# Nanophotonique Silicium

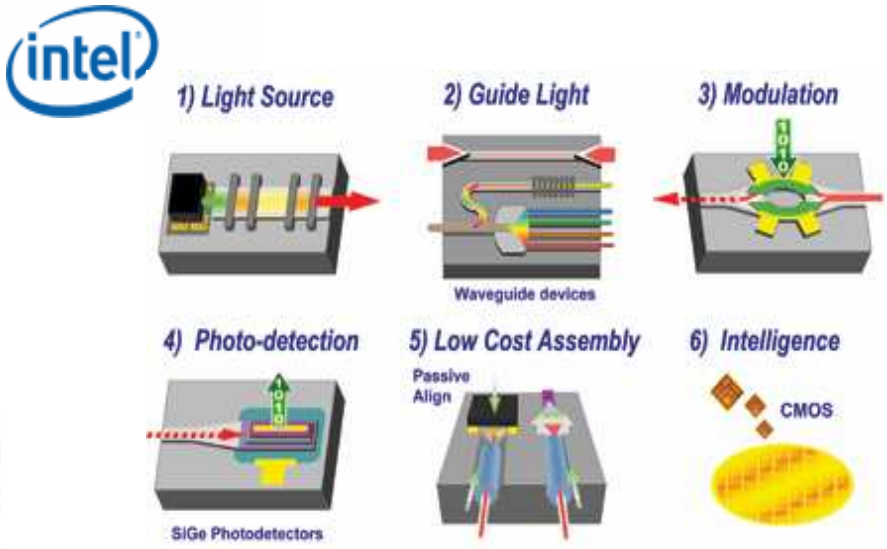

**Laboratoire Silicium Nanoélectronique Photonique et Structures**

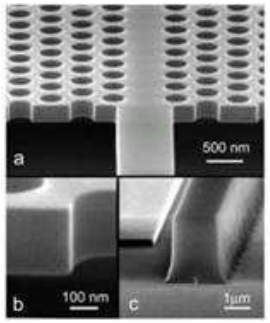
**Département de Recherche Fondamentale sur la Matière Condensée**

**CEA/Grenoble**

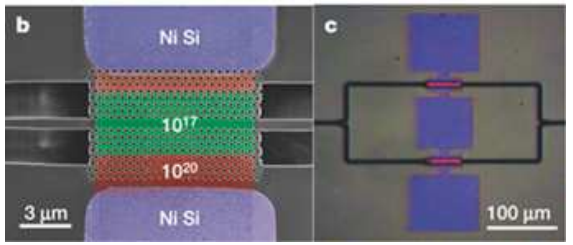

# Nanophotonique ?!

## Nanoélectronique pourrait….devrait….devra… utiliser les photons ?!




Guide d'onde : 2.4 db/mm (**IBM**)

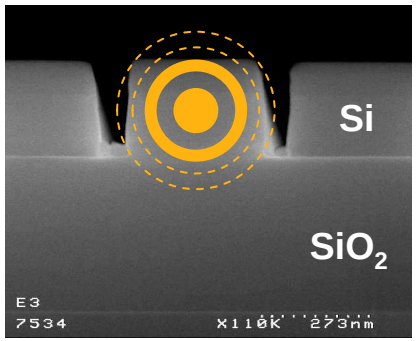


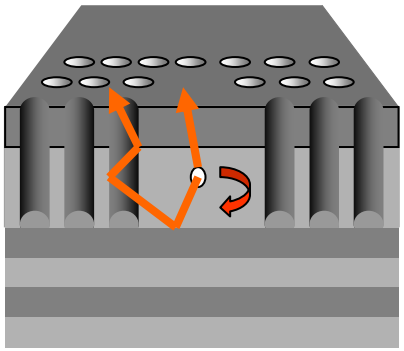

Modulateur Thermo-optic (**IBM**)

*Electrically pumped hybrid AlGaInAs-silicon evanescent laser*
A.W.Fang et al., 2 October 2006 Optics Express (Intel - UCSB)

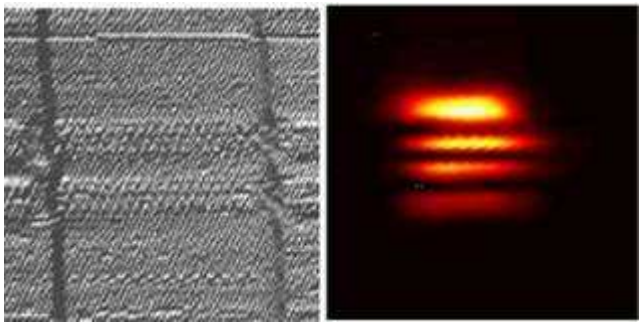
# Nanophotonique Silicium

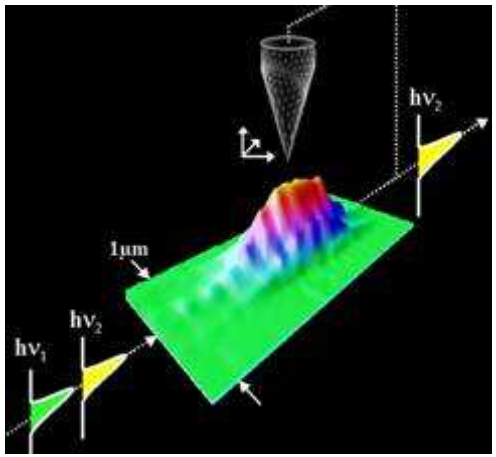
## Contrôler l'émission de lumière,



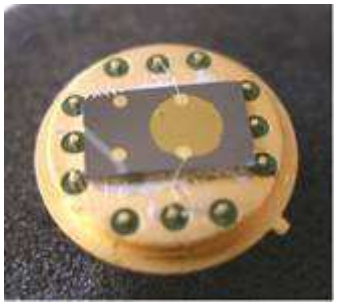



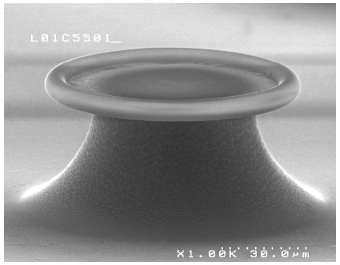
## contrôler sa localisation,

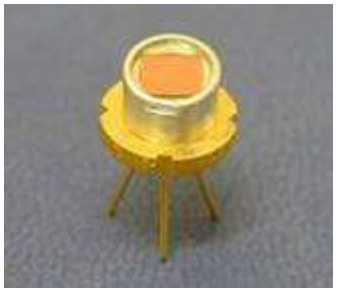




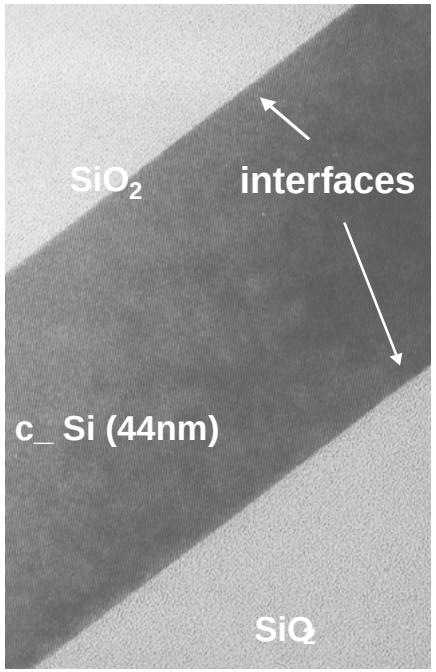

## pour réaliser des dispositifs ...



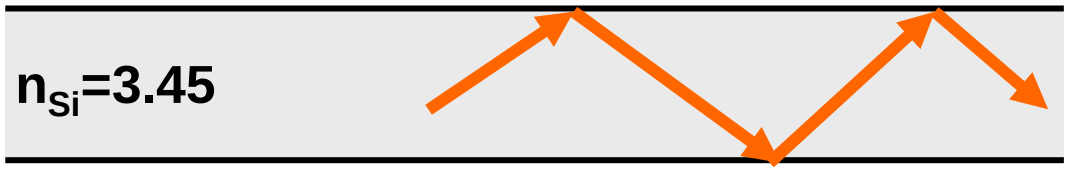




# Un matériau de choix, le Silicium sur Isolant (SOI)

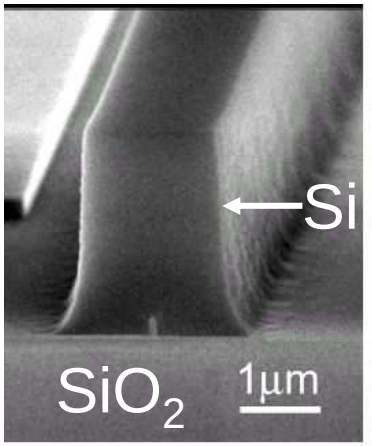



$n_{air}=1$

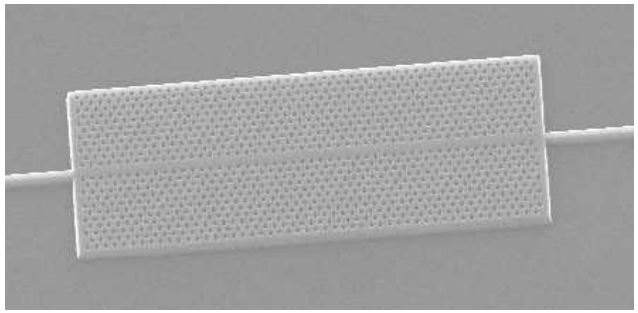


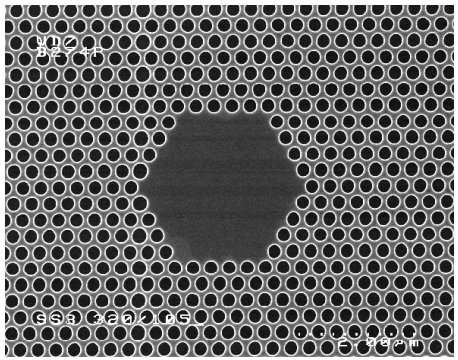

$n_{SiO2}=1.48$

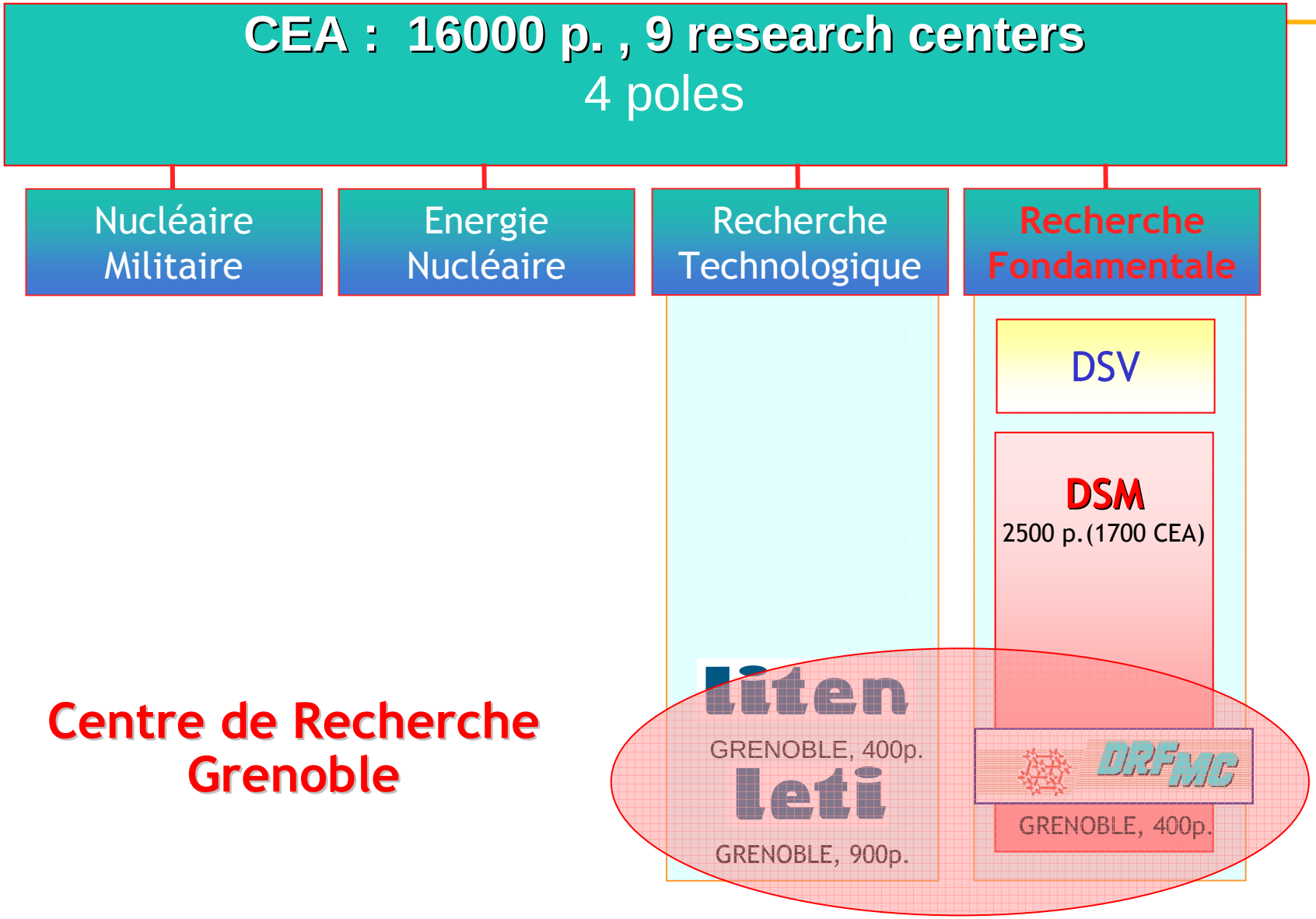
**Guidage par réflexion totale interne**



# Le SOI et les Cristaux Photoniques





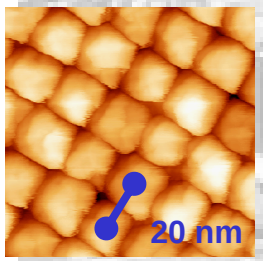

CEA : 16000 p. , 9 research centers
4 poles
Nucléaire Militaire
Energie Nucléaire
Recherche Technologique
Recherche Fondamentale
DSV
DSM
2500 p.(1700 CEA)
liten
GRENOBLE, 400p.
leti
GRENOBLE, 900p.
DRFMC
GRENOBLE, 400p.
Centre de Recherche Grenoble

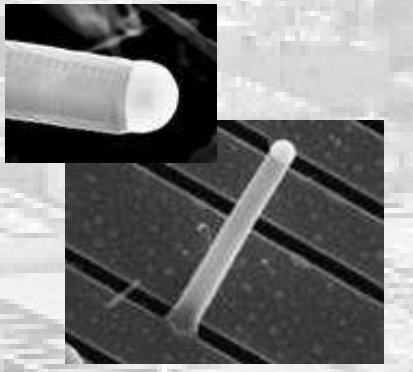
# MINATEC Centre

45 000 m²

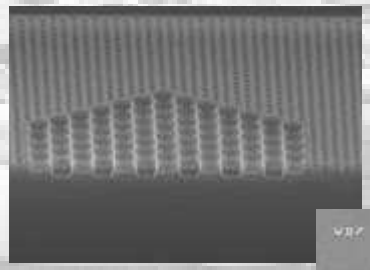
# Le Laboratoire SiNaPS / DRFMC

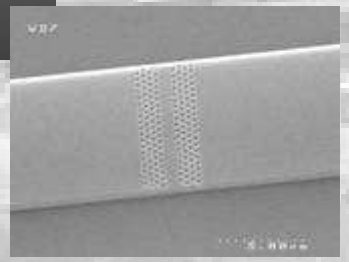
**nanostructures Si**

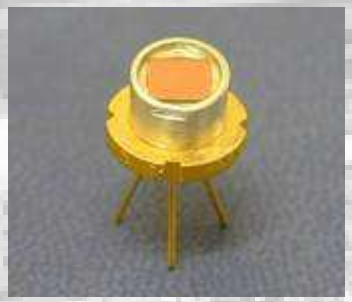


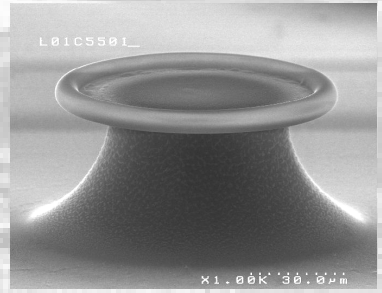



**nanophotonique Si**







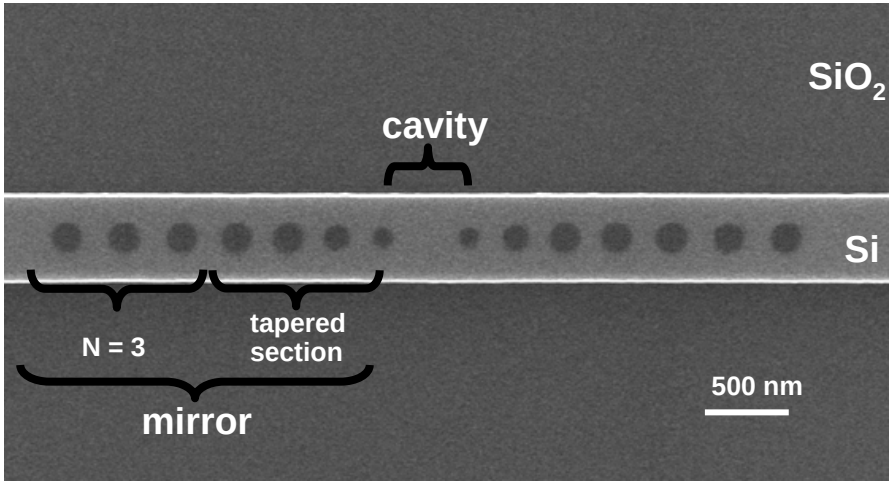



**MINATEC center**

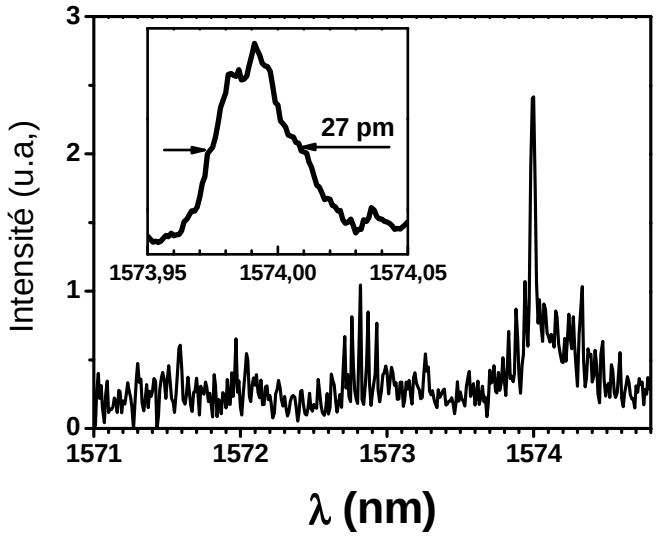
**jusqu'à la réalisation de dispositifs electro-optiques**

# Cavités à grands Q

Collaboration IOTA & LTM




N=7




**Q > 60.000**

V~ 0.6 $(\lambda/n)^3$
~ 0.052 $\mu m^3$

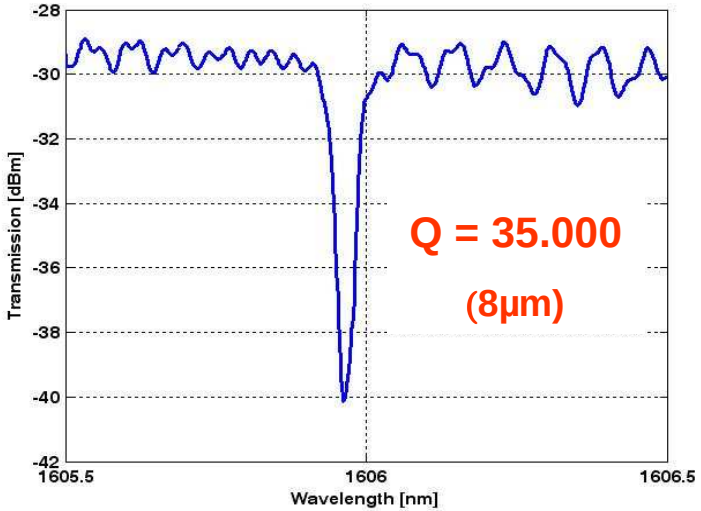
*P.Velha et al, Appl. Phys. Lett., 89 (2006)*

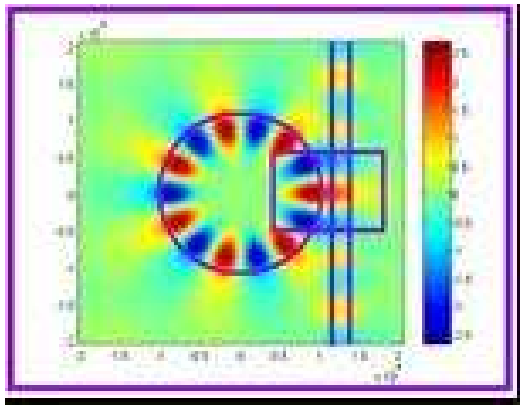
*P.Velha et al, New Journ. Phys., 8 (2006)*

# Add drop

**Collaboration IMEP & LETI**

**@ λ = 1606 nm**

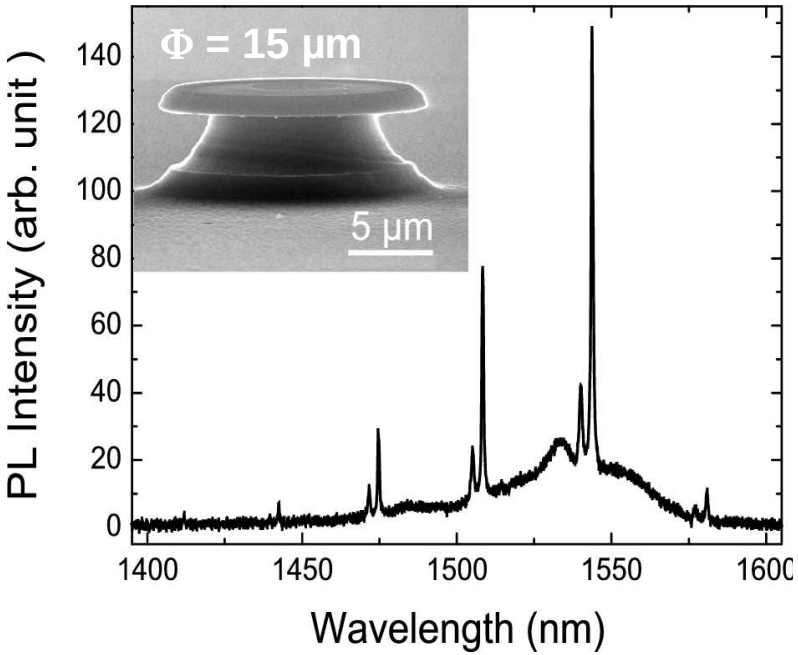



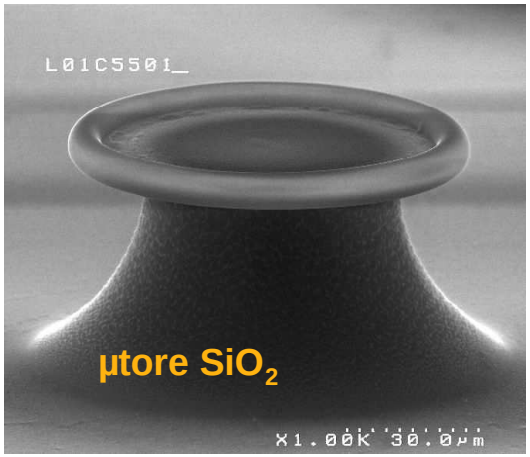



*A.Morand, et al., Optics Express, 14 (26), 12814 (2006).*

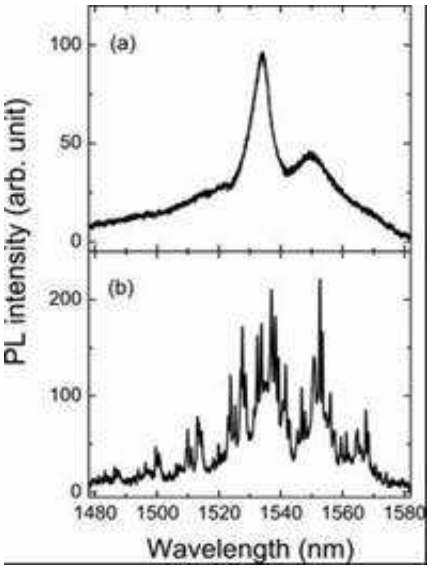
**µdisque $SiO_2$ + dépot SRO:Er + fusion laser CO2**

**$Q = 10^3 - 10^5$**



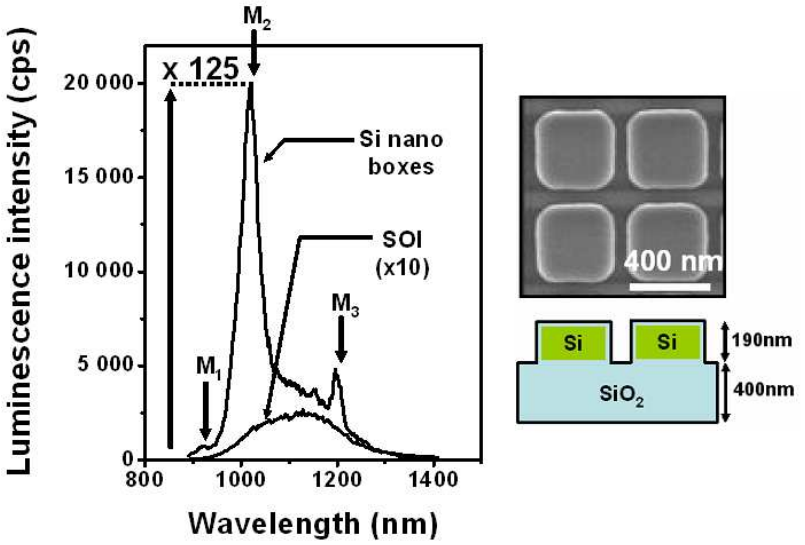

**$Q > 10^8$**



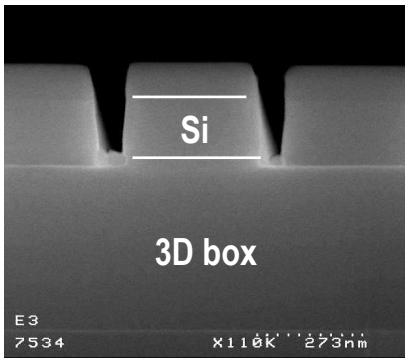

*J. Verbert et al., Appl. Phys. Lett. 86, 1 (2005)*

*J. Verbert et al., Eur. Phys. J. Appl. Phys. 34 (2006)*

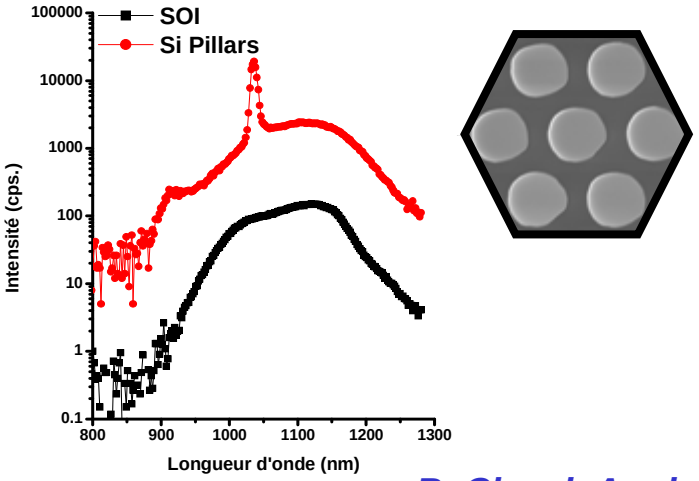
# Localisation des porteurs et émission à l'ambiante




*B. Cluzel, Appl. Phys. Lett., 88 (2006)*




**La localisation sans confinement quantique permet une émission à 1.145µm à l'ambiante**

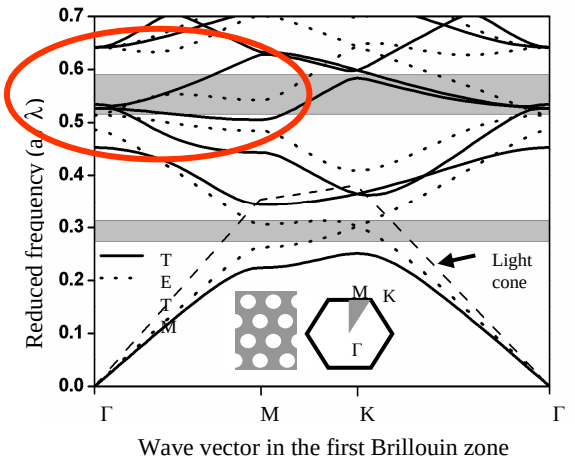


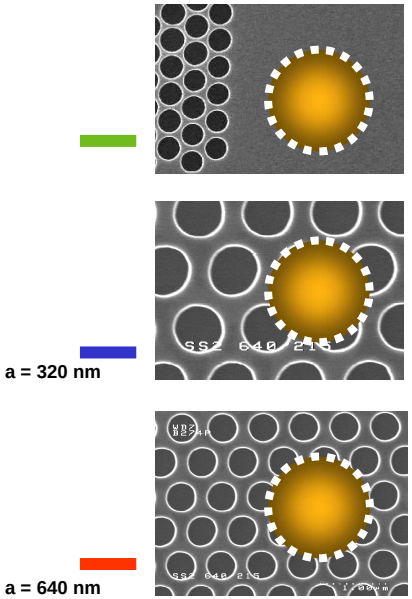

*B. Cluzel, Appl. Phys. Lett., 89 (2006)*

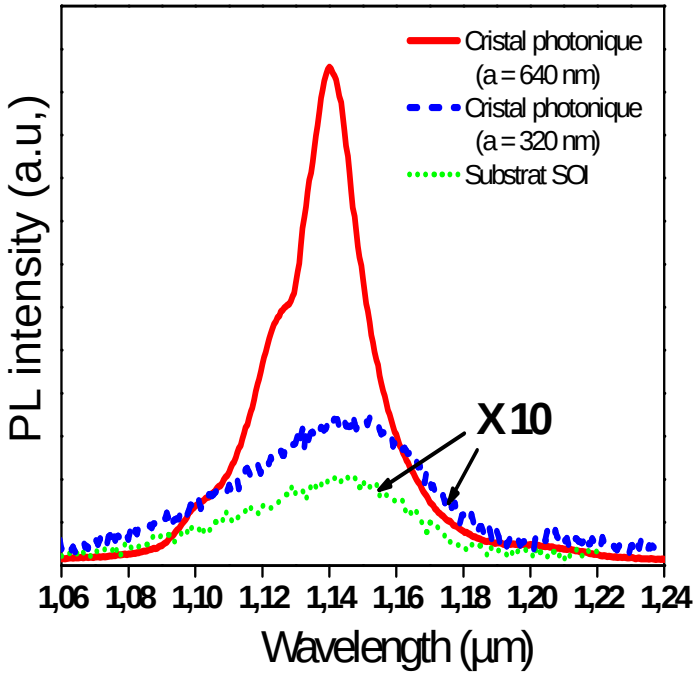
# Structure à cristaux photoniques à modes lents

- **Augmentation de l'extraction de 70%**
- **Plus de 35% de la lumière est extraite verticalement**

**Spot d'excitation et de collection = 2 µm**



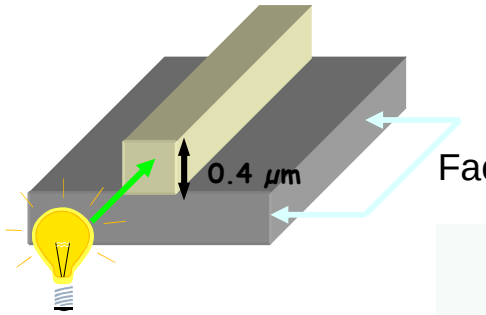



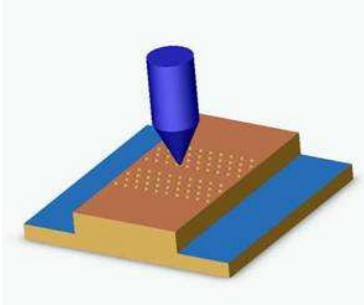

*M. Zelsmann, Appl. Phys. Lett. 83 (13), 2542 (2003)*

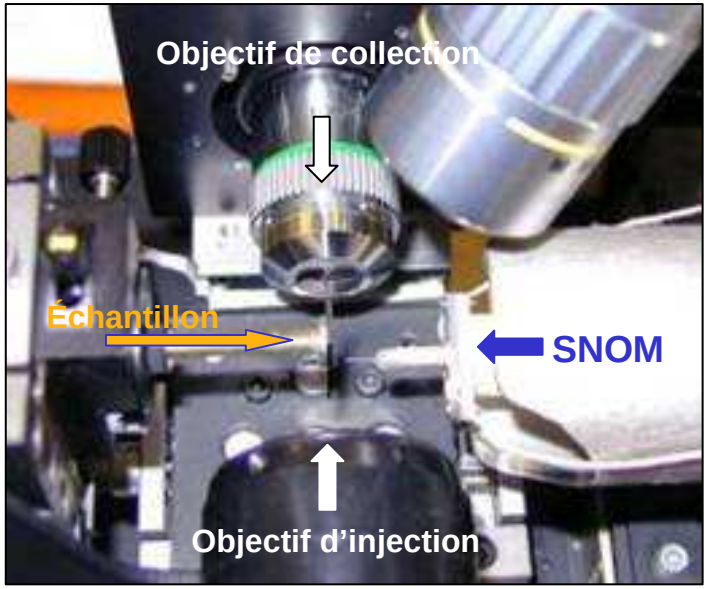
# Spectroscopie en champ proche

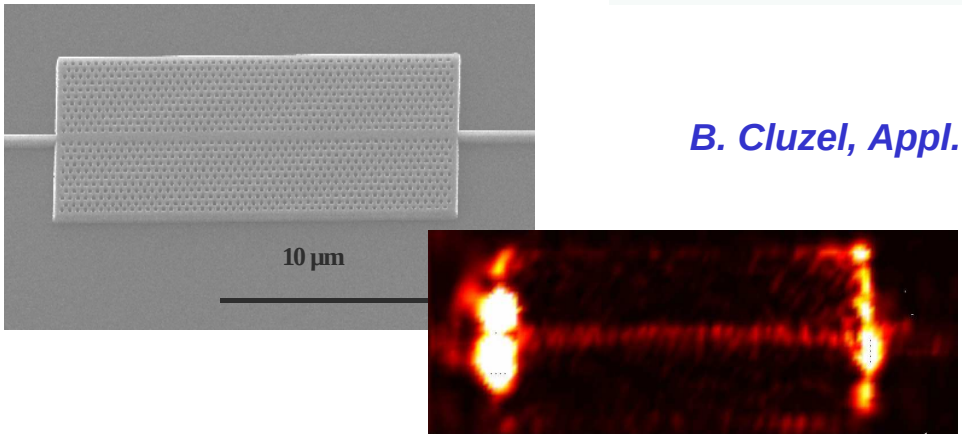
Collaboration LPUB



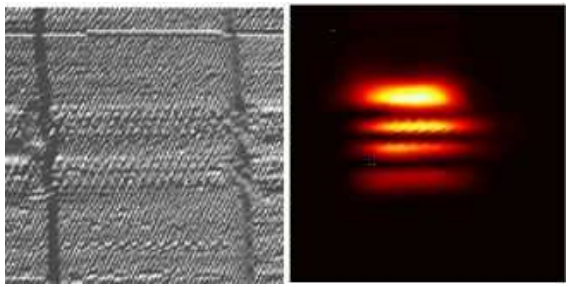

Facettes clivées





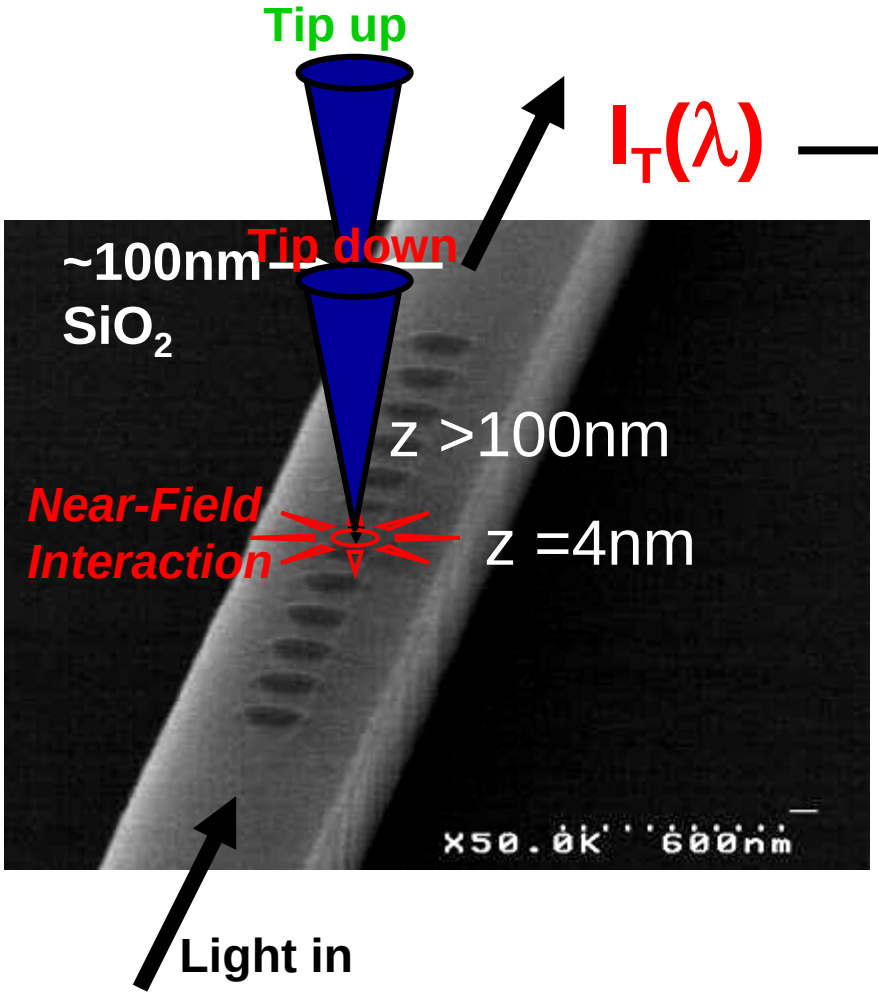




*B. Cluzel, Appl. Phys. Lett. 88, (2006)*

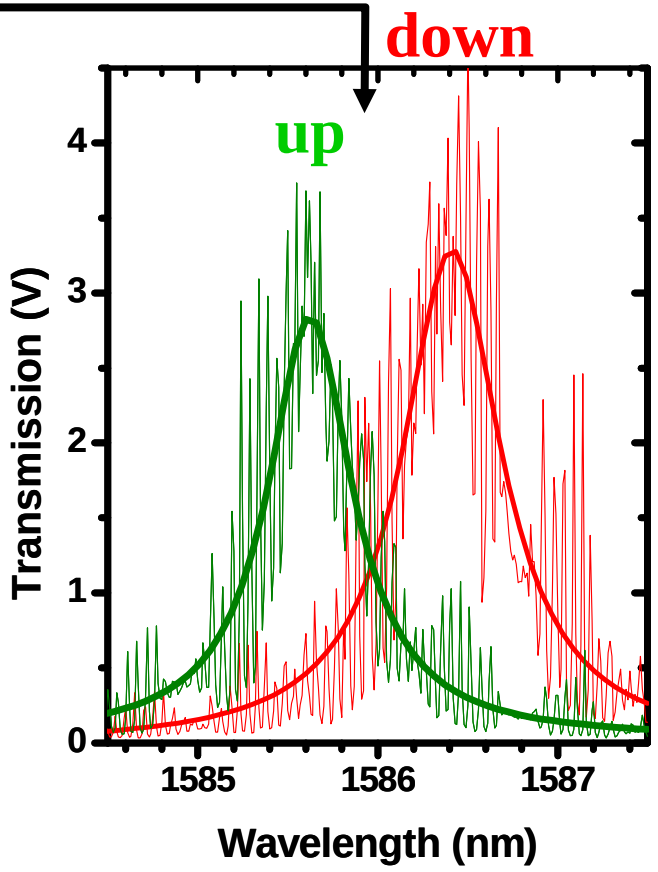


*B. Cluzel, Appl. Phys. Lett. 85 (2004)*

*B. Cluzel, J. Appl. Phys. 98, (2005)*




$I_T(\lambda)$




Nanocavité accordable en champ proche

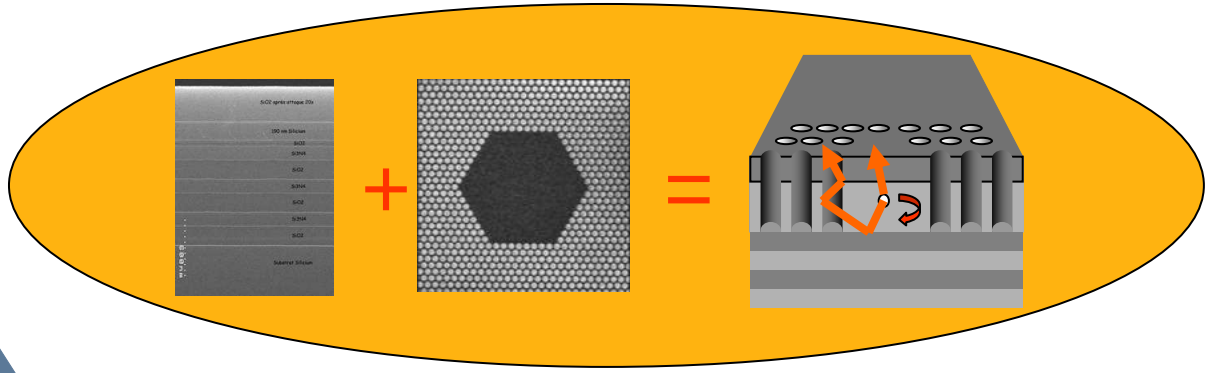
Accord sur ~ 1nm
Sans dégradation de Q

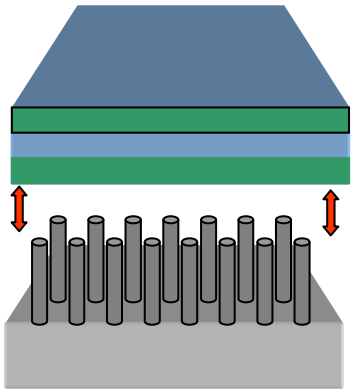
# Collaborations

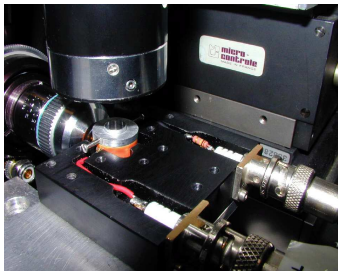
http://www-drfmc.cea.fr/
thomas.charvolin@cea.fr
emmanuel.hadji@cea.fr

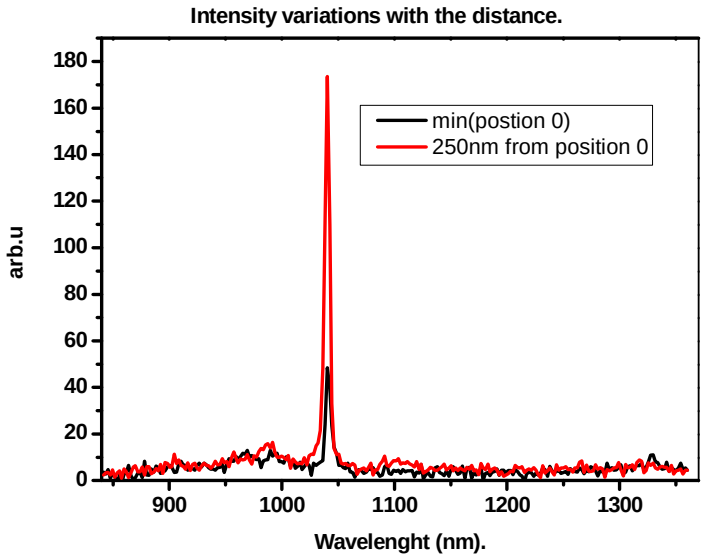
# Du 2D au 3D : interaction 1D + 2D

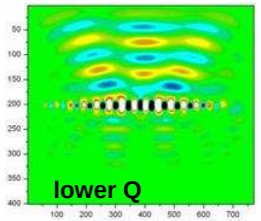
**Collaboration LEOM & IEF**

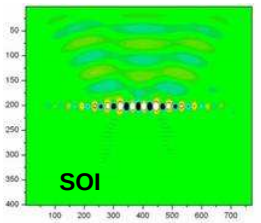


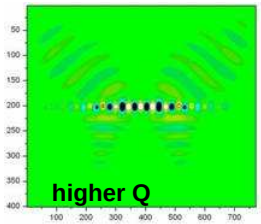







*E. Hadji, Proc. SPIE - Phot. West 2005*

*X. Li, Appl. Phys. Lett 88, 091122 (2006)*

# Cristaux photoniques bi-dimensionnels : diagramme de bandes