Nanoparticle Based 1D Photonic Crystals

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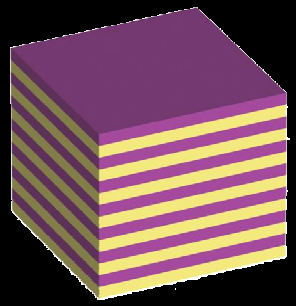
Photonic Crystals Introduction

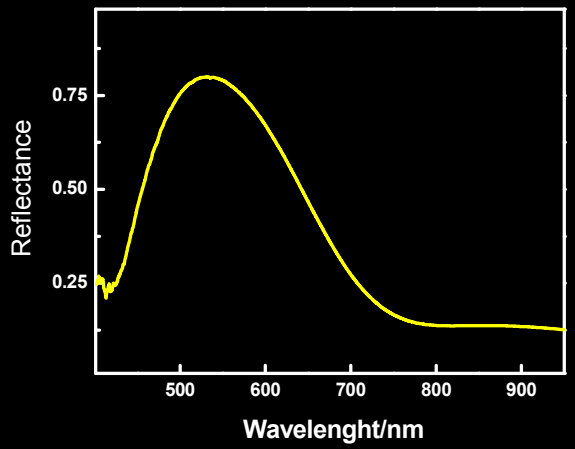
Periodical modulation of the Refractive Index (RI)

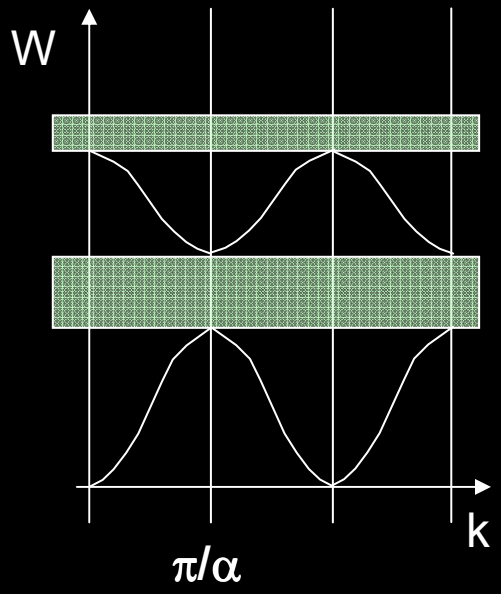
Formed by periodic arrangements of "building blocks"

Propagation of photons is affected



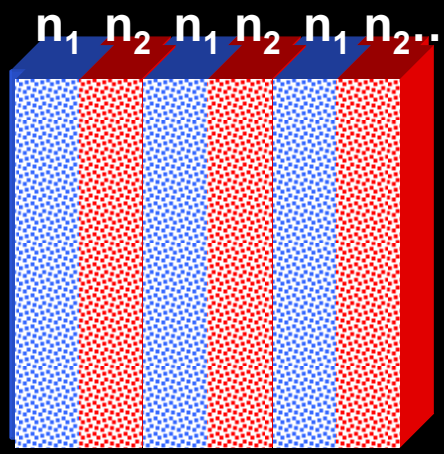
1D





E. Yablonovitch. *Phys. Rev. Lett.* 1987, **58**, 2059 and S. John. *Phys. Rev. Lett.* 1987, **58**, 2486

One Dimensional Photonic Crystals (1D PC)



Thickness

Refractive Index Contrast

Porosity → Optical Chemical Sensing

Photoconducting Bragg Mirrors

SiO_2/TiO_2 PC

Building up

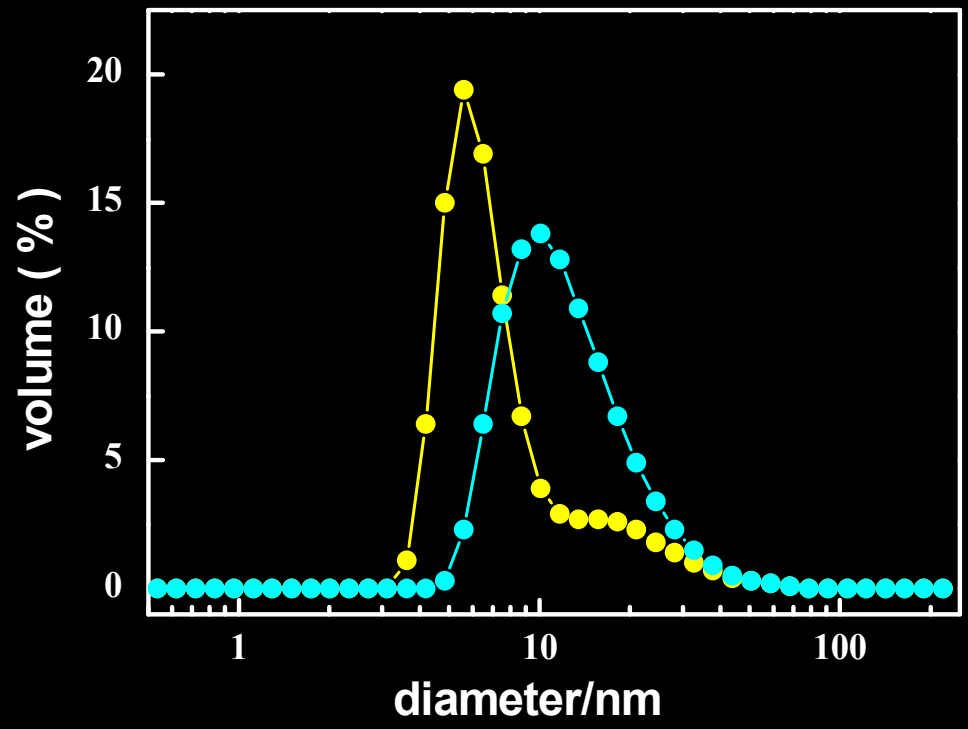
Sol Gel Chemistry

TiO_2 nanoparticulated sol

low [TMAOH], 250º

SiO_2 nanoparticulated sol

commercial Ludox® particles



Spin-Coating Deposition → **Spin-Coating Deposition** → **Thermal Treatment**

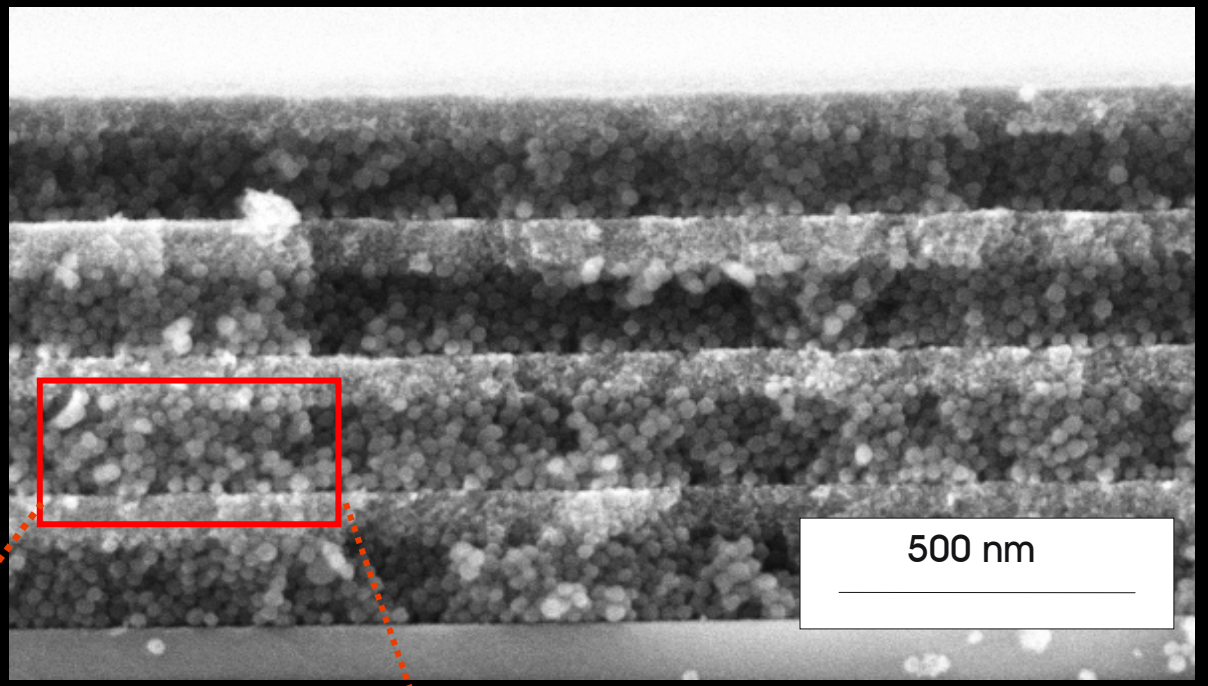
Layer 1

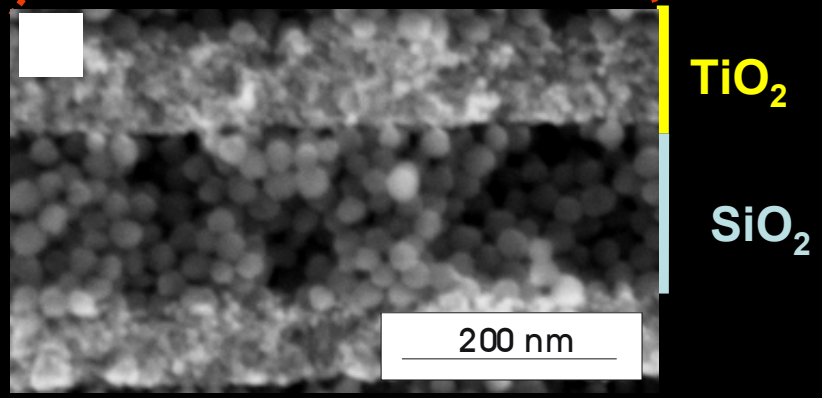
Layer 2

450ºC, 1800s

SiO_2/TiO_2 PC

Microstructure



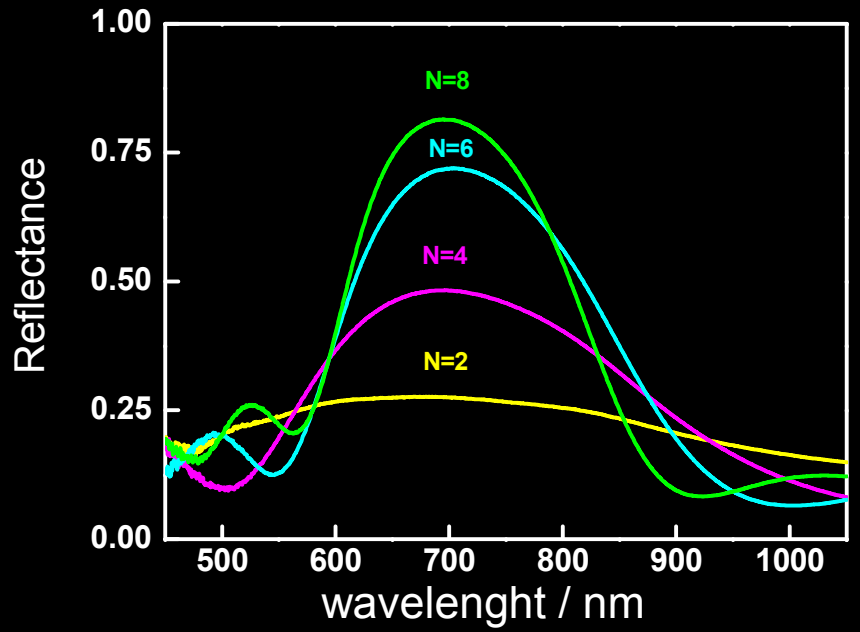


TiO_2

SiO_2

SiO_2/TiO_2 PC

Optical Properties

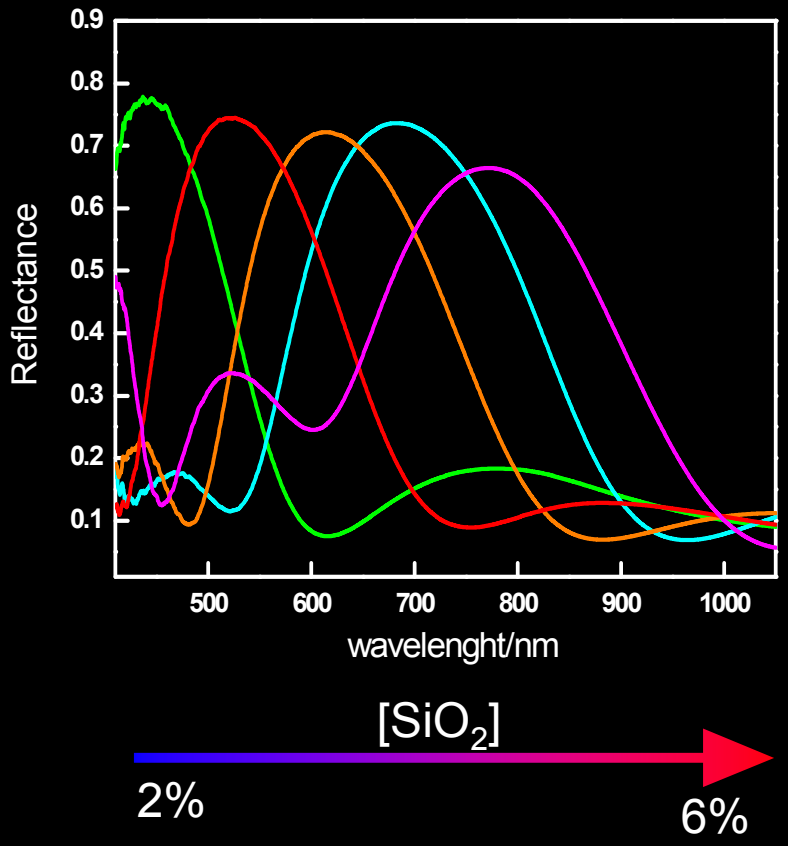


n_{TiO2}= 1.74 (2.44)

n_{SiO2}= 1.24 (1.51)

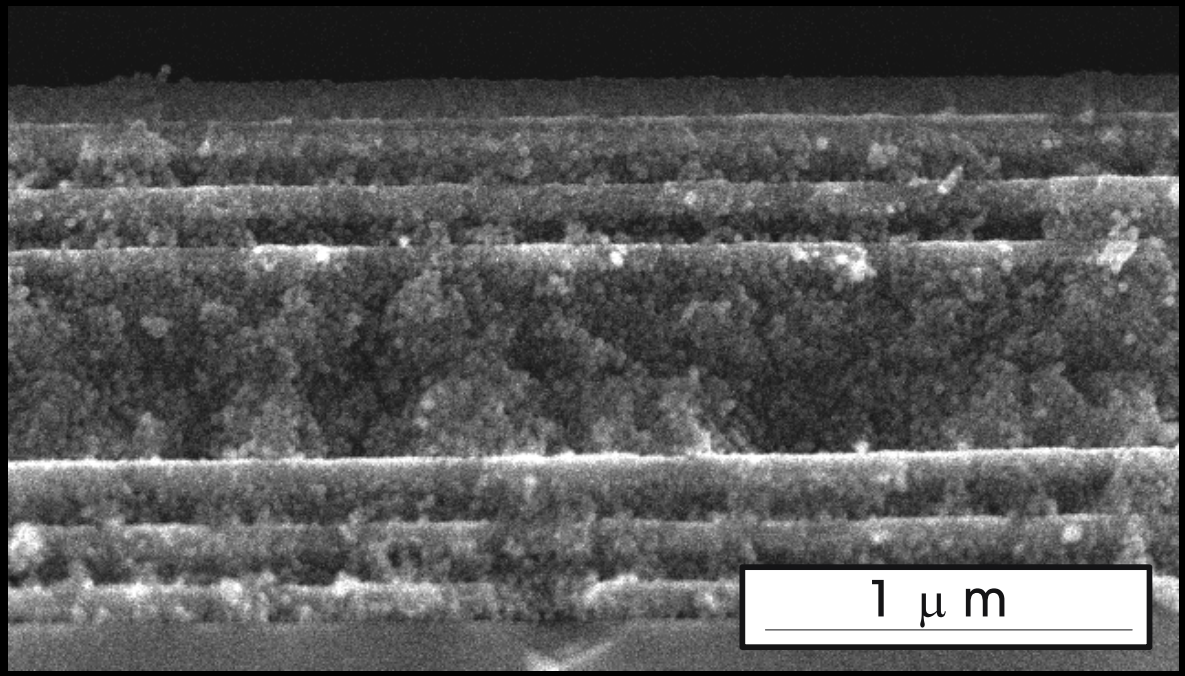
46% porosity

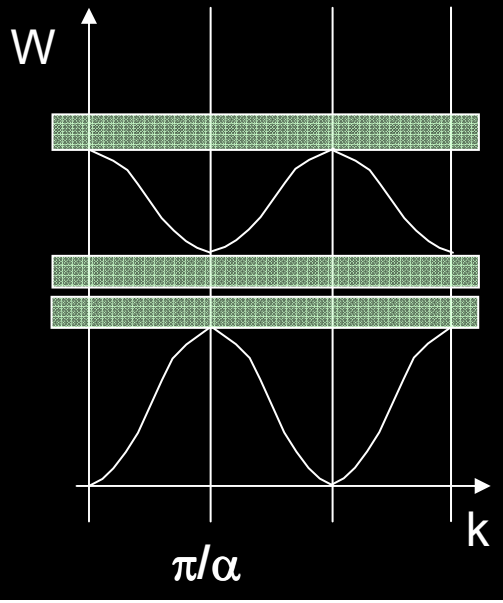
SiO_2 concentration increase

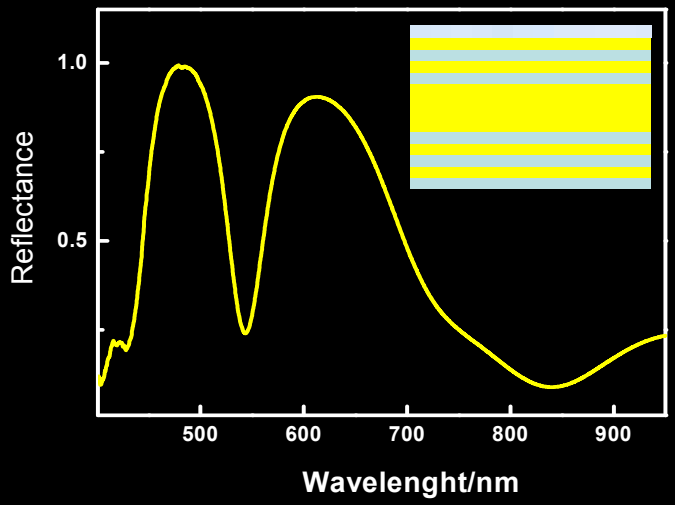


SiO_2/TiO_2 PC

Creating a Defect



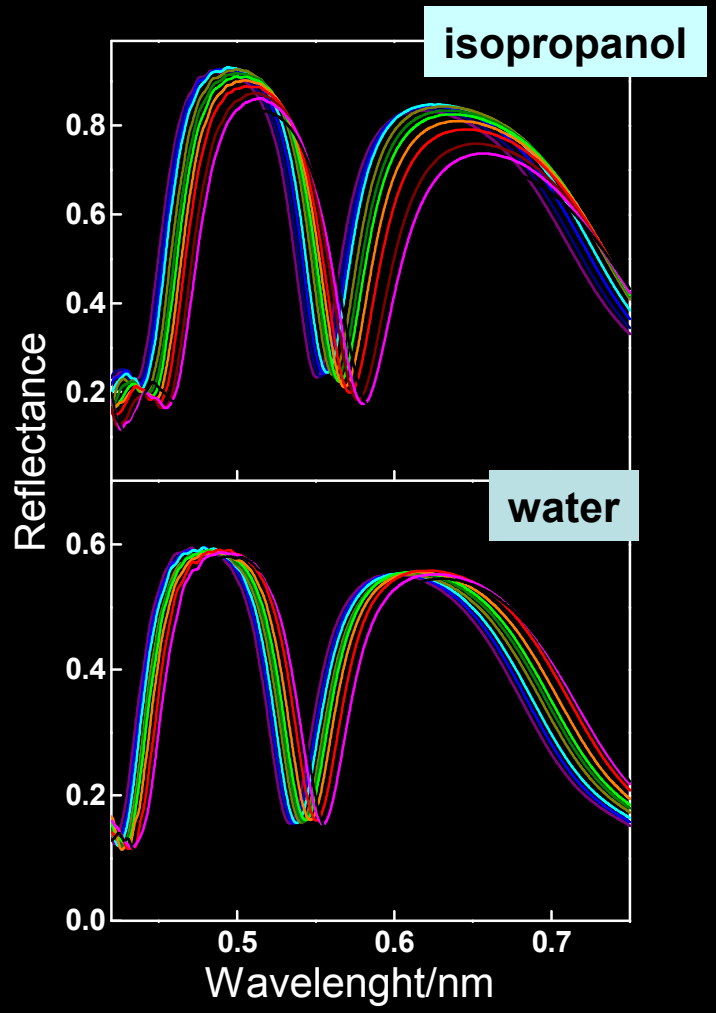


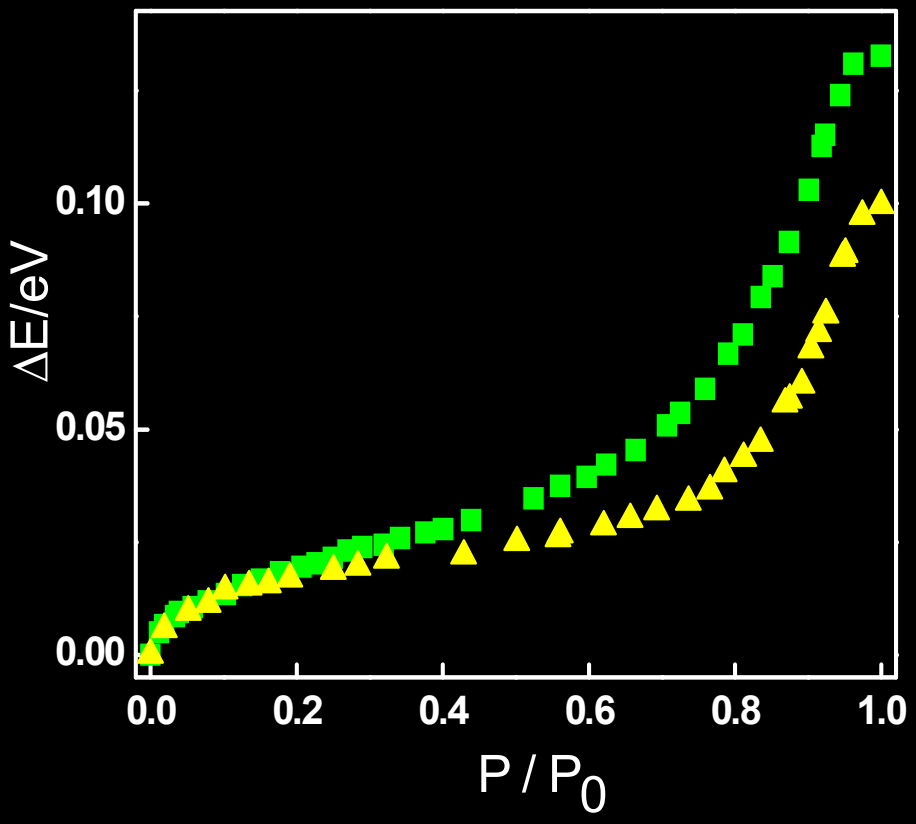


SiO_2/TiO_2 PC

Optical Chemical Sensing

Response against vapor pressure





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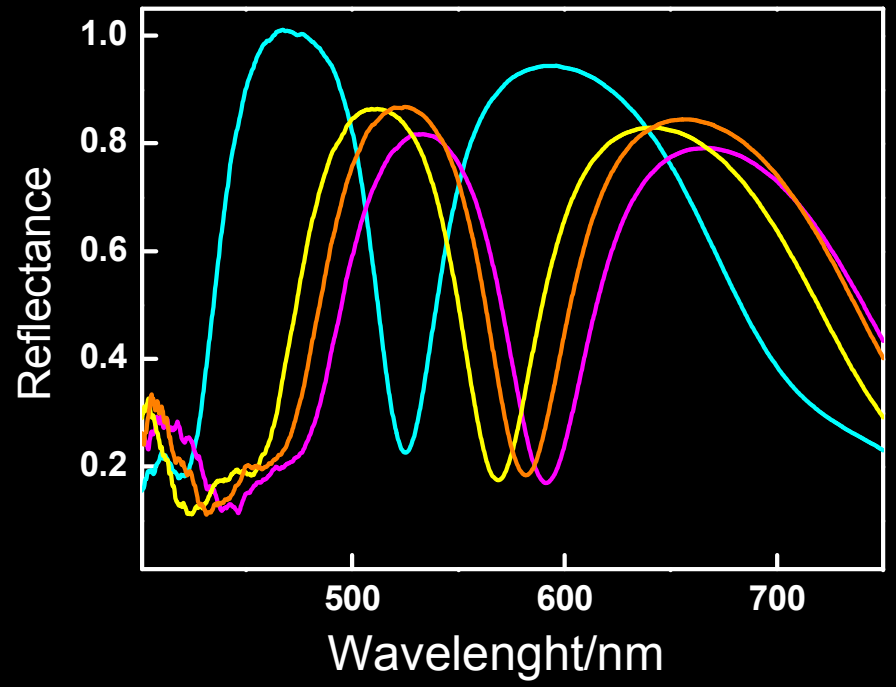
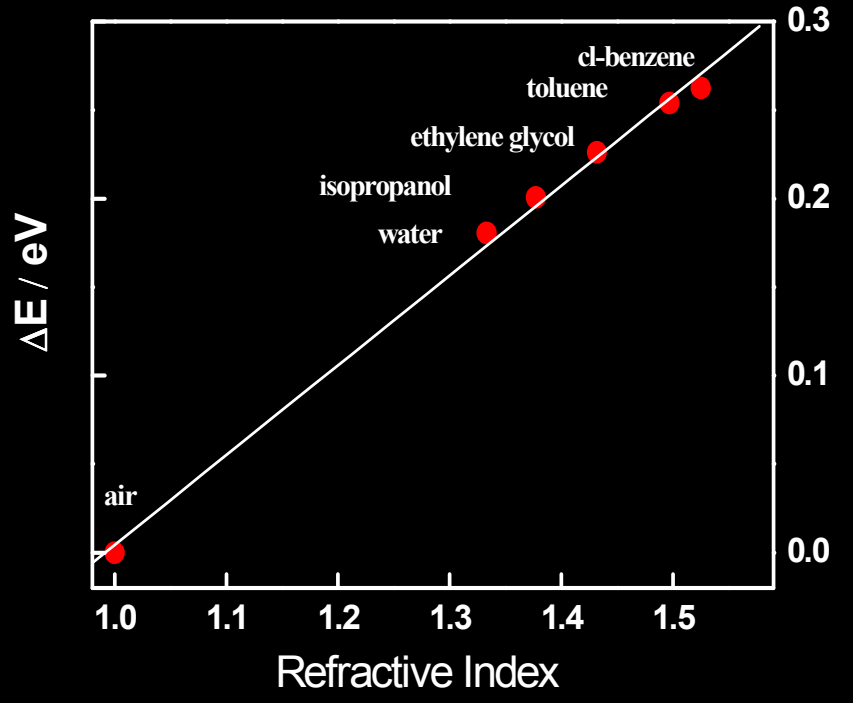
SiO_2/TiO_2 PC

Optical Chemical Sensing

Response against different liquids





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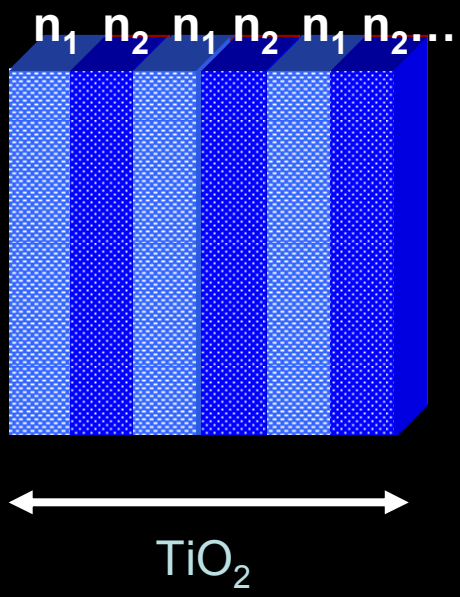
Photoconducting Bragg Mirrors



Thickness

Refractive Index Contrast

Porosity

TiO_2/TiO_2 PC

Building Up

Same Material

↓

Different Aggregation States

↓

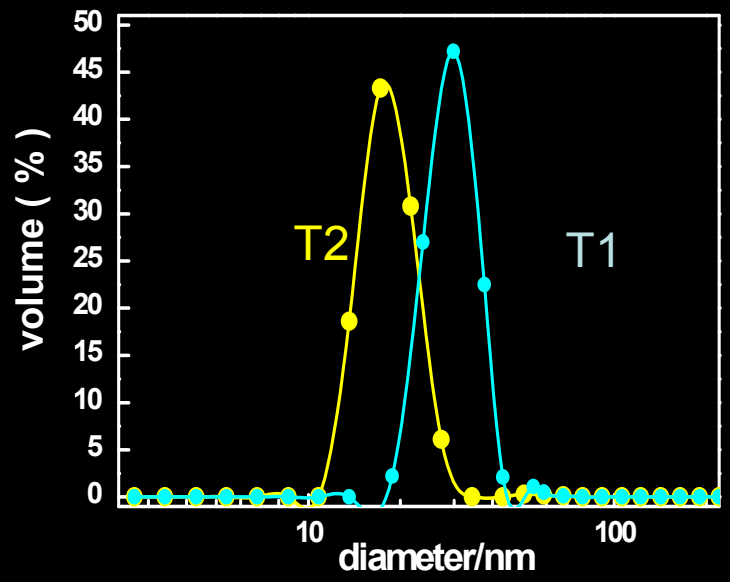
Different Porosity

↓

Different Refractive Index

T1 sol: low [TMAOH], 250º

T2 sol: high [TEAOH], 85ºC



One layer

Spin-Coating Deposition

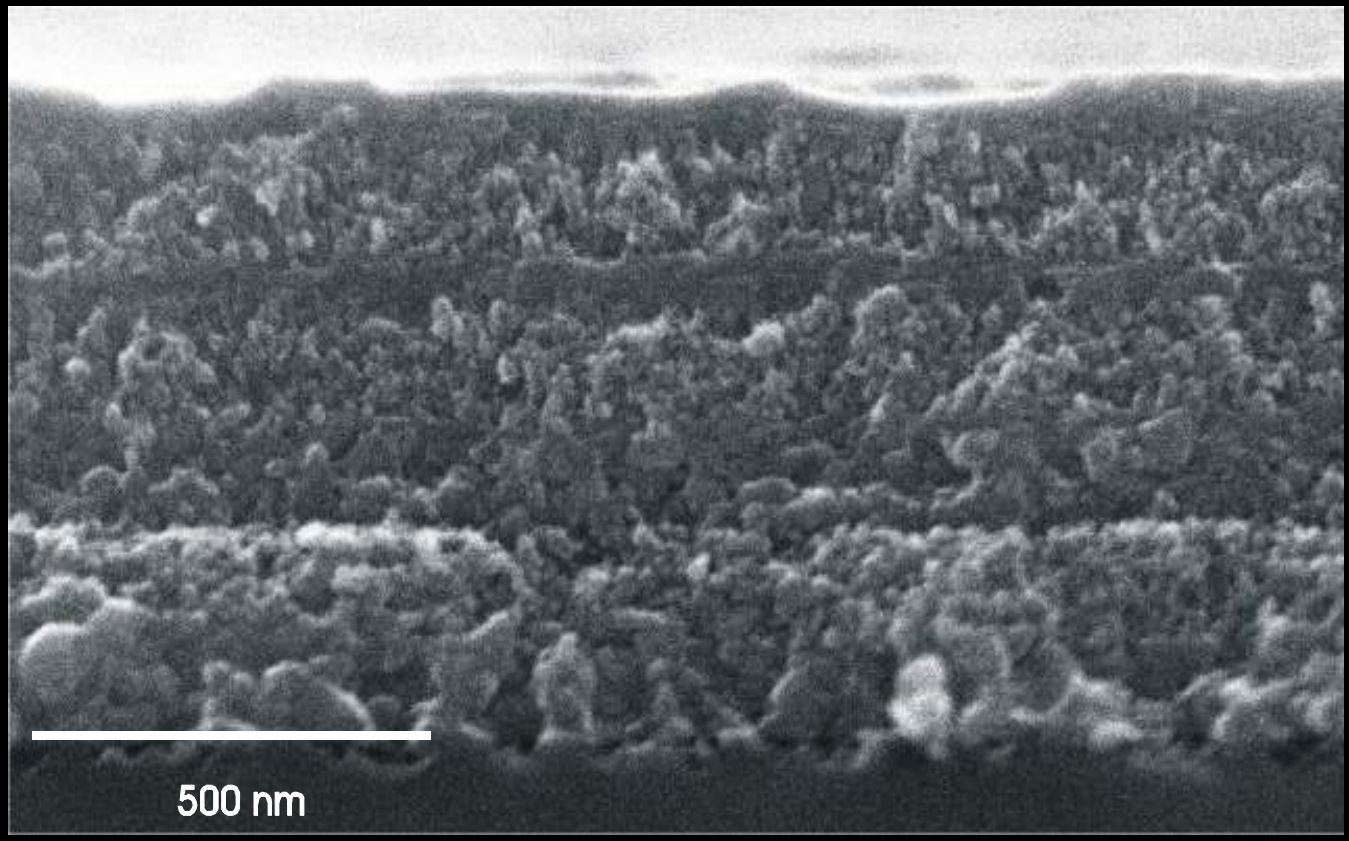
→ Thermal Treatment

400ºC, 1800s

M. E. Calvo et al. Adv. Funct. Mat. in press

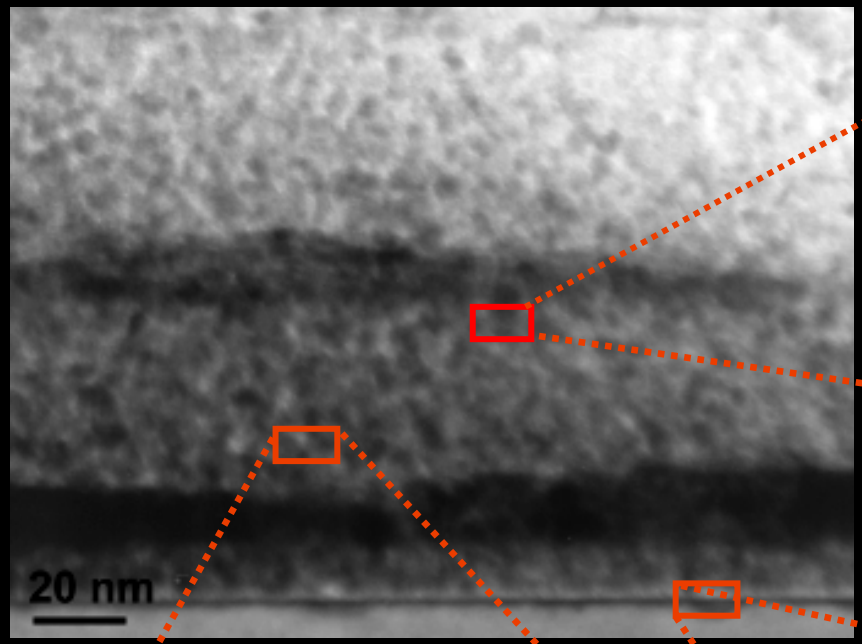
TiO_2/TiO_2 PC

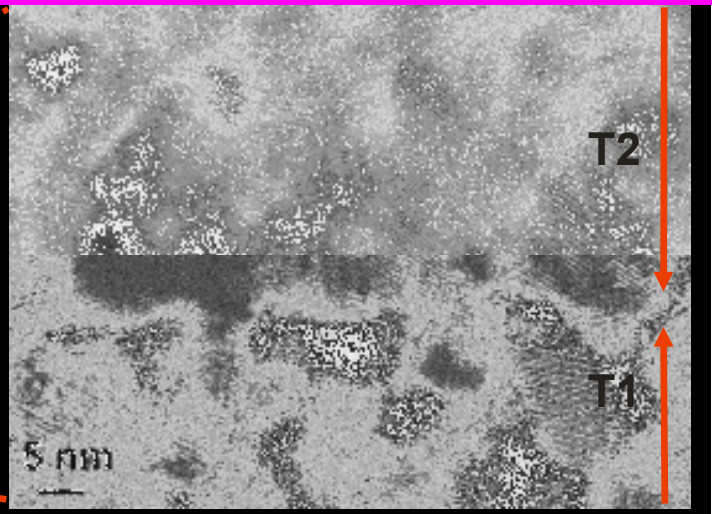
Microstructure

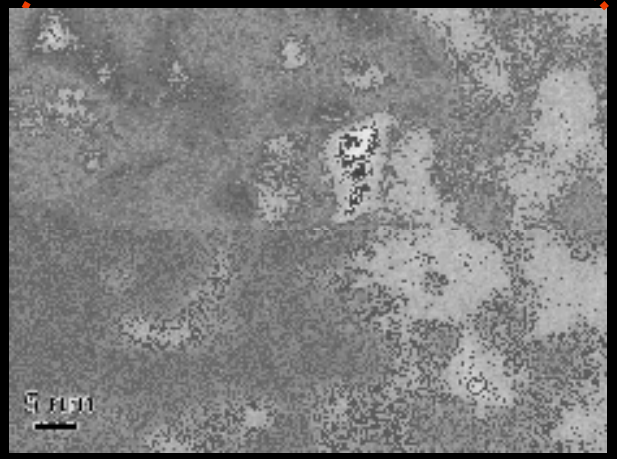


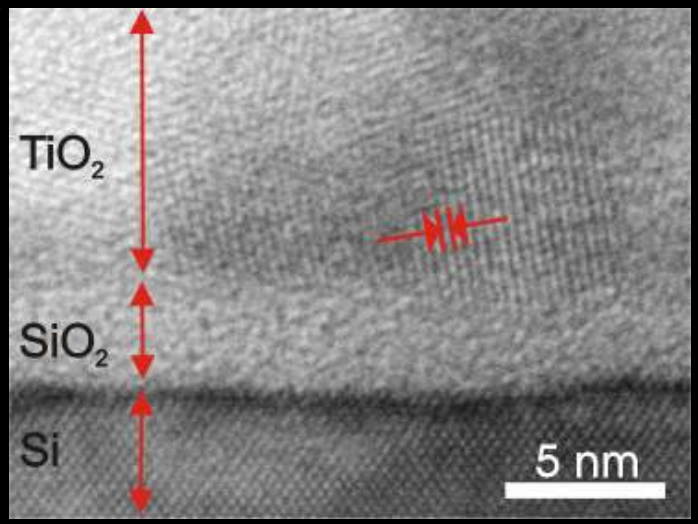
TiO_2/TiO_2 PC

Microstructure



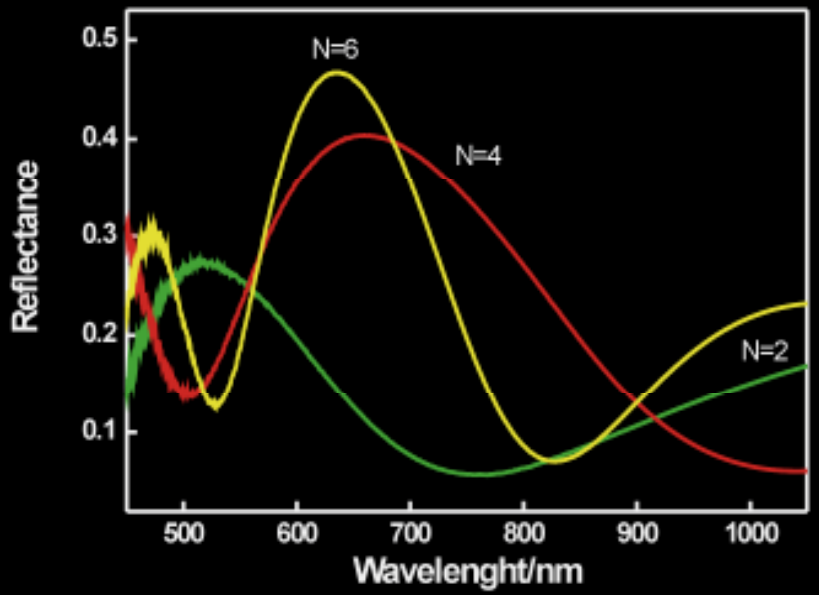


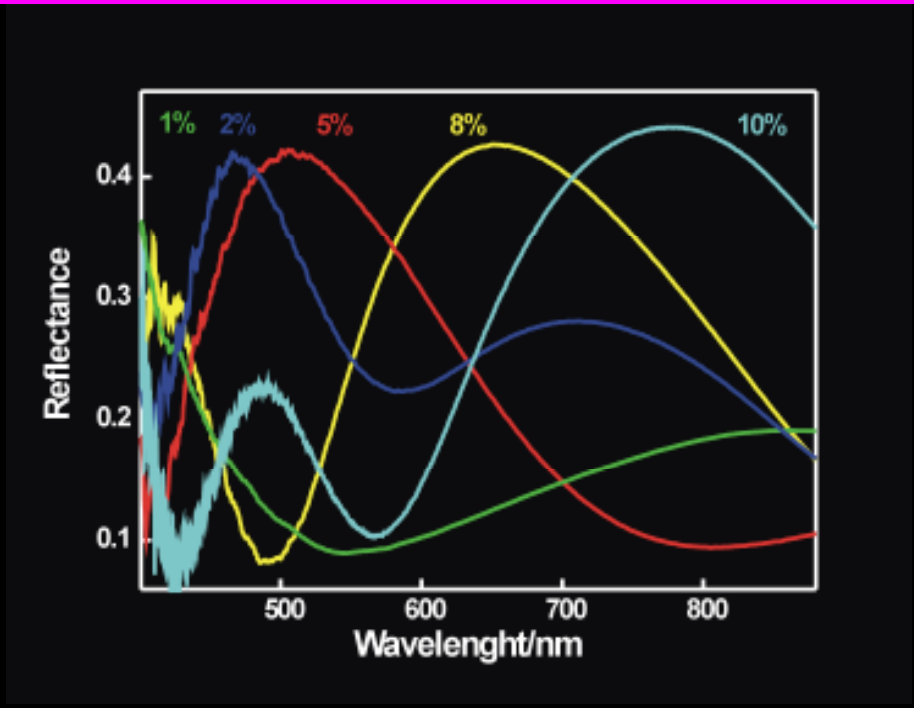




TiO_2/TiO_2 PC

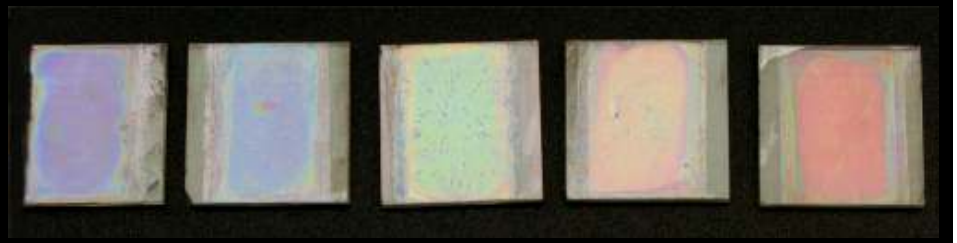
Optical Properties





n_{T1}= 1.78 40% porosity

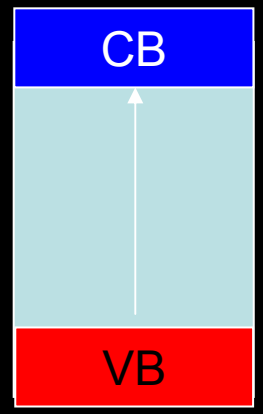
n_{T2}= 2.05 16% porosity

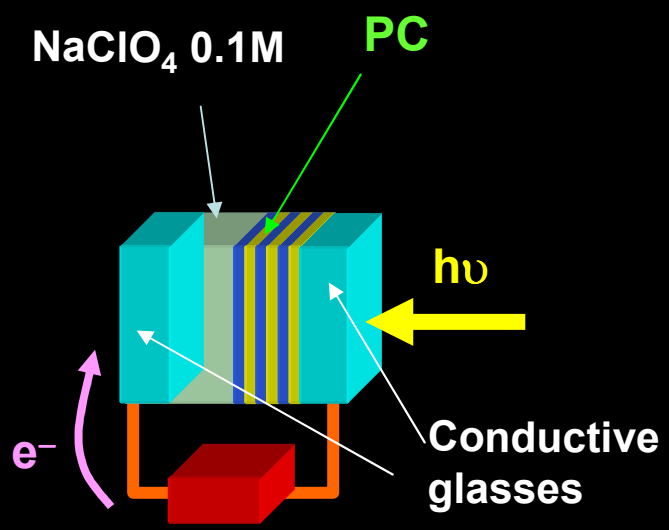


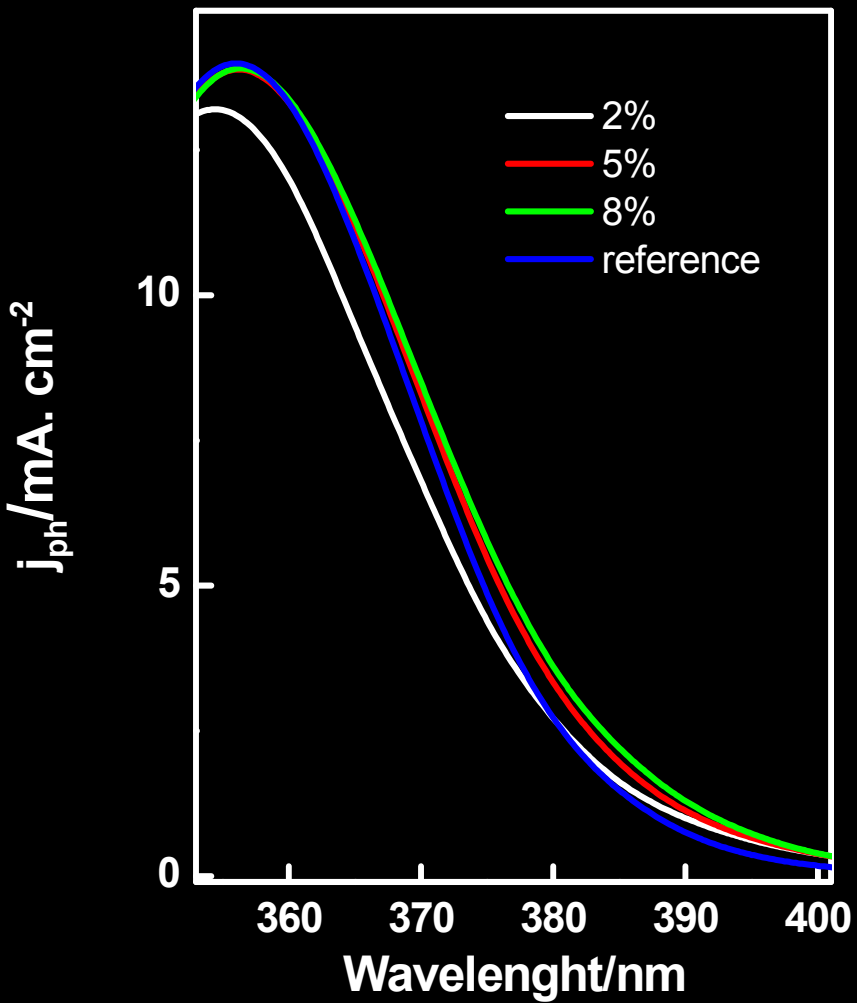
T2 sol concentration increase

TiO_2/TiO_2 PC

Photocurrent Response

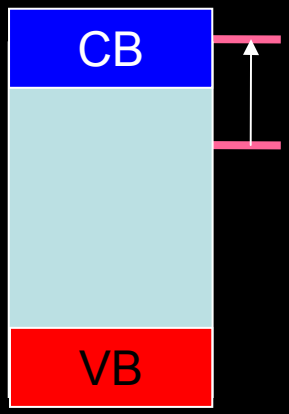


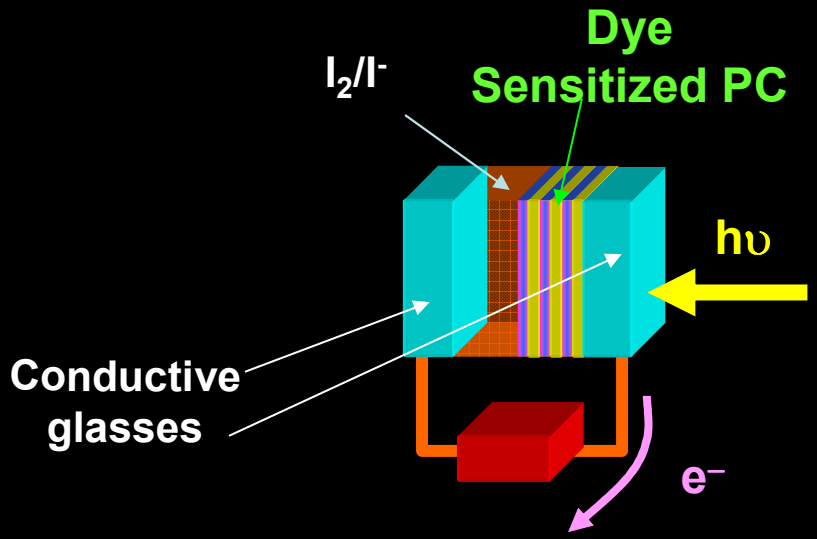


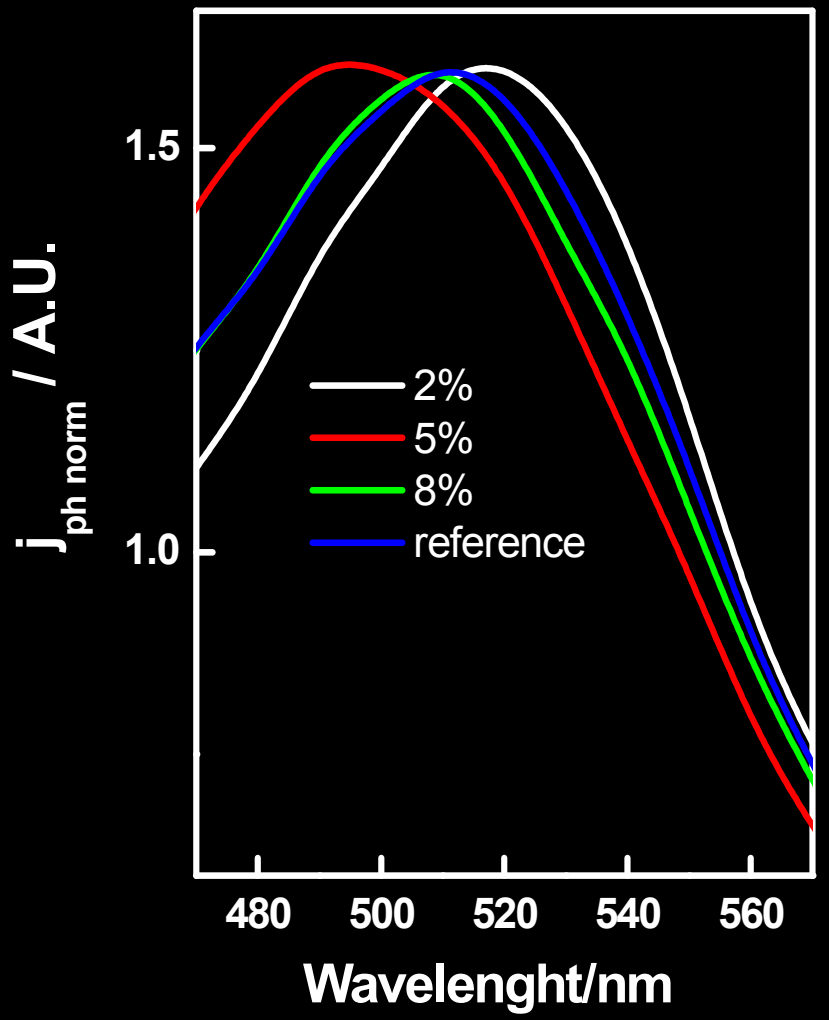


TiO_2/TiO_2 PC

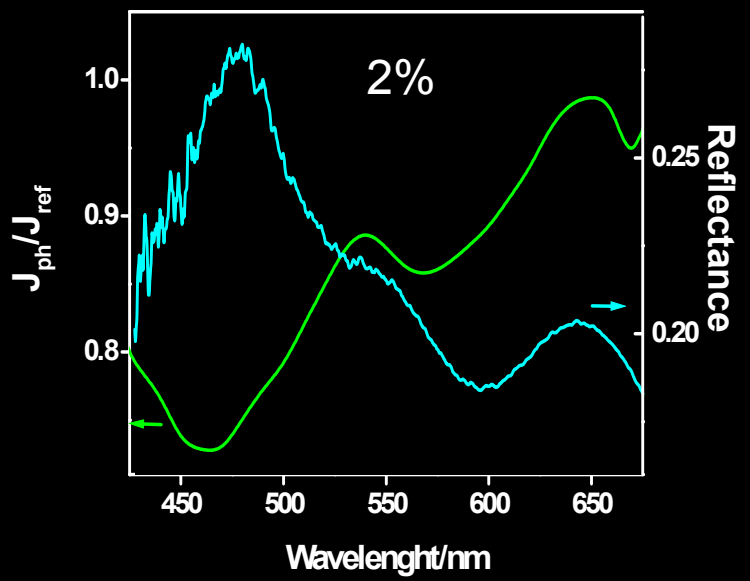
Photocurrent Interplay

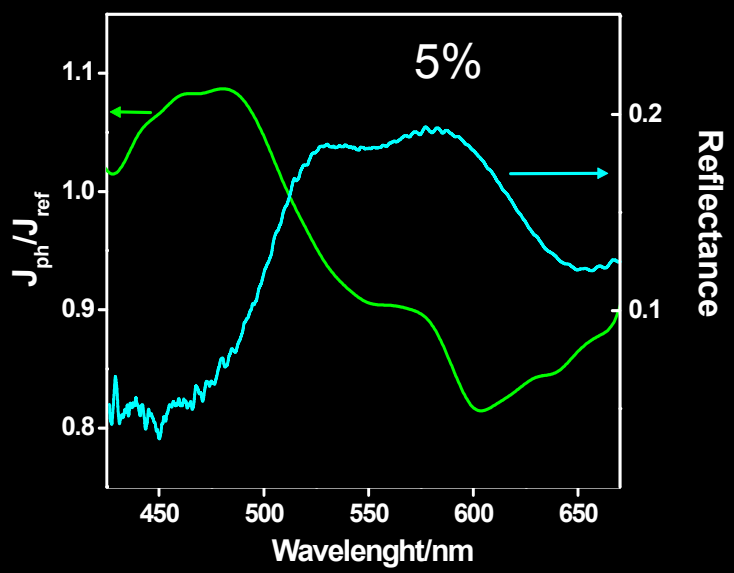


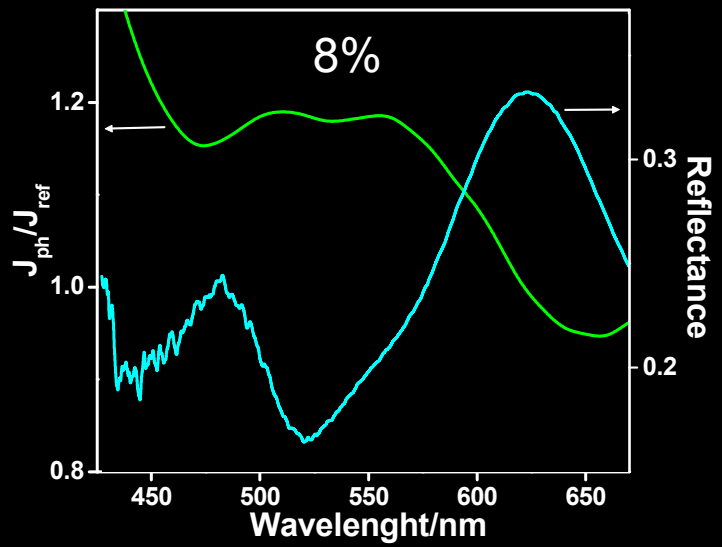




TiO_2/TiO_2 PC Photocurrent Interplay







Summary and Conclusions

TiO_2/SiO_2 and TiO_2/TiO_2 1D PC can be obtained from controlled deposition of nanoparticulated sols

TiO_2/SiO_2 1D PC can be used as chemical sensors

We have built TiO2 multilayers that combine efficient adsorption and photogenerated electron transport with photonic crystal properties

Photocurrent can be modulated by the interplay between photonic crystal properties

Members

Optical Nanomaterials Group, Institute of Materials Science of Seville (CSIC-US)

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- Silvia Colodrero
- Gabriel Lozano
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- Nuria Hidalgo
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Funding: Fundación Ramón Areces, Grant "Colloidal Photovoltaic Materials"
and MAT 2005-03028