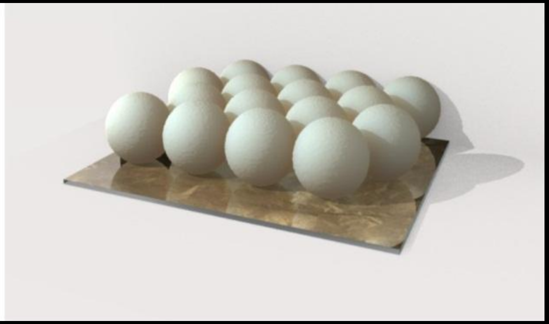
Antonio García-Martín

Instituto de Microelectrónica de Madrid



J. Galisteo-López, M. López-García, A. Blanco, C. López

Instituto de Ciencia de Materiales de Madrid

Consejo Superior de Investigaciones Científicas

Hybrid photonic-plasmonic crystals based on self-assembled structures

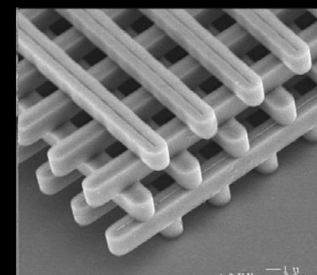
http://www.imm-cnm.csic.es/magnetoplasmonics http://luxrerum.org

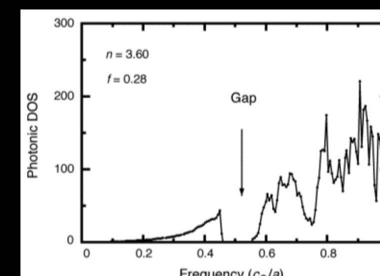
The quest for the control of light propagation (3D)

PHOTONIC CRYSTALS

E. Yablonovitch PRL (1987)
S. John PRL (1987)

Periodic structures
λ~period

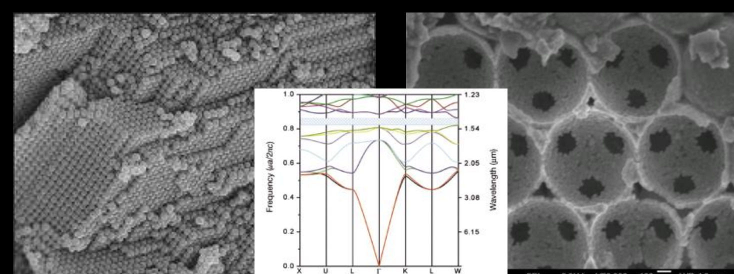




S.Y. Lin et al, Nature (1998)

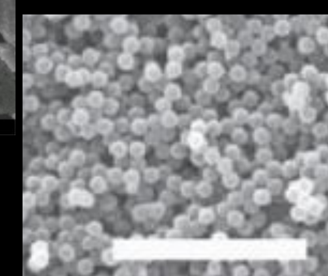
Inexpensive technique
self assembly

J. Galisteo-López et al, Adv. Mater. (2011)



A. Blanco et al, Nature (2000)

Also for random systems

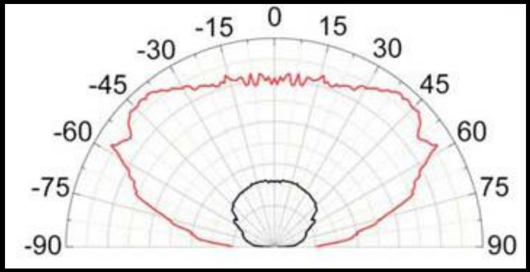


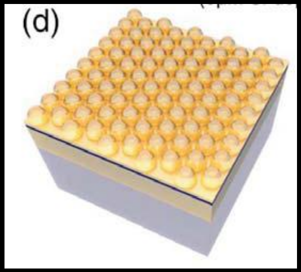
M. Reufer et al, APL (2007)
P.D. Garcia et al, Adv. Mater. (2007)

Manipulation of light

In two dimensions (2D)

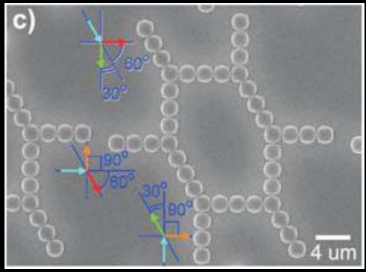
Microlens arrays

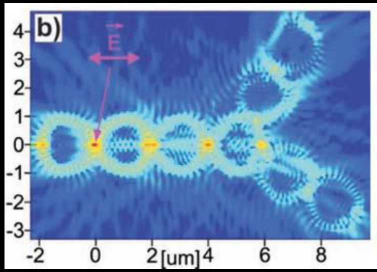




W.Y. Fu et al, APL (2009)

Coupled resonator WGs

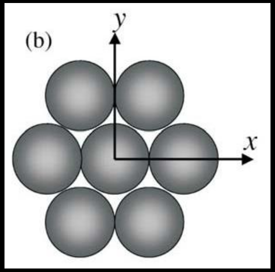


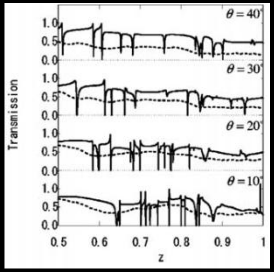


T. Mitsui et al, Adv. Mater. (2010)

2D Photonic Crystals

periodicity based on natural tendency
cost effective approach
large areas



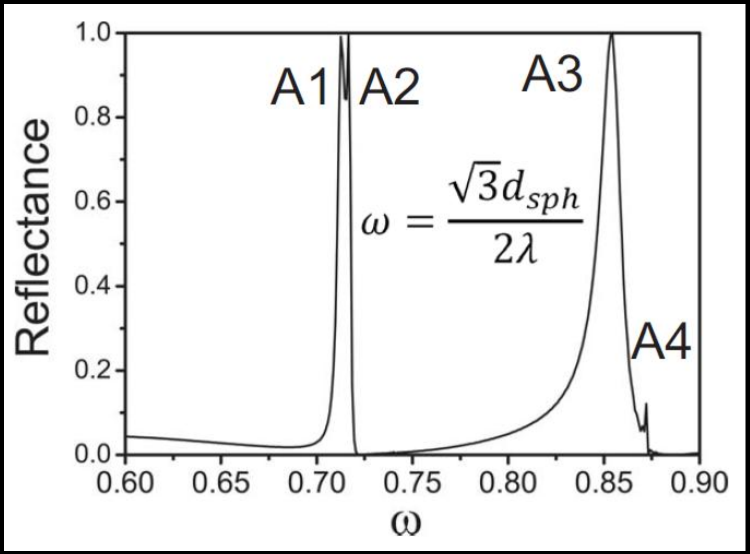


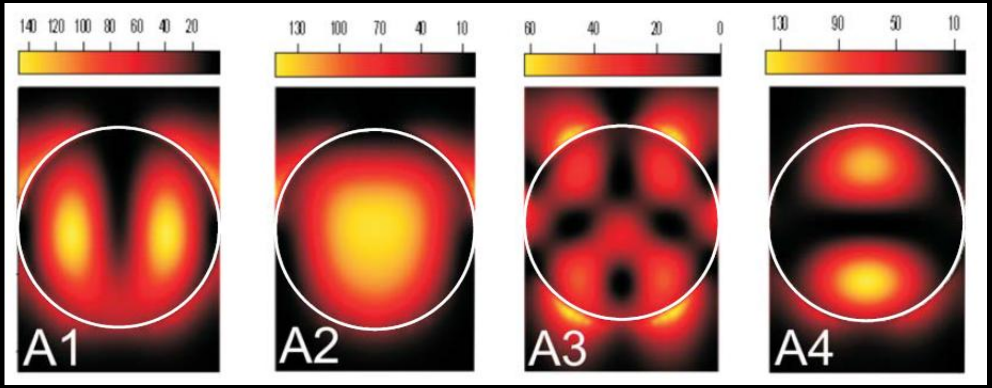
Y. Kurokawa et. al, PRB (2004)

3D light confinement in 2D slab PhC

Applications demanding strong light-matter interaction

In-plane: Bragg diffraction
Vertical: total internal reflection
Ideal scenario: **free-standing**



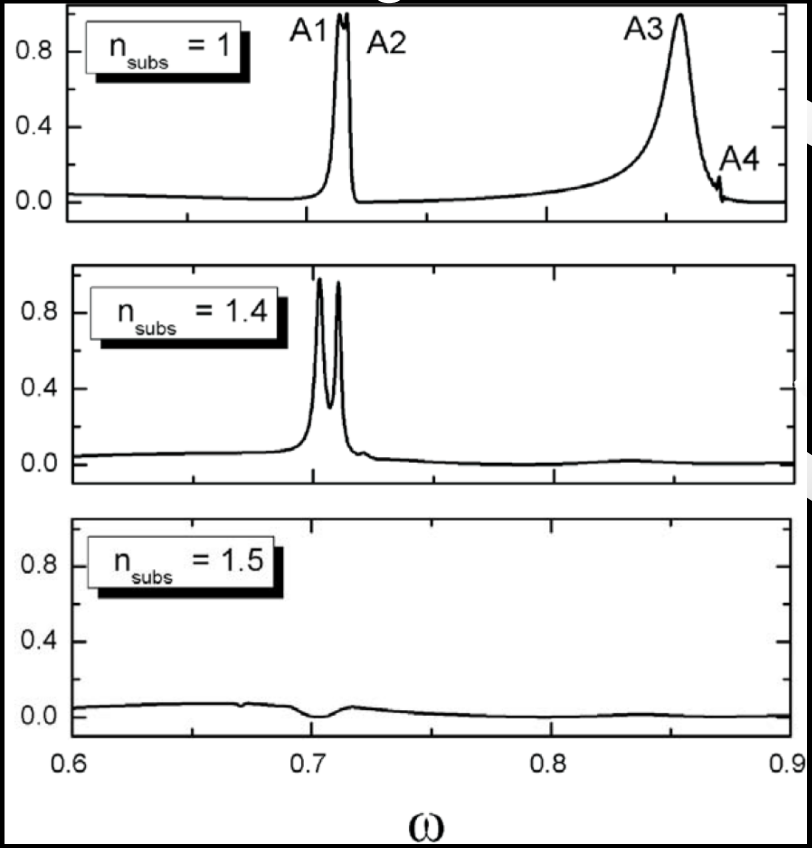


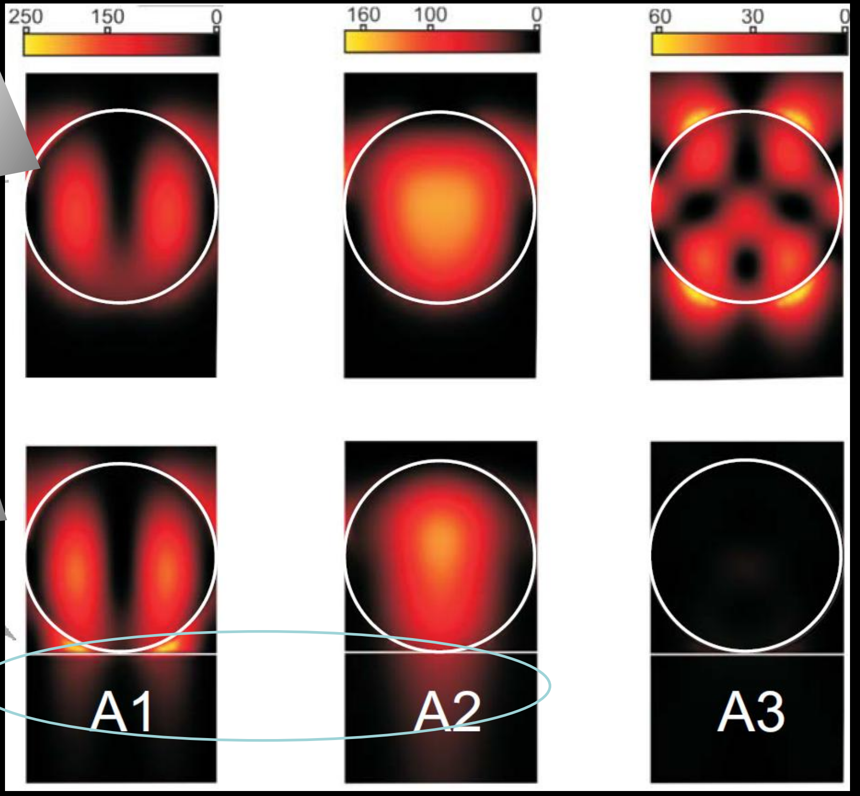
Realistic case

Spheres over a substrate (dielectric)

Pro: Easy to grow and manipulate

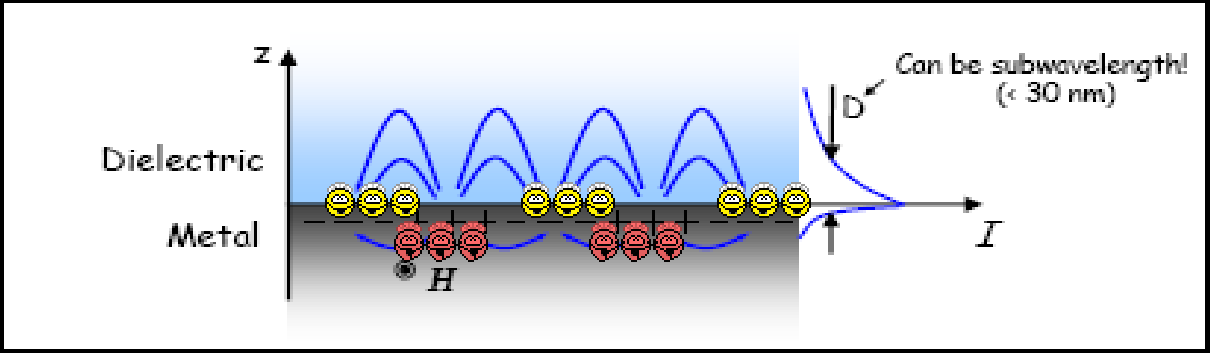
Against: leakage





Plasmonics?

Plasmons: electromagnetic modes at metal-dielectric interfaces



Main characteristics

Localization of the EM field in subwavelength volumes

What if we combine this with self-assembly?

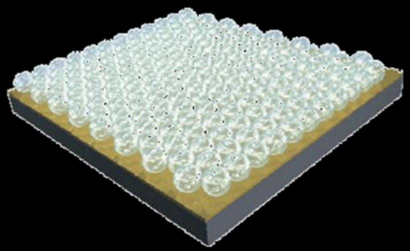
Metallodielectric systems

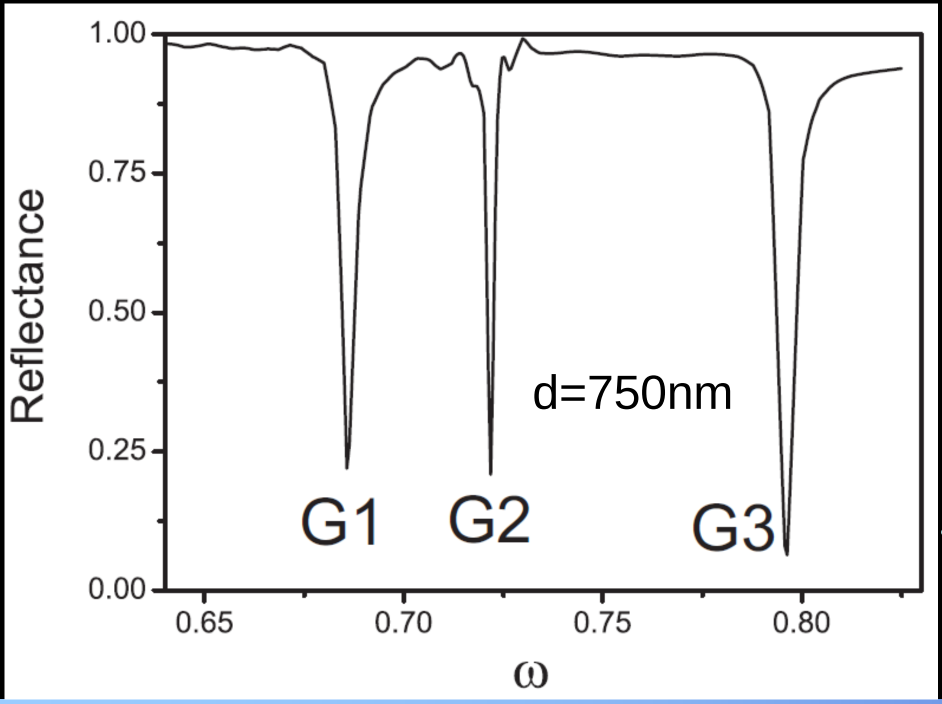
Spheres over a substrate (metallic)

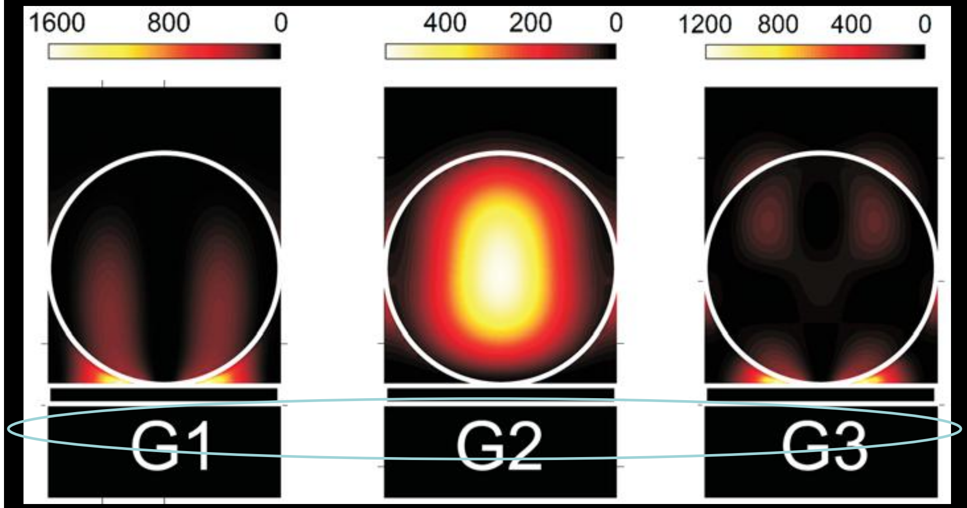
Pro: would be easy to grow and manipulate

Leakage?: Reduced !!!

Good quality factor $Q = \frac{\omega}{\Delta\omega}$







J. Galisteo-Lopez et. al, APL (2011)

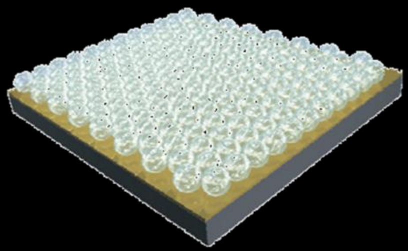
Spheres over a substrate (metallic)

Varying sphere diameter

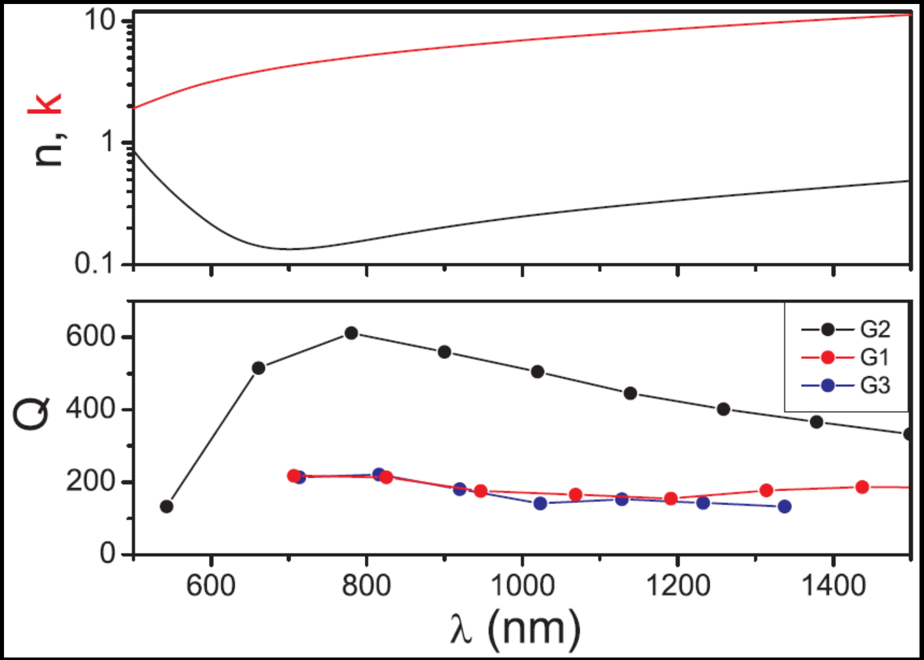
Q_{WG}: governed by n

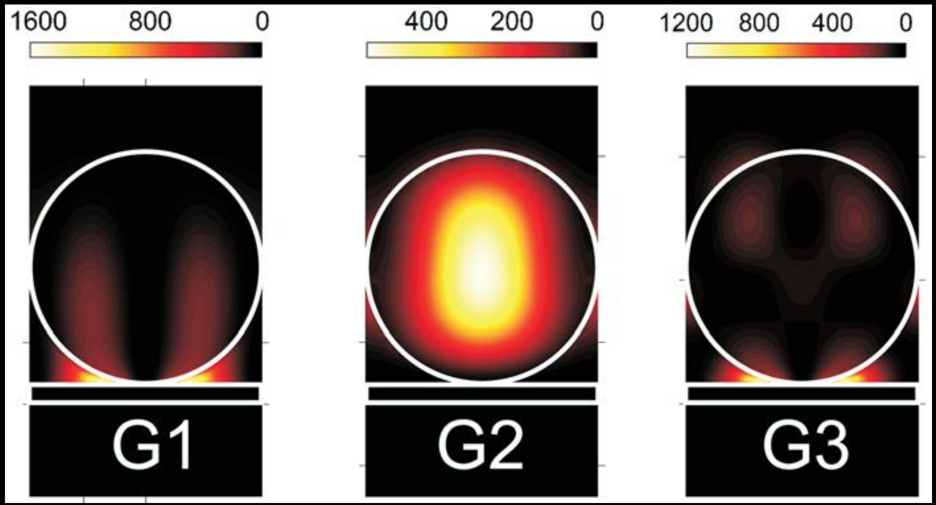
Q_{SPP}: governed by k

$$Q = \frac{\omega}{\Delta\omega}$$



Can we actually do it?

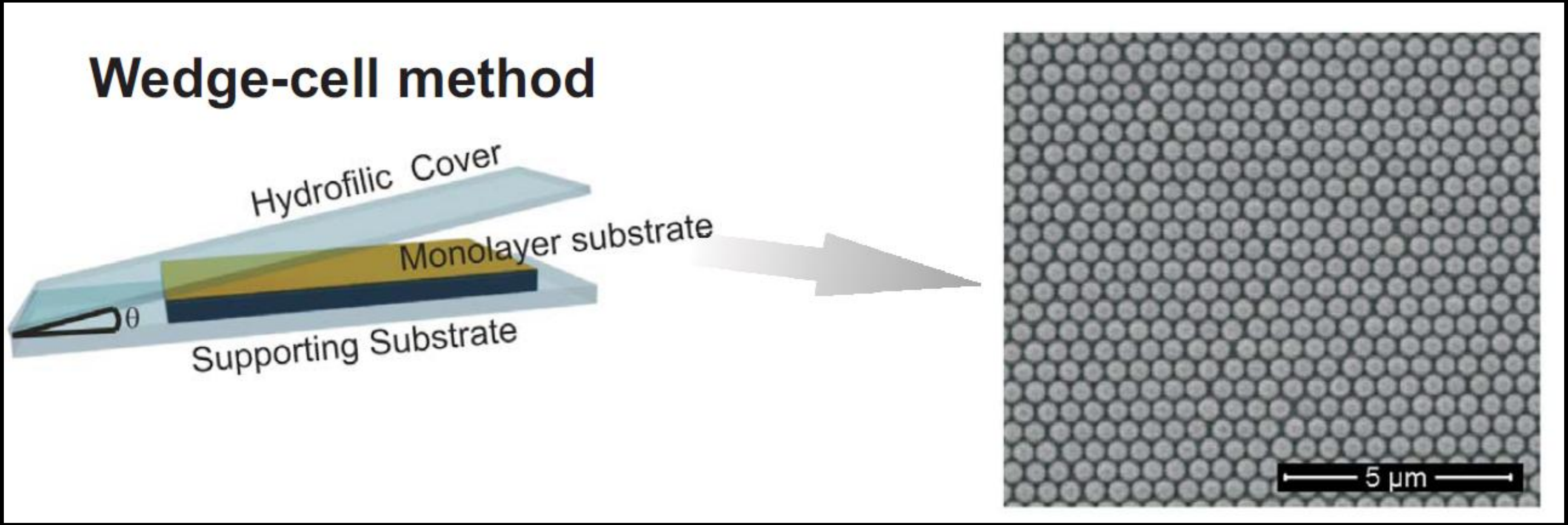




J. Galisteo-Lopez et. al, APL (2011)

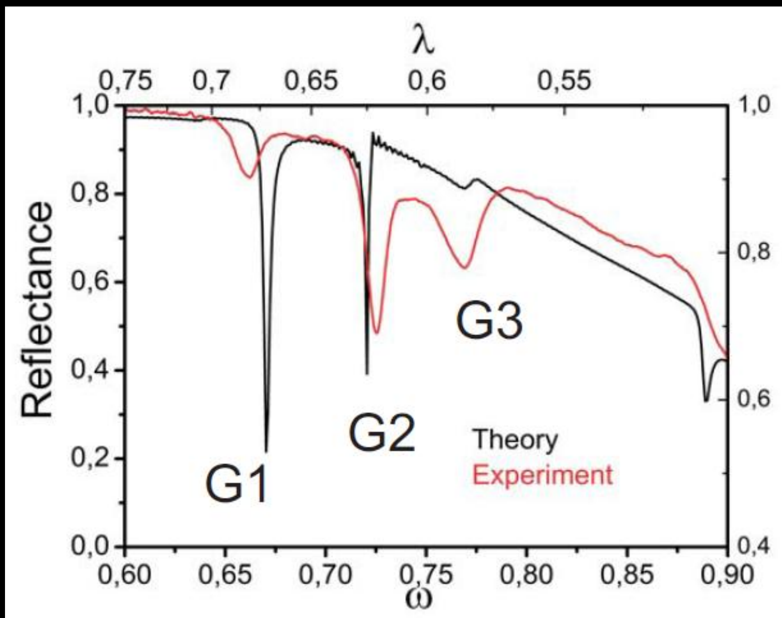
Fabrication

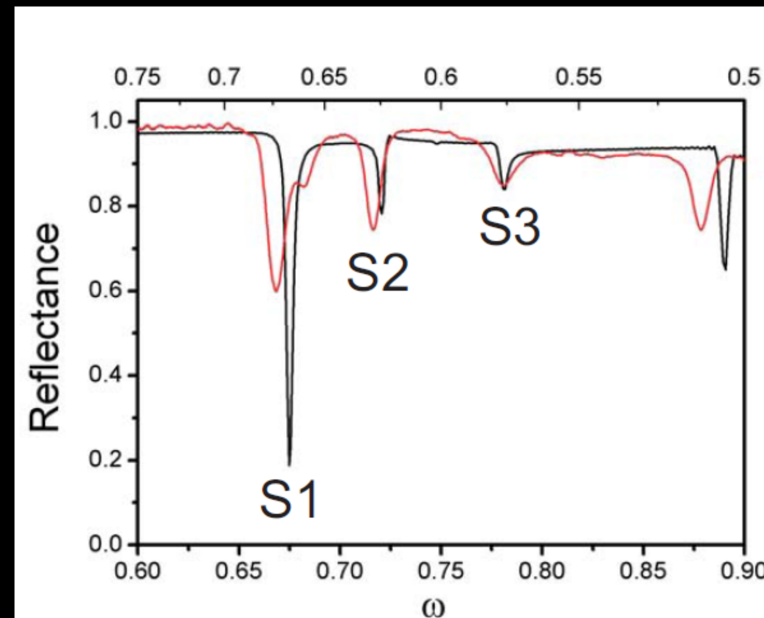
Organic (polystyrene) spheres: doped with Rh6G
Metallic substrates: gold, silver
Dielectric substrates: silicon, glass



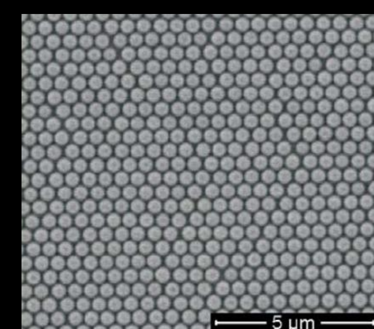
J. Galisteo-Lopez et. al, Adv. Mater. (2011)

Optical response: Reflection at normal incidence





Gold d=470nm **Silver**

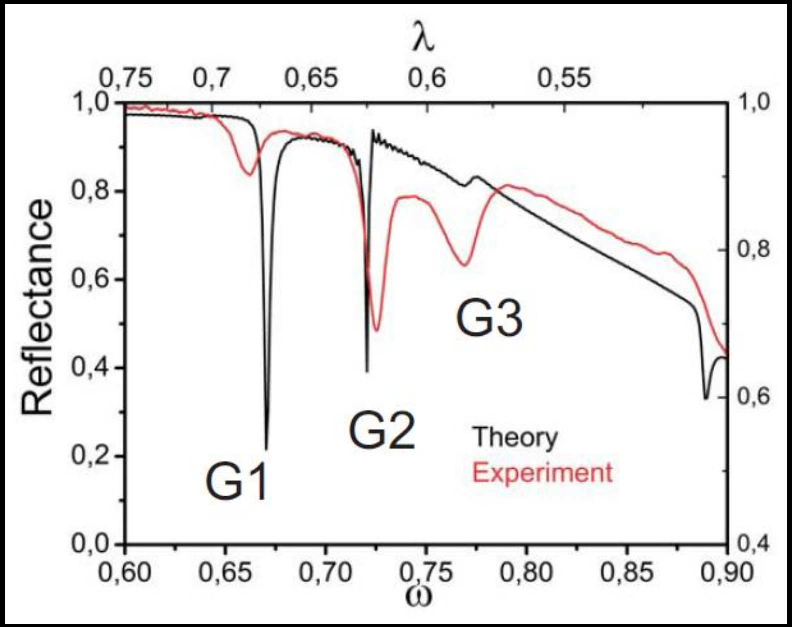


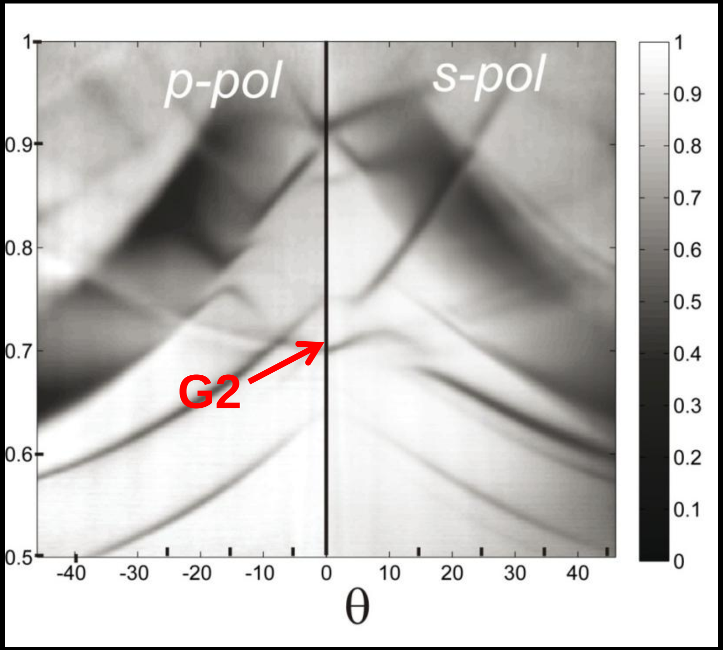
Good agreement with theory, but reduced Q due to structural imperfections

M. Lopez-Garcia et. al, Small (2010)

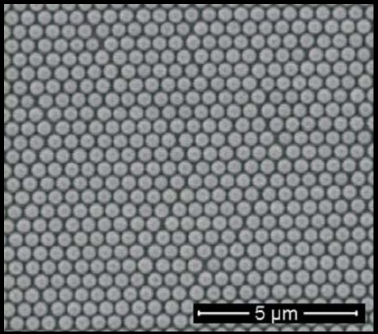
Metallodielectric systems

Dispersion relation





Gold

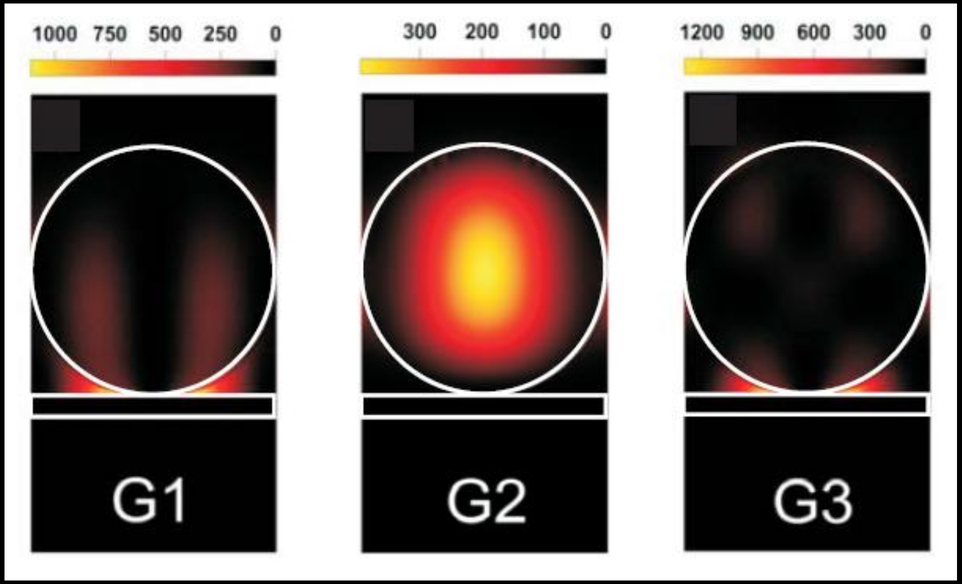


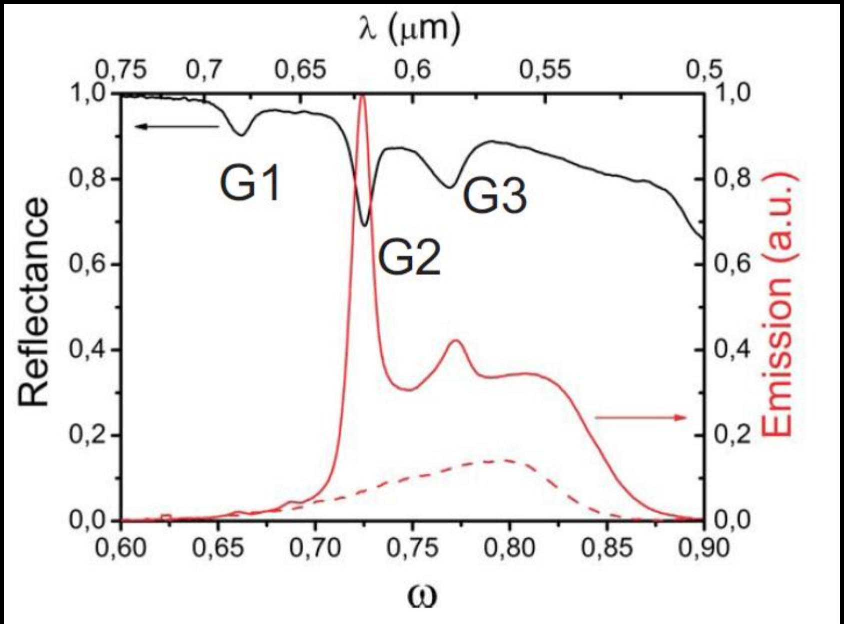
Good agreement with theory, but reduced Q due to structural imperfections

M. Lopez-Garcia et. al, Small (2010)

Metallodielectric systems

Emission at normal direction



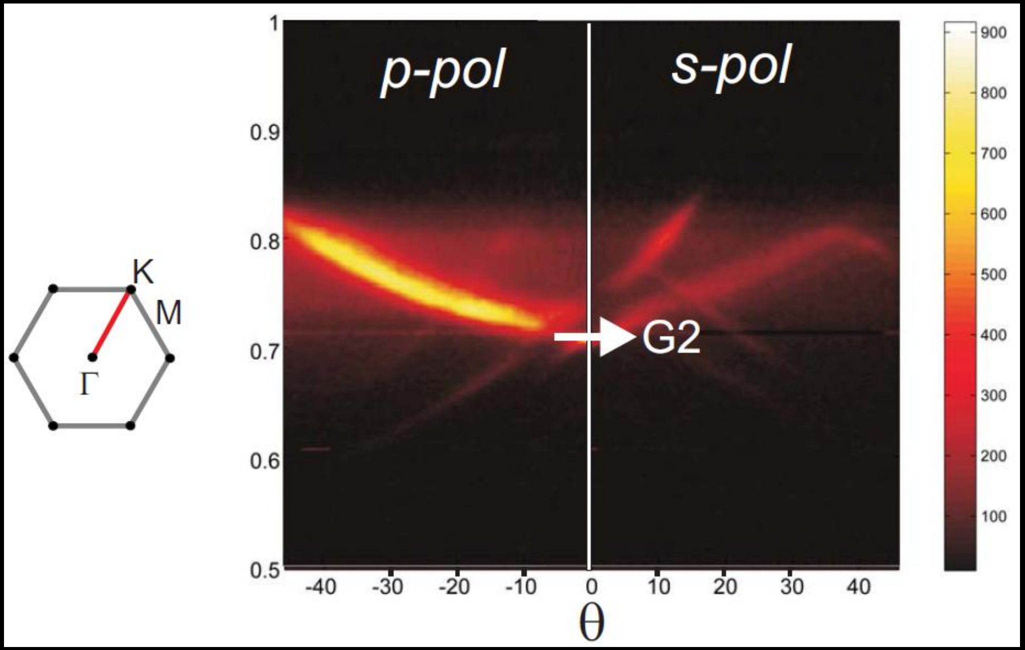


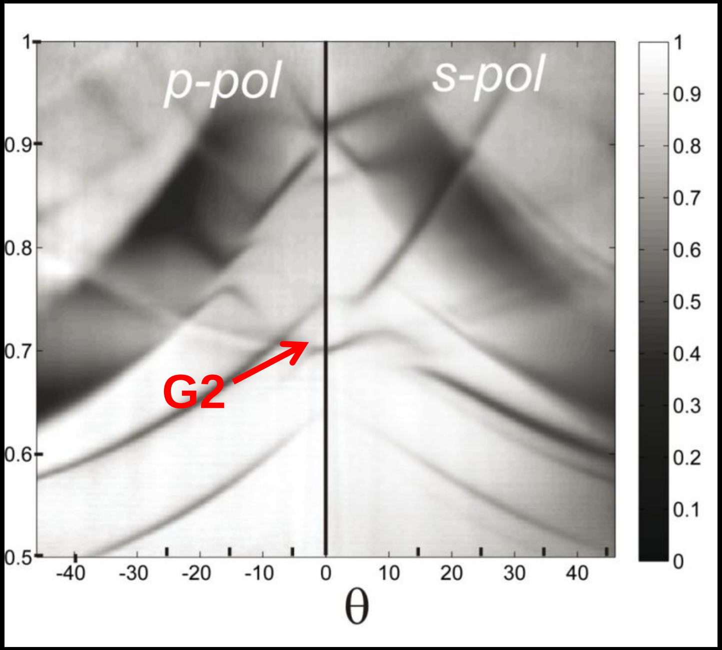
overall enhancement of spontaneous emission
20x enhancement at WG-modes

M. Lopez-Garcia et. al, Small (2010)

Metallodielectric systems

Angle and polarization resolved emission



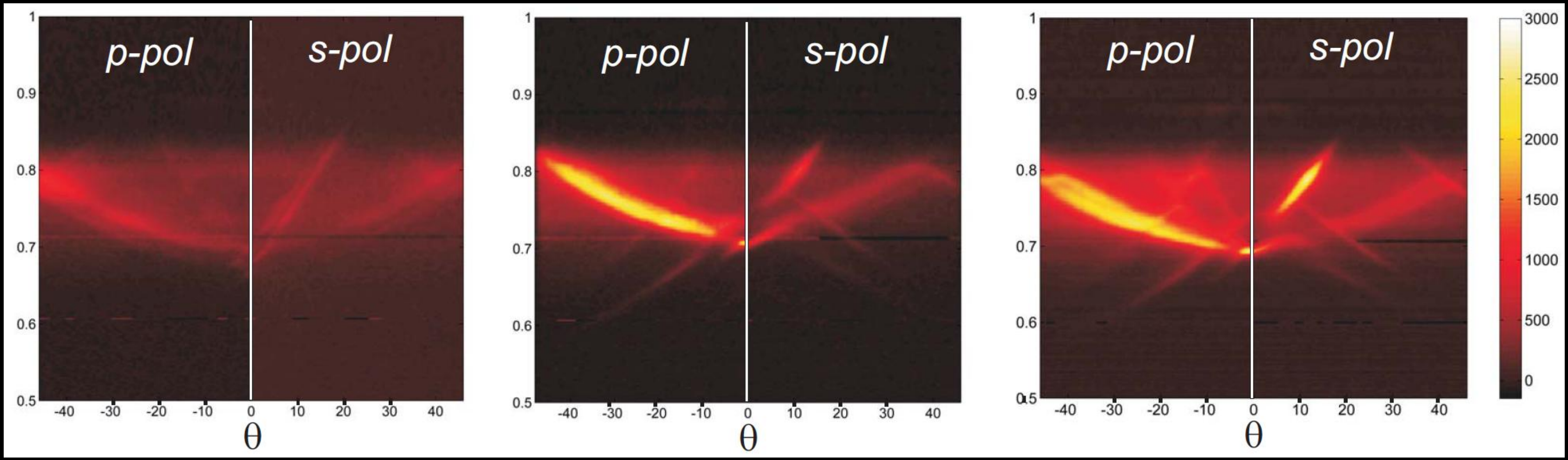


Emission channeled by certain modes
Enhancement is directional and polarized

M. Lopez-Garcia et. al, Small (2010)

Angle and polarization resolved emission

Si Au Ag

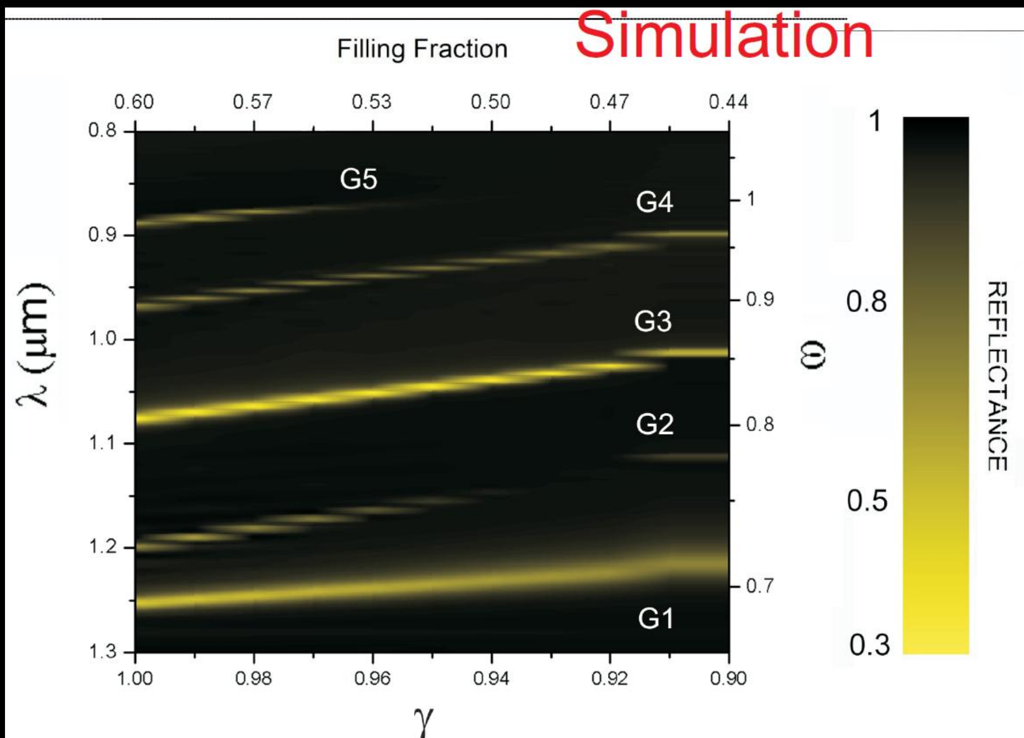


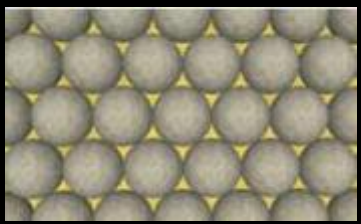
Emission channeled by certain modes
Enhancement is directional and polarized

M. Lopez-Garcia et. al, Small (2010)

Metallodielectric systems

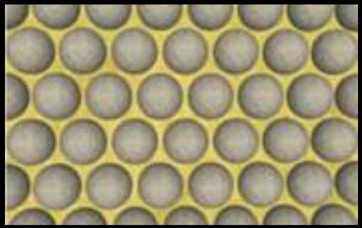
Tunability





Plasma etching

O_2

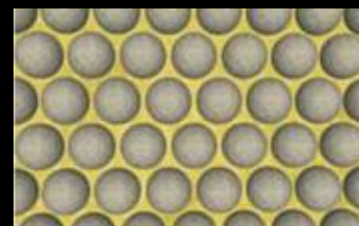


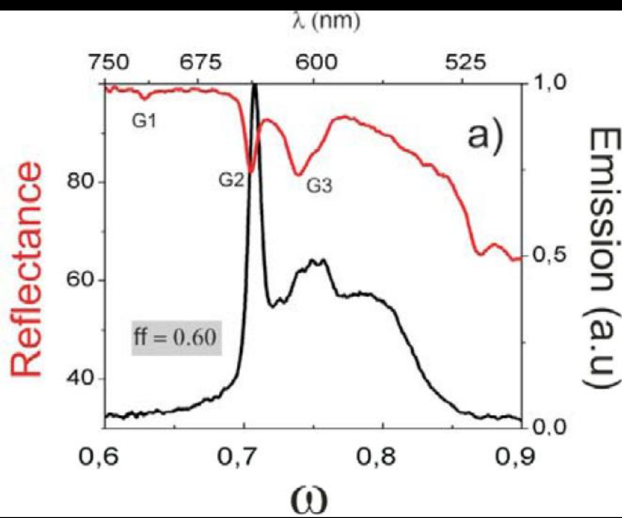
Wavelength depends on sphere radius

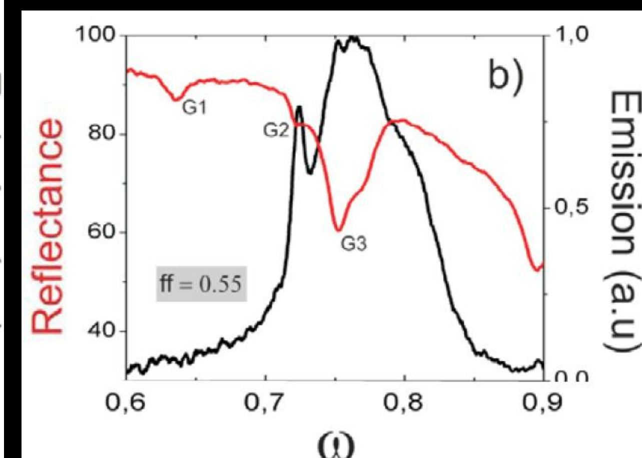
M. Lopez-Garcia et. al, Adv. Fun. Mater. (2010)

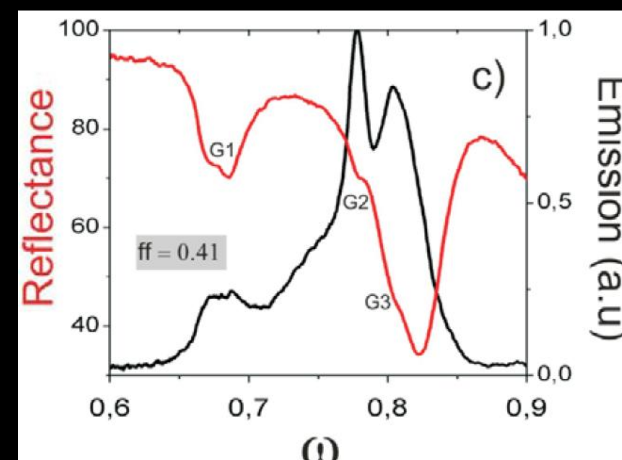
Metallodielectric systems

Tunability





Wavelength choosing by sphere ratio

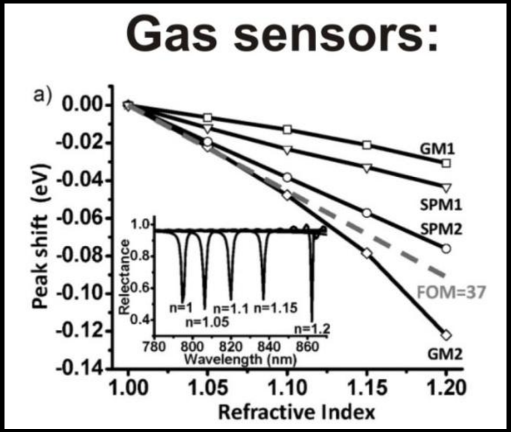
M. Lopez-Garcia et. al, Adv. Fun. Mater. (2010)

Summary

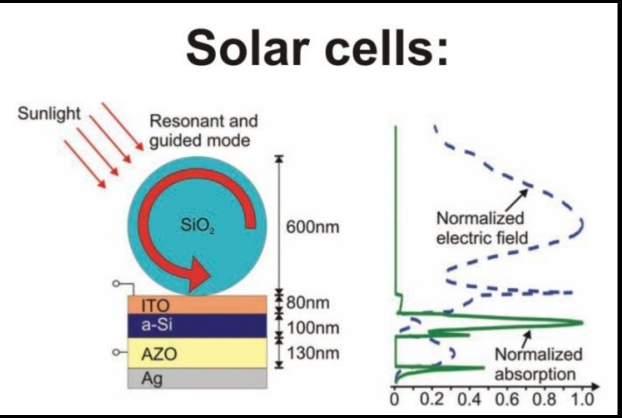
Hybrid self-assembled metallodielectric systems

Cost effective approach
Strongly modified field intensity distribution
Enhanced light matter interaction
Wavelength choosing by sphere ratio

Applications



Yu et al, Adv. Mater. (2011)



Grandidier et al, Adv. Mater. (2011)