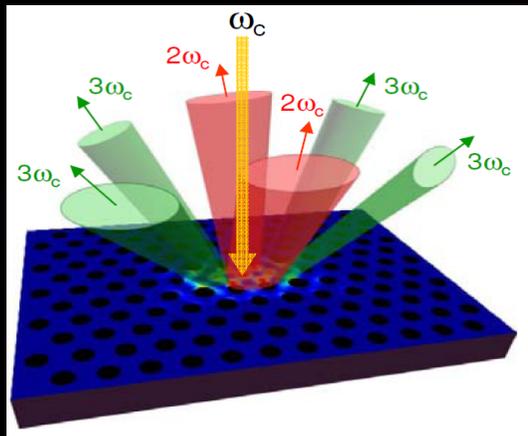


- Electrically driven
- Operates CW at room T
- Exhibits a narrow linewidth

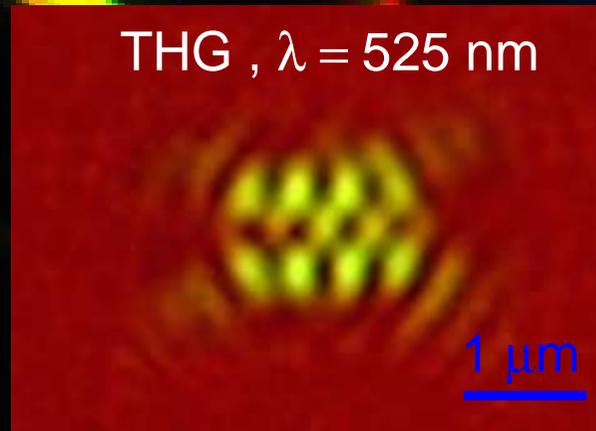
- Emits in the telecom window
- Is small (μm -sized)
- Operates at low power

Nonlinear optics in Si PhC cavities

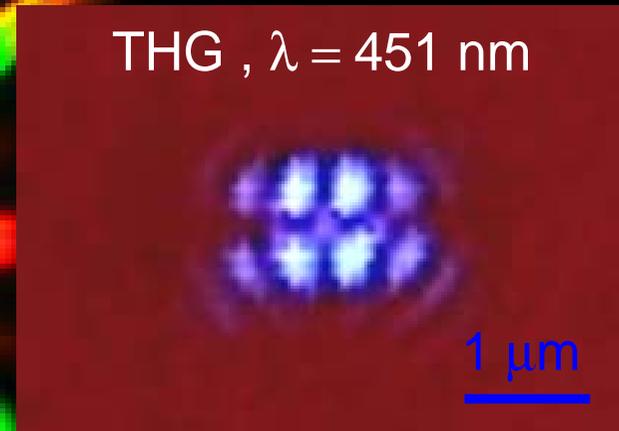
Use a photonic crystal (PhC) cavity to strongly enhance nonlinear optical properties of silicon



THG , $\lambda = 525$ nm

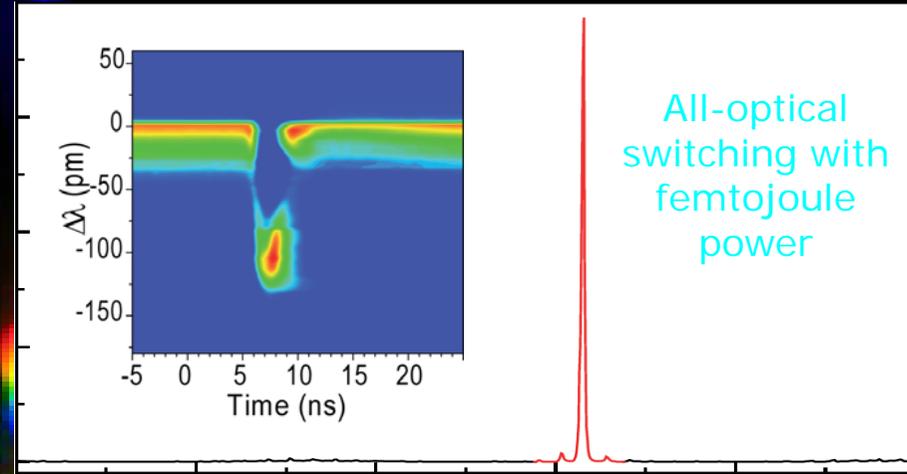
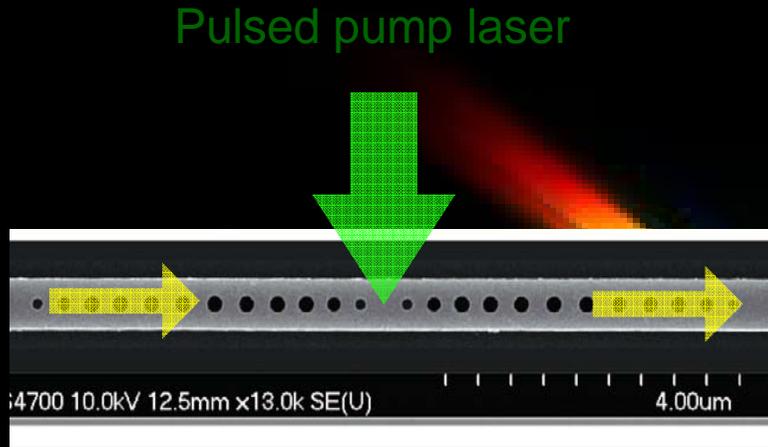


THG , $\lambda = 451$ nm



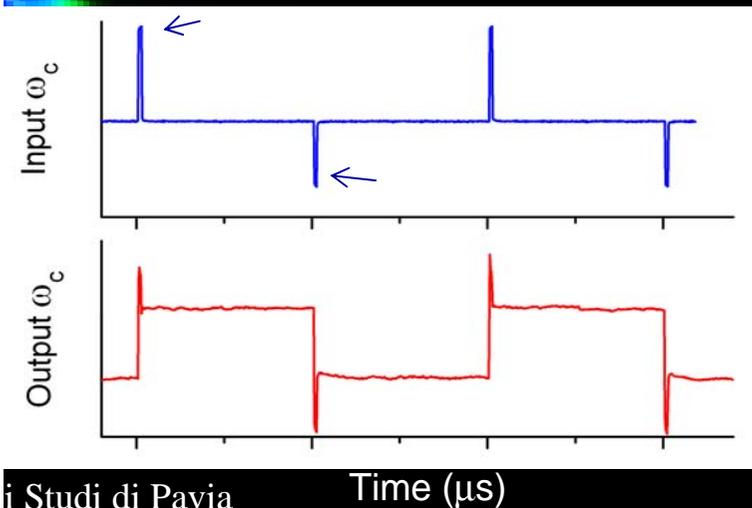
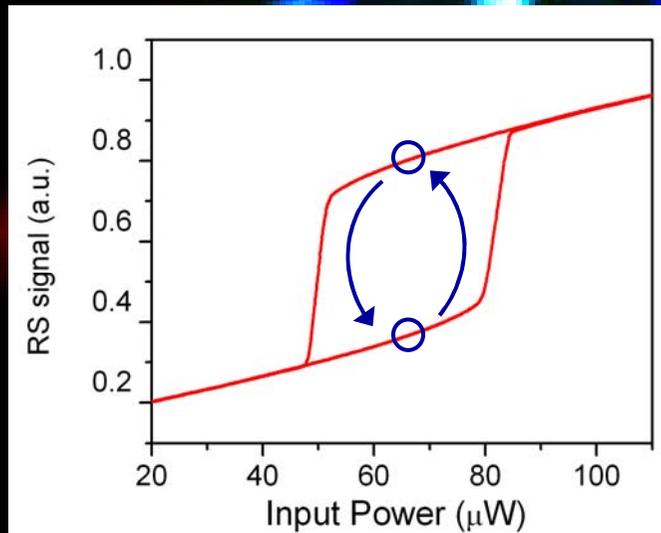
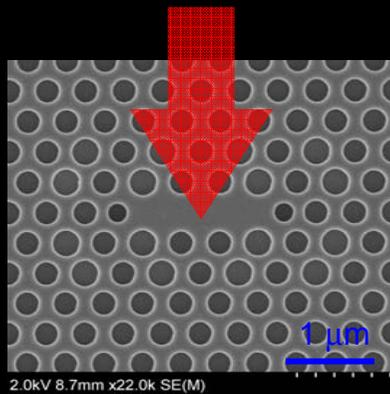
- Very efficient second- and third-harmonic generation at ultra-low pump power (μW) in continuous-wave regime
- Realization of a bright, visible and microscopic light source in silicon

All-optical switching (transistor) in Si PhC nanocavities



All-optical RAM in Si PhC nanocavities

IR control beam

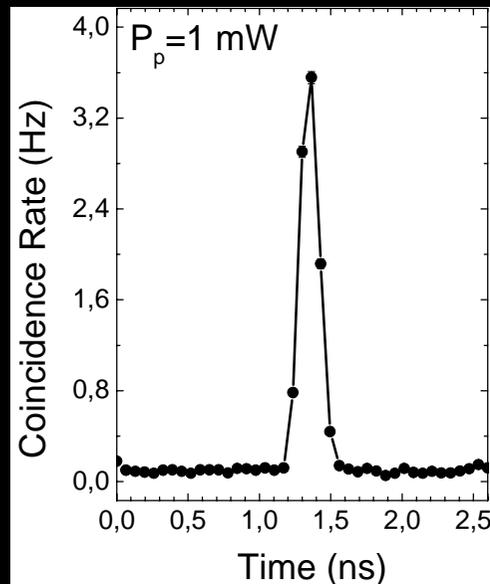
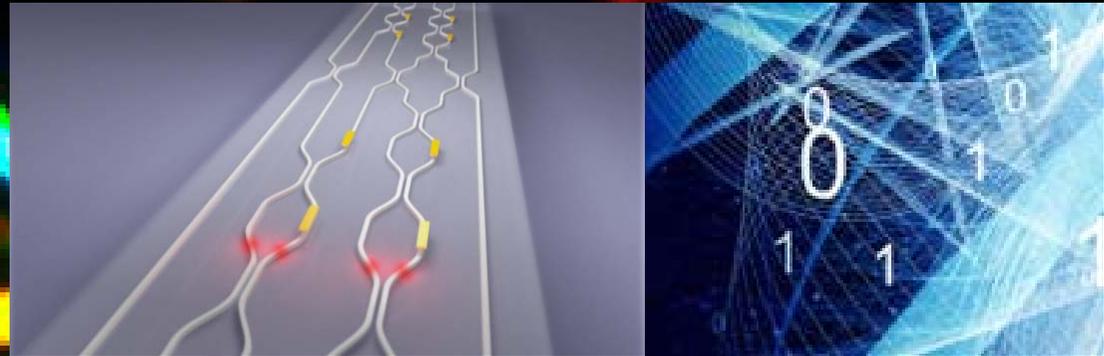


Experimental activity on quantum photonics

Goal: realization of silicon nano- and micro-devices for the emission of quantum states of light.

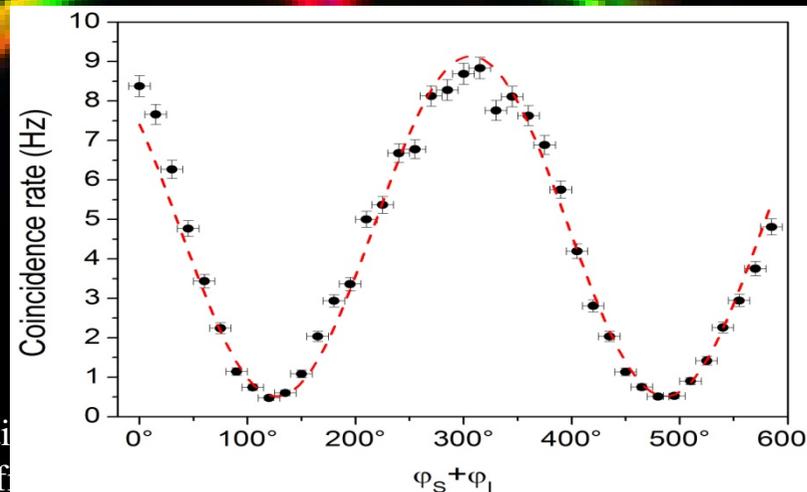
Applications:

- quantum cryptography
- on-chip quantum computing



Recent results:

- Emission of correlated photons from silicon ring resonators
- Entangled photon pairs from a silicon microdevice



Violation of Bell inequality by 10 standard deviations

Experimental activity on quantum photonics

Available instrumentation:

- Superconducting single photon counters
- Several tunable IR laser sources (CW and ps-pulsed)
- Time correlator with ps resolution
- Ultrastable interferometers with nm resolution developed at our lab



Next goals

- Emission of heralded single photons from silicon devices, for long distance quantum communications over fiber networks
- Development of a source of identical photons integrated on-chip to be used as q-bits in integrated quantum simulators
- Study of third order optical nonlinearities in silicon resonators to achieve high speed and high resolution quantum tomography of the emitted states

Fotovoltaico

Concentratori solari a luminescenza

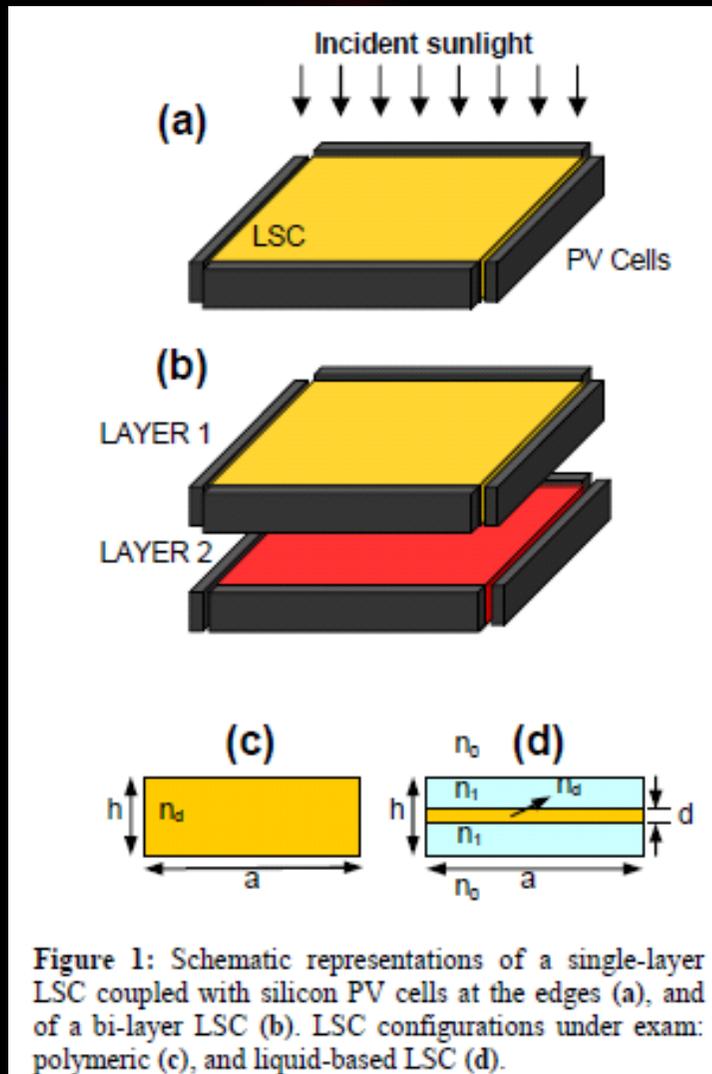


Figure 1: Schematic representations of a single-layer LSC coupled with silicon PV cells at the edges (a), and of a bi-layer LSC (b). LSC configurations under exam: polymeric (c), and liquid-based LSC (d).

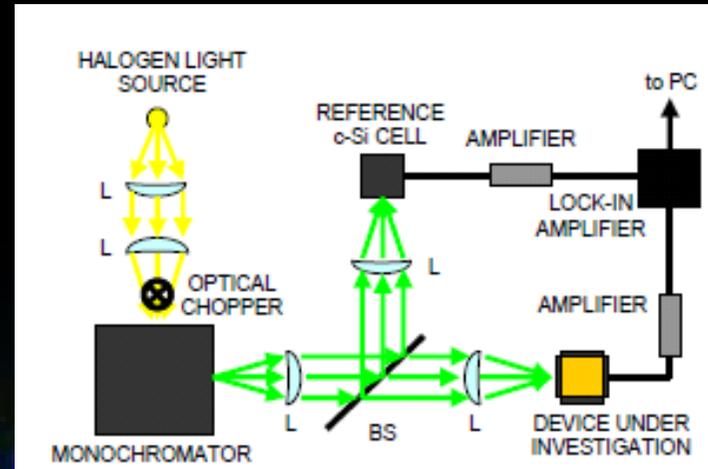
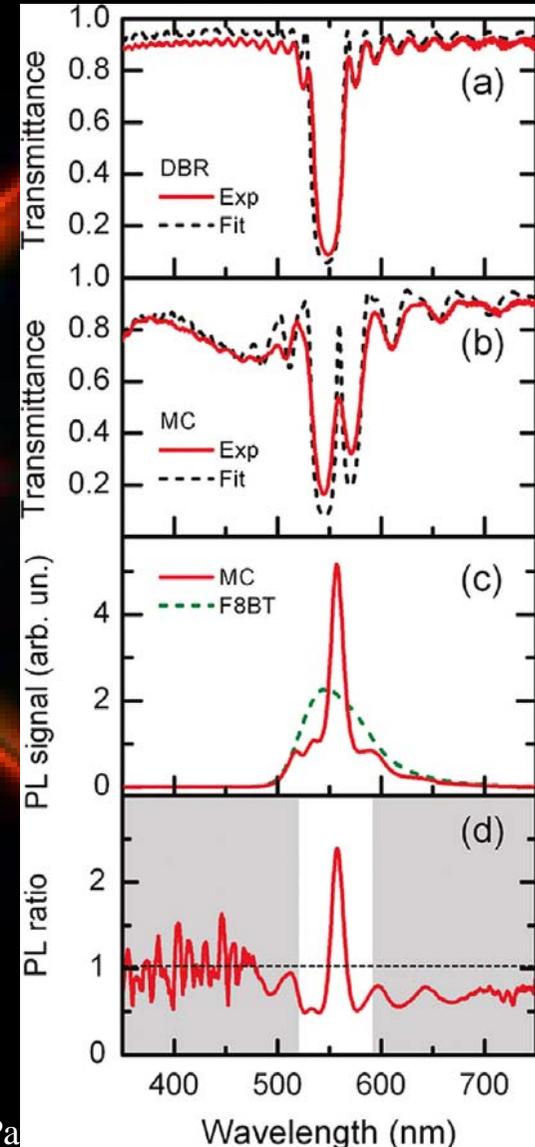
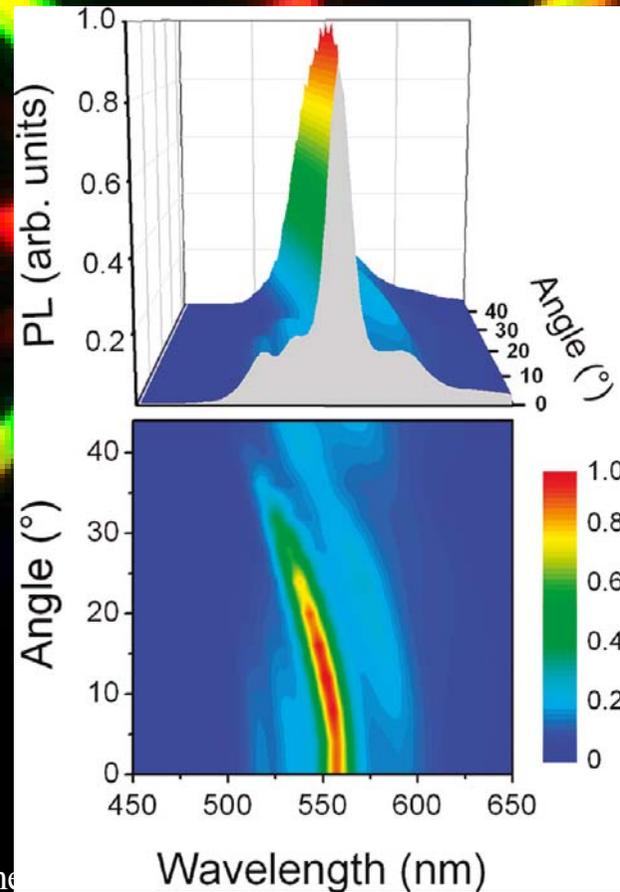
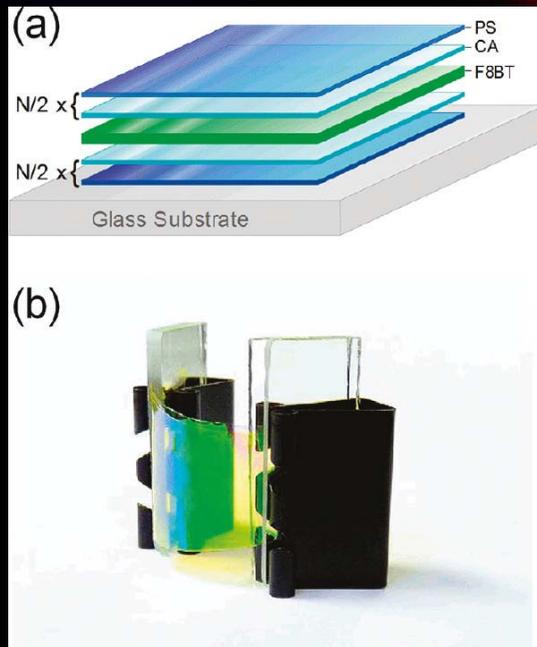


Figure 3: Scheme of the experimental setup used for external quantum efficiency measurement.



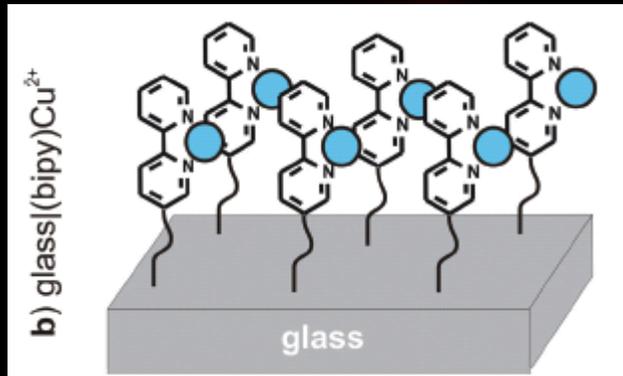
Flexible polymer microcavities and Bragg structures

Fotonica in plastica

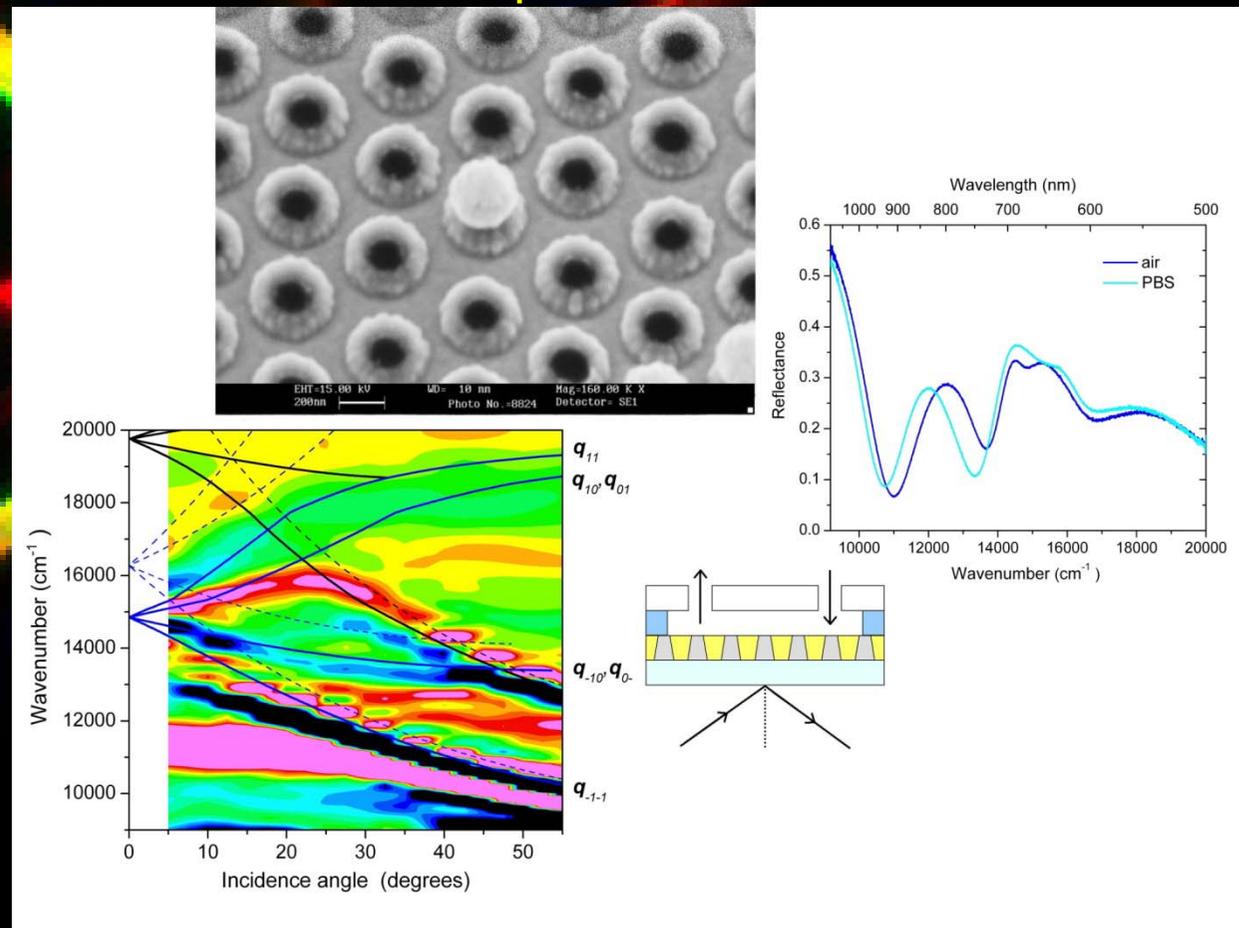
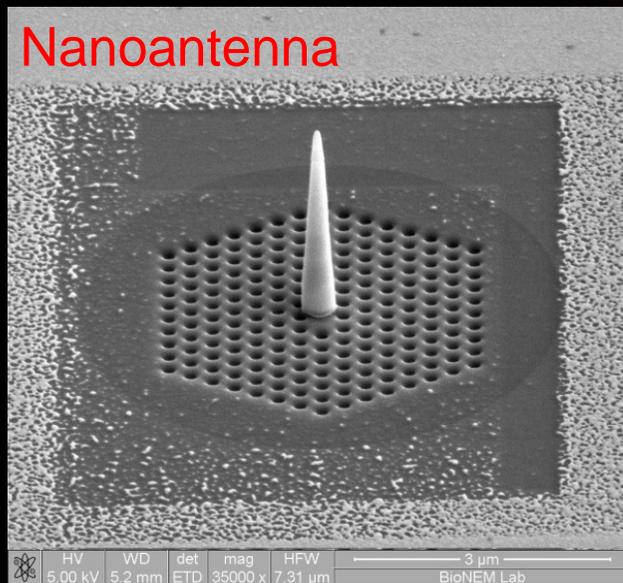


Nanostrutture metalliche e Plasmonica

Antimicrobial surfaces



Surface Plasmon resonance based multiparameter biosensor





Daniele Bajoni

Fotonica Quantistica

Fotonica in silicio

Fotovoltaico



Matteo Galli



Giorgio Guizzetti

Nanostrutture in carbonio



Vittorio Bellani



Maddalena Patrini

Plasmonica

Applicazioni bio

Sistemi organici e polimerici



Franco Marabelli