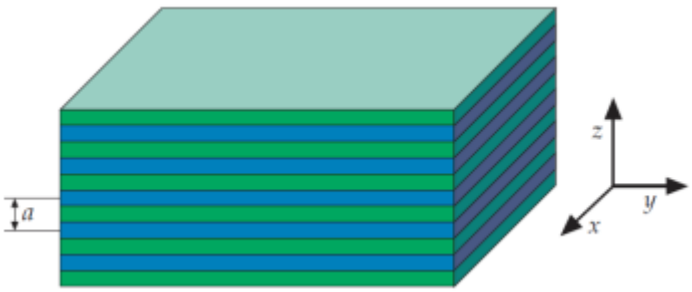
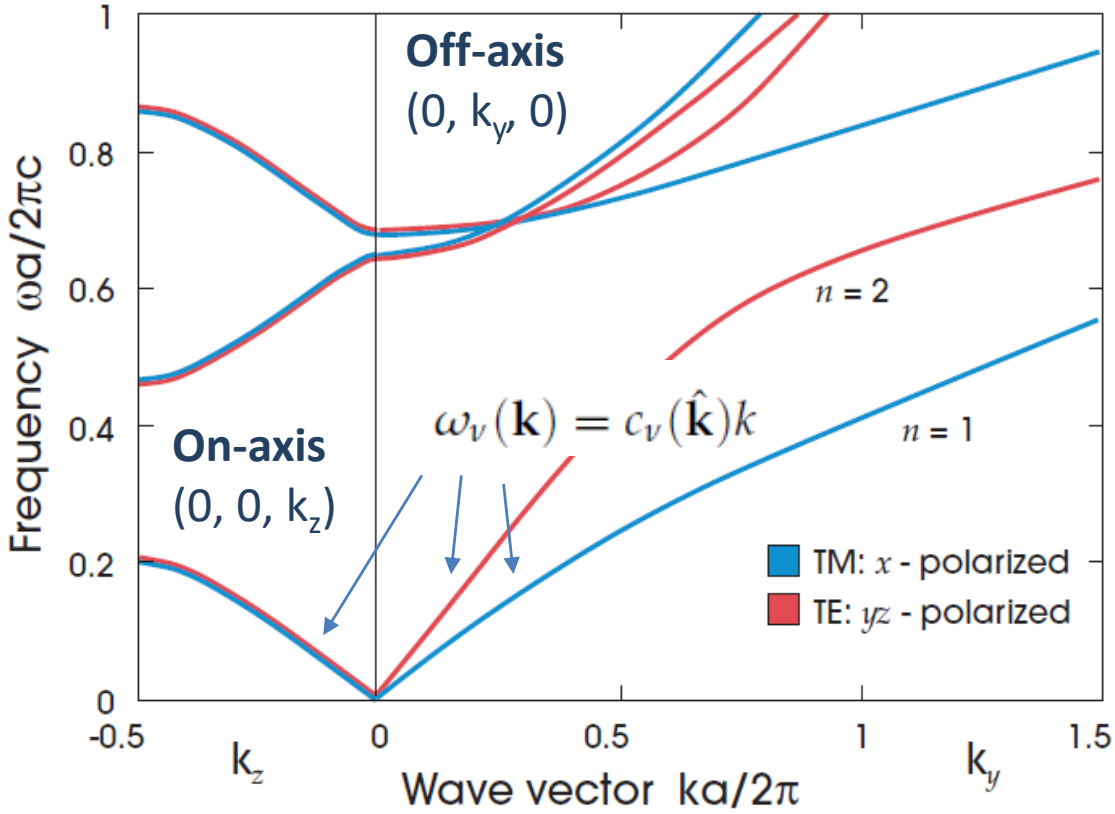


J D Joannopoulos et al. (2008), *Photonic Crystals: Molding the Flow of Light* (2nd ed.), Princeton NJ: Princeton University Press

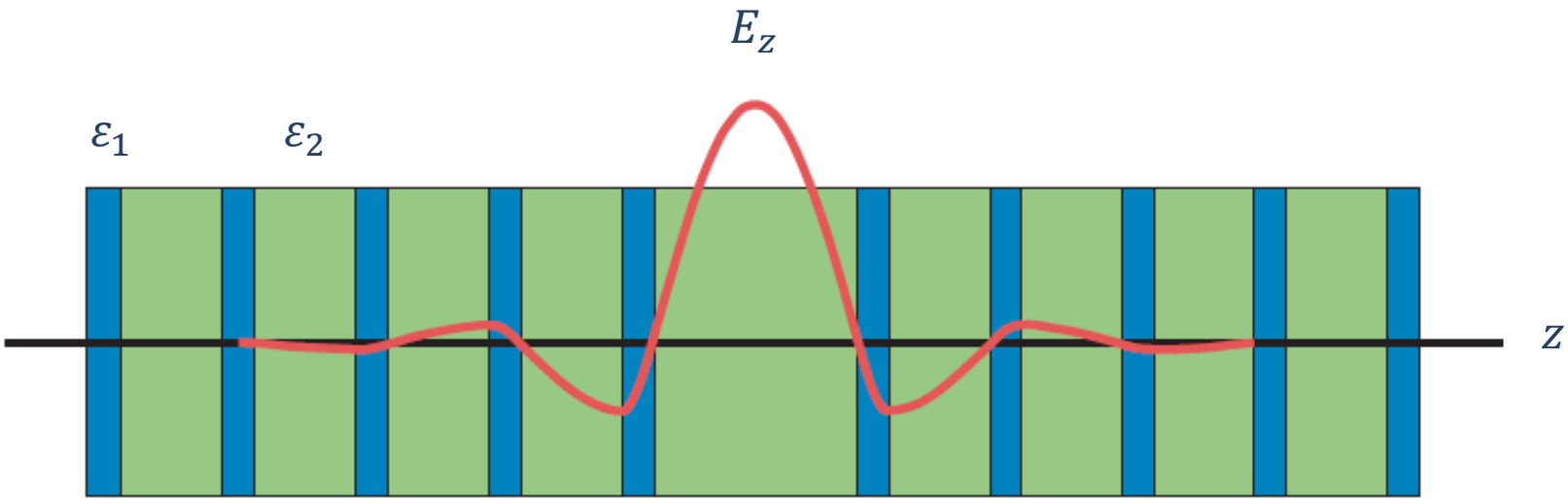


Polarization Degeneracy
TE vs TM polarization

On-axis propagation:
- Bandgap
- Polarization Degeneracy

Off-axis propagation:
- no bandgap

Defects in the periodicity: $\varepsilon_1 > \varepsilon_2$



On axis propagation:

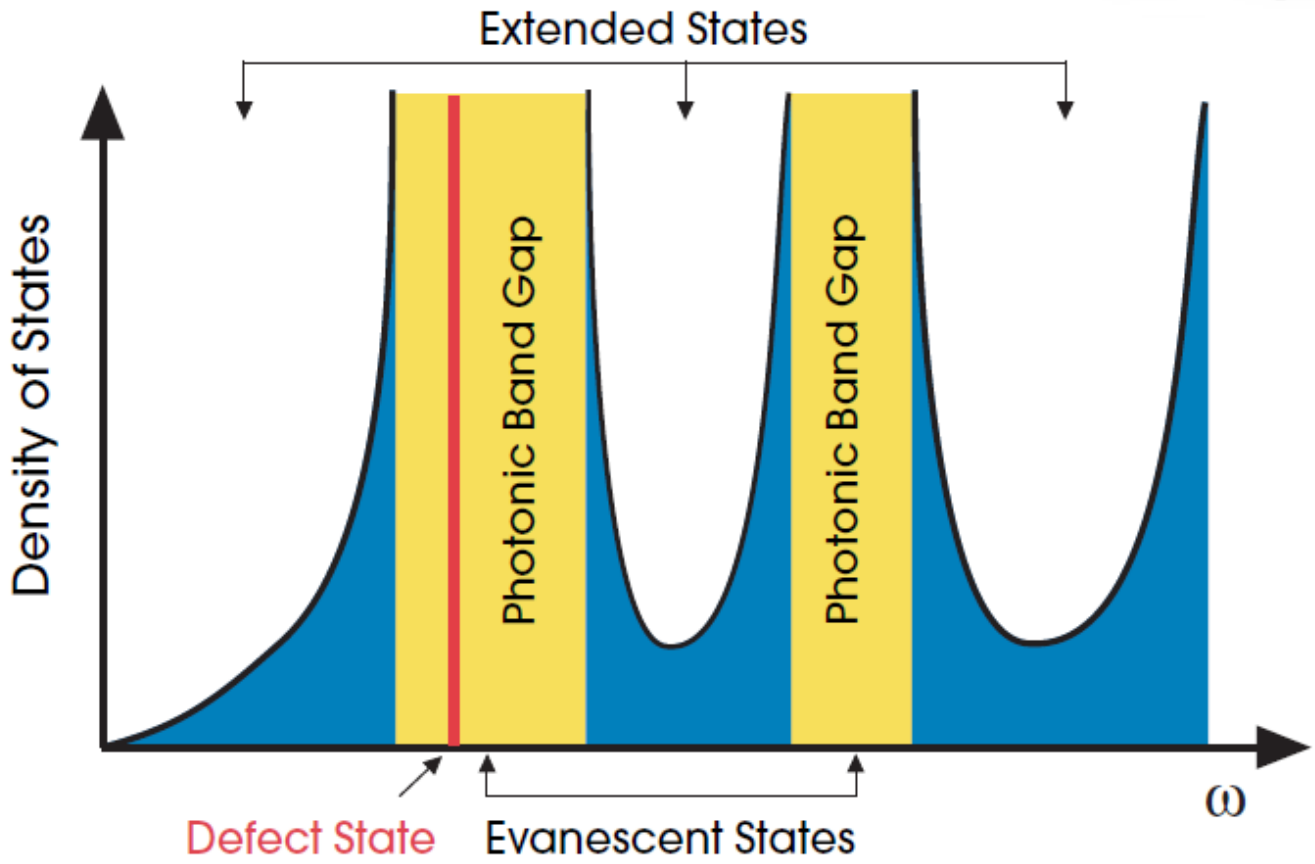
- Defects in the gap
- No extended modes
- Localization of the field in the defect

J D Joannopoulos et al. (2008), *Photonic Crystals: Molding the Flow of Light* (2nd ed.), Princeton NJ: Princeton University Press

1D Photonic Crystals

Defects in the periodicity: density of states

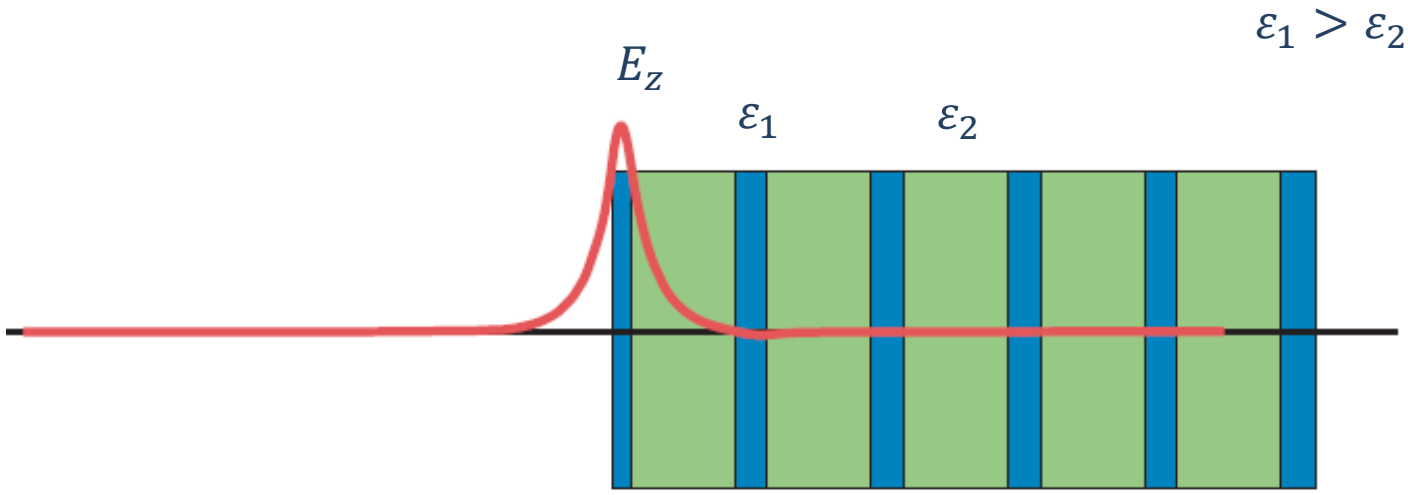
$$g(\omega) = \sum_s \int \frac{dS}{(2\pi)^3} \frac{1}{|\nabla \omega_s(\mathbf{k})|}$$



Pass-band filters: dielectric Fabry-Perot filter

J D Joannopoulos et al. (2008), *Photonic Crystals: Molding the Flow of Light* (2nd ed.), Princeton NJ: Princeton University Press

Defects in the periodicity: surface states

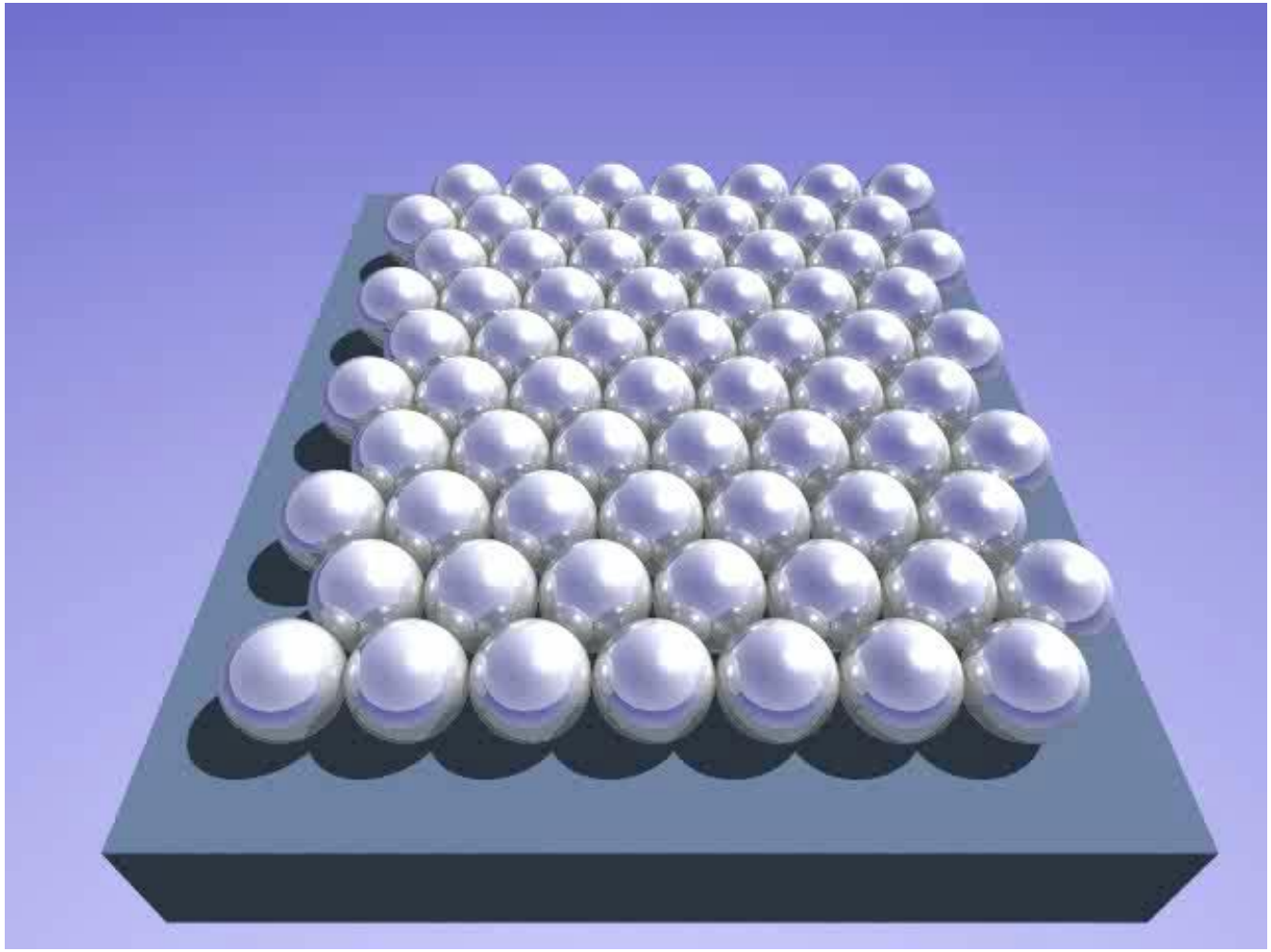


Off axis propagation:

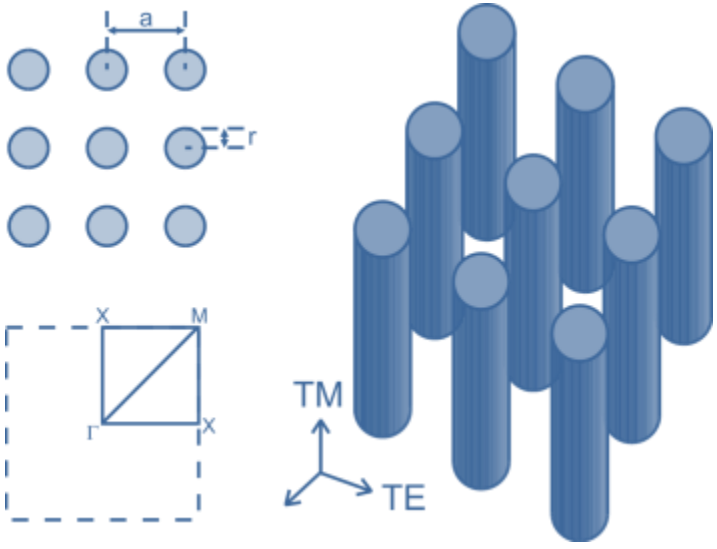
- Surface states
- No extended modes
- Localization of the field at the surface

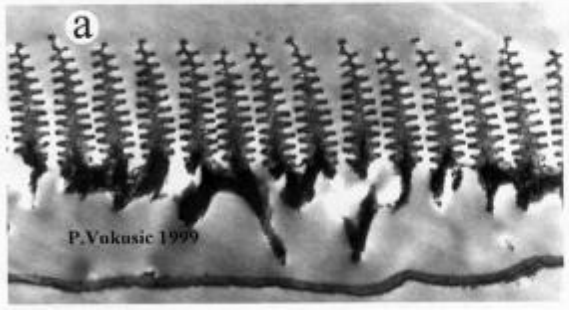
J D Joannopoulos et al. (2008), *Photonic Crystals: Molding the Flow of Light* (2nd ed.), Princeton NJ: Princeton University Press

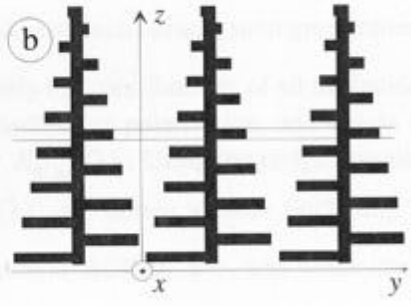
2D Photonic Crystals: optical semiconductors

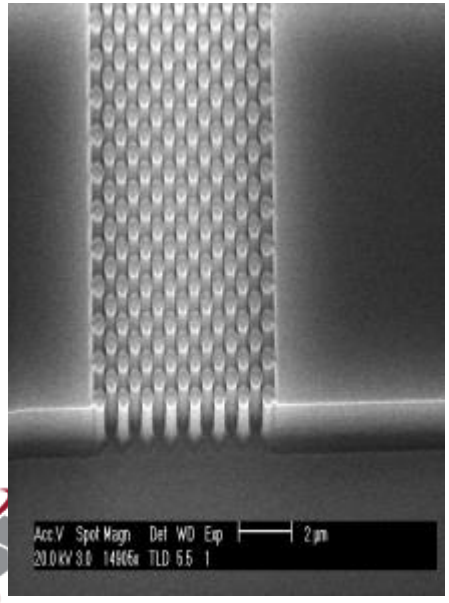


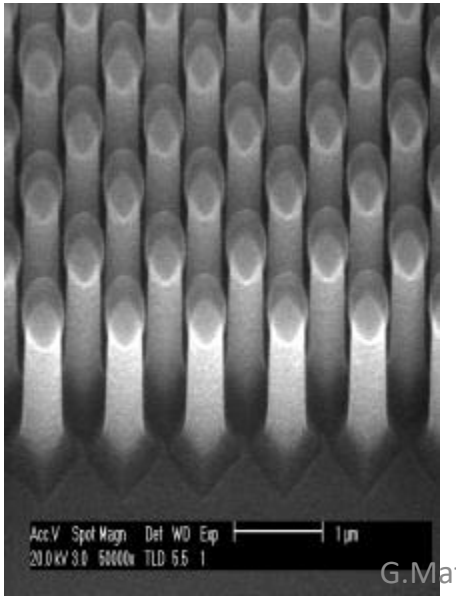
2D Photonic crystals



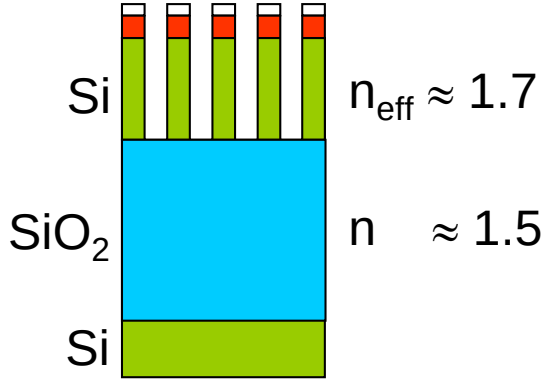




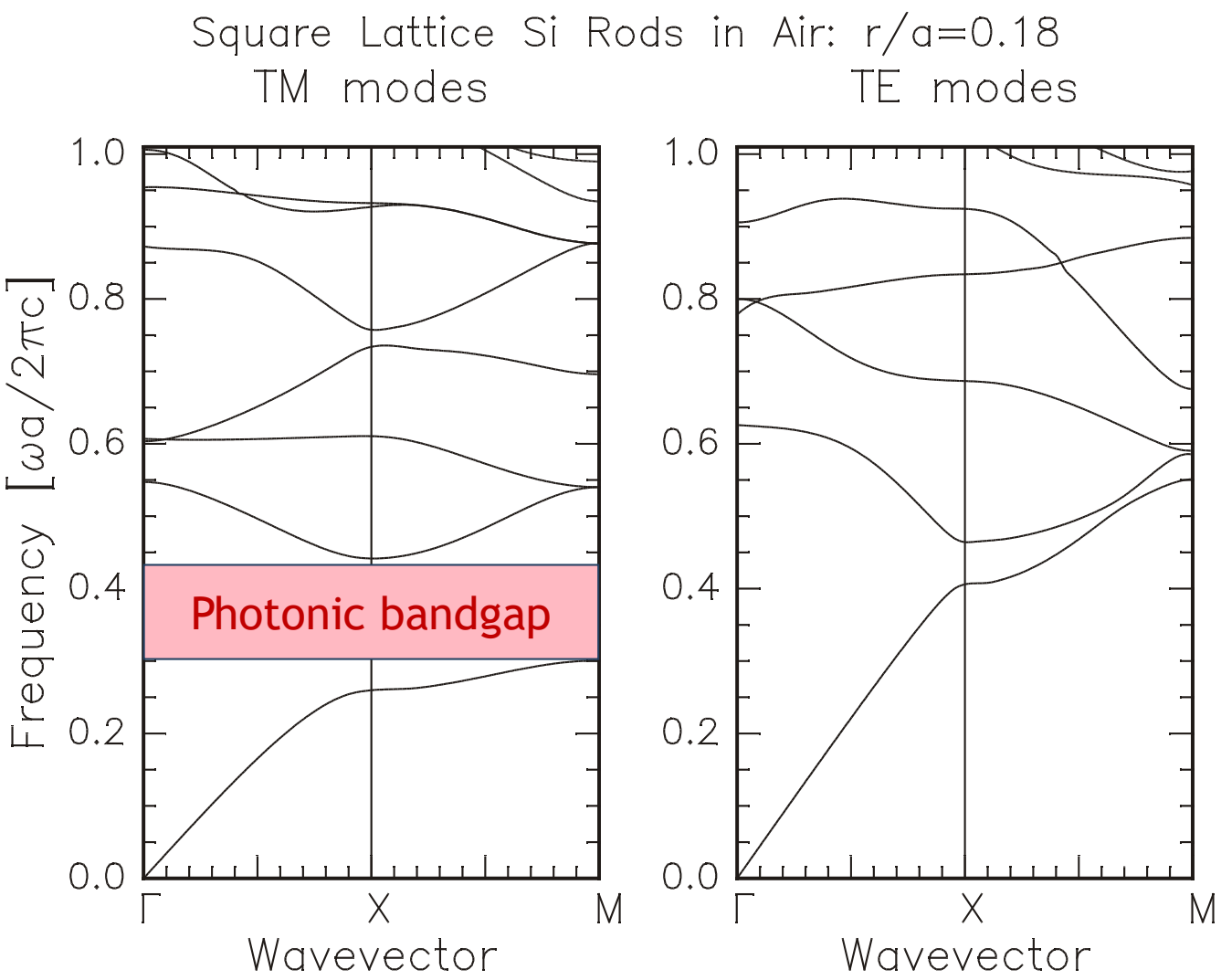


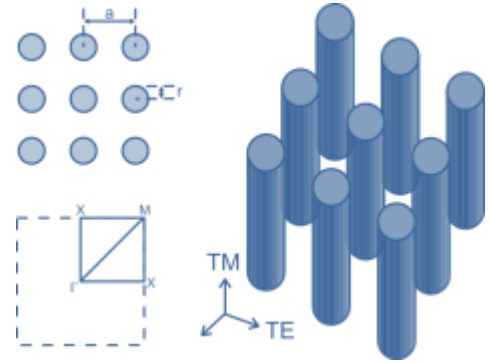


Silicon-on-insulator (SOI)



2D Photonic crystals



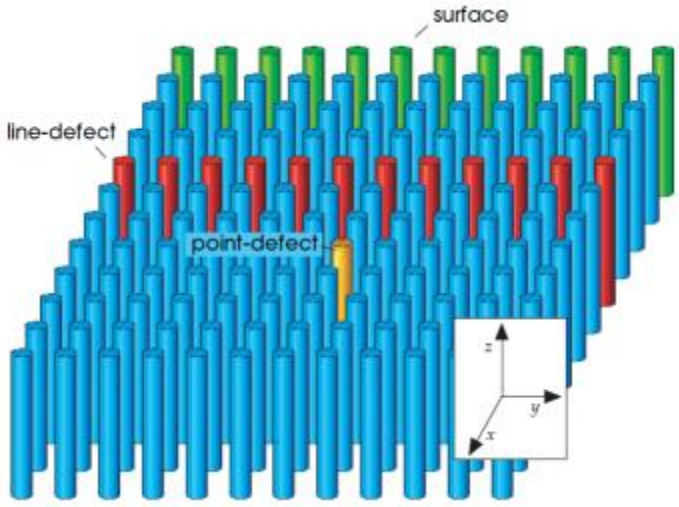


TM bandgaps: isolated high-ε

TE bandgaps: connected high-ε lattice

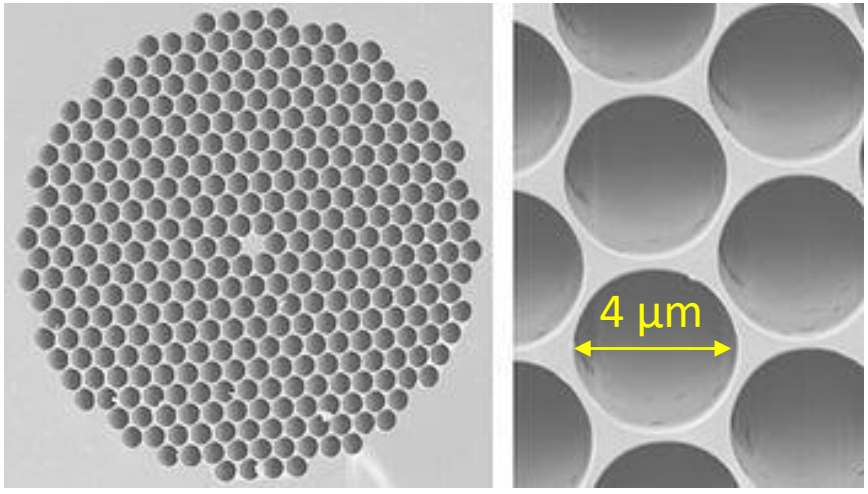
Band structure for two polarizations

Photonic crystal waveguides

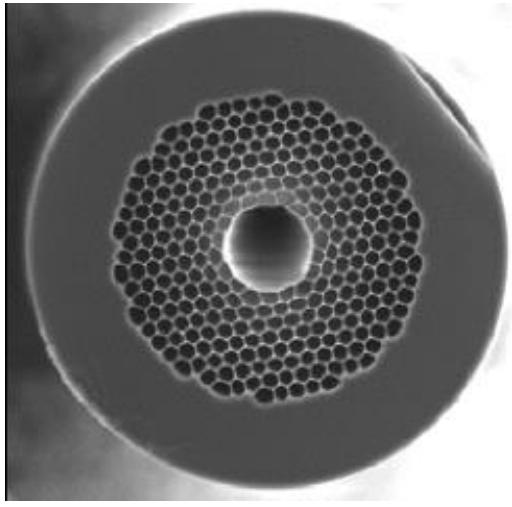


A point defect (e.g., a missing pillar) create a state in the gap: cavity mode and light trapping. (like defects in semiconductors)

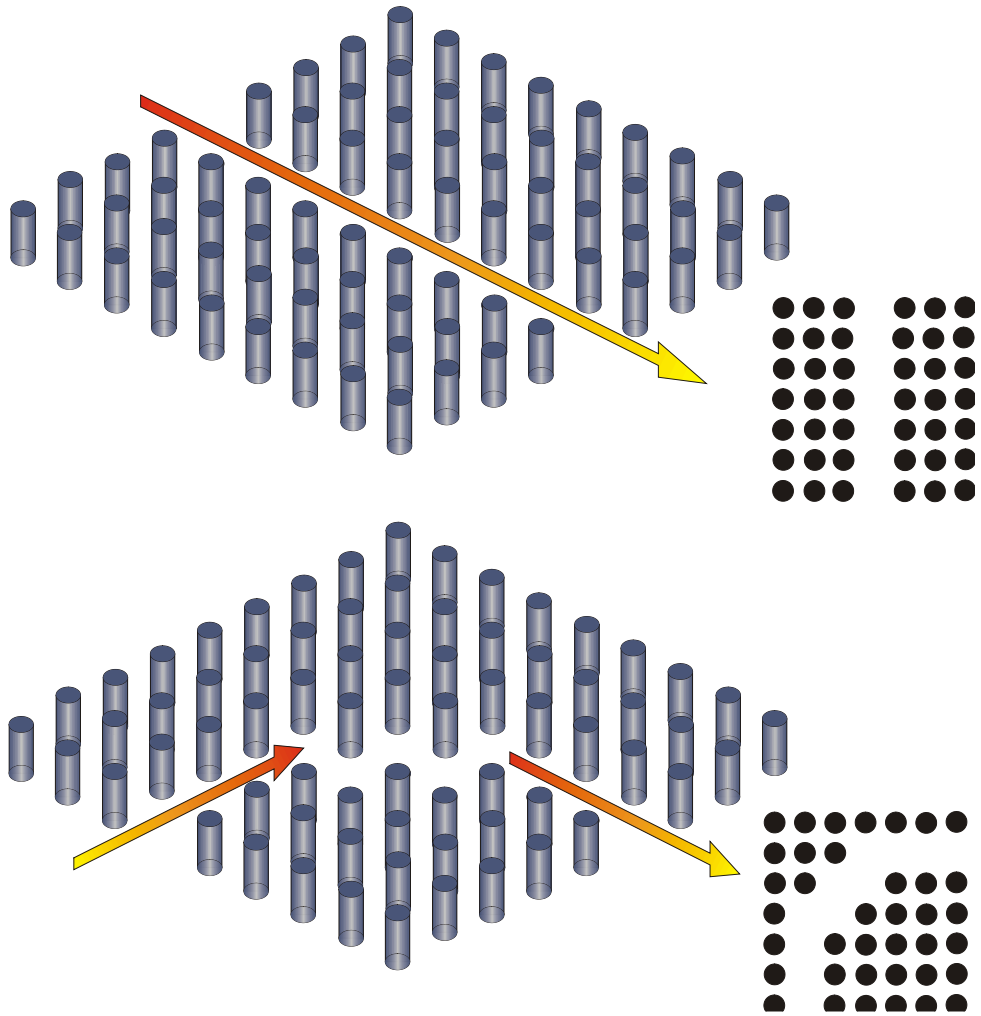
Photonic optical Fibers

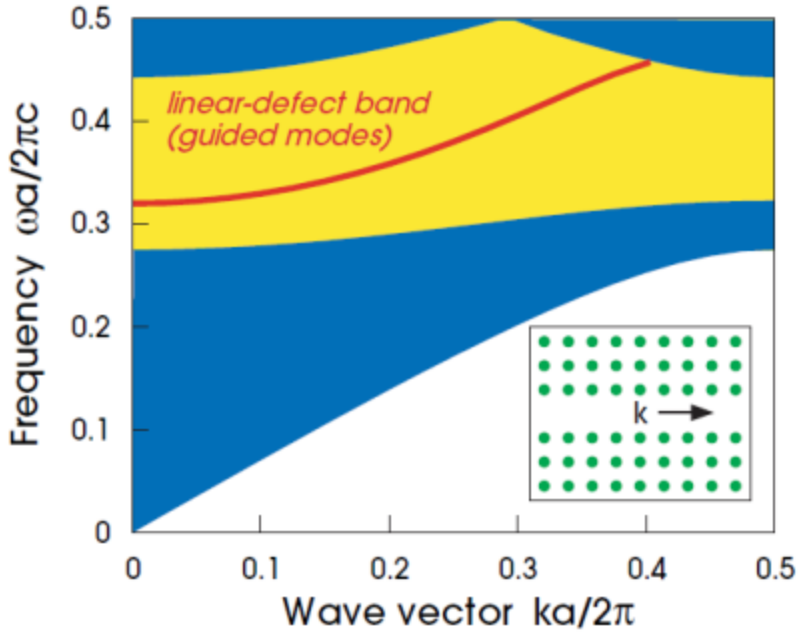


Photonic bandgap Fibers



Photonic crystal waveguides





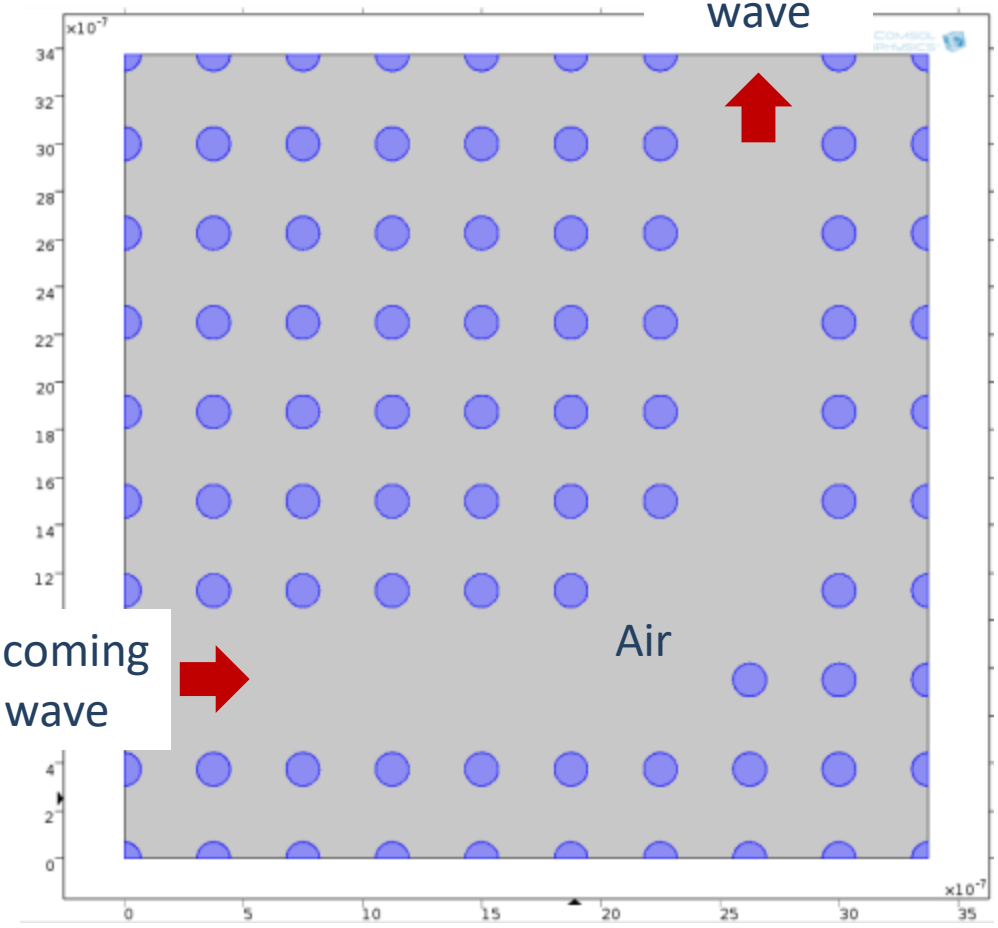
2D photonic crystal waveguide bend

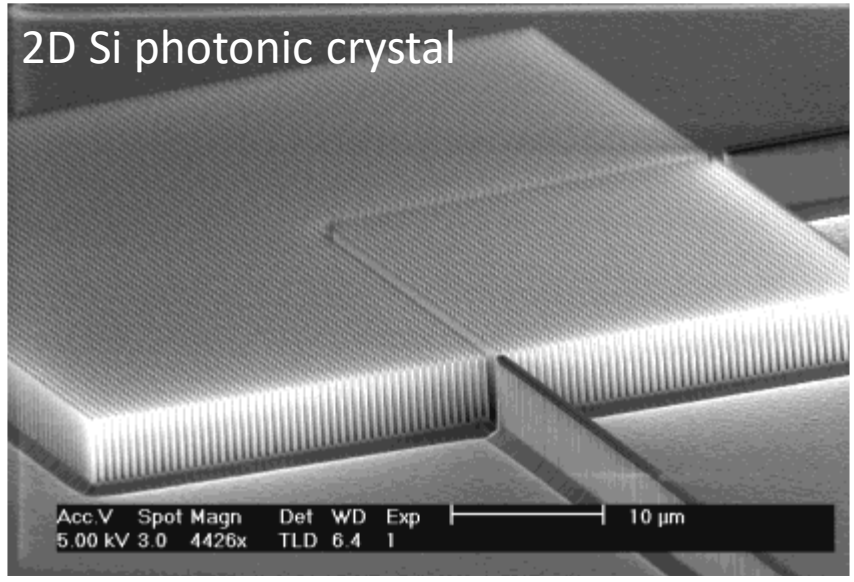
$\varepsilon_1 = 13\ (GaAs)$

$\varepsilon_2 = 1$

Pillars (GaAs)

Outgoing wave





A. Polman (FOM)

$$-\nabla \cdot \nabla E_z - n^2 k_0^2 E_z = 0$$

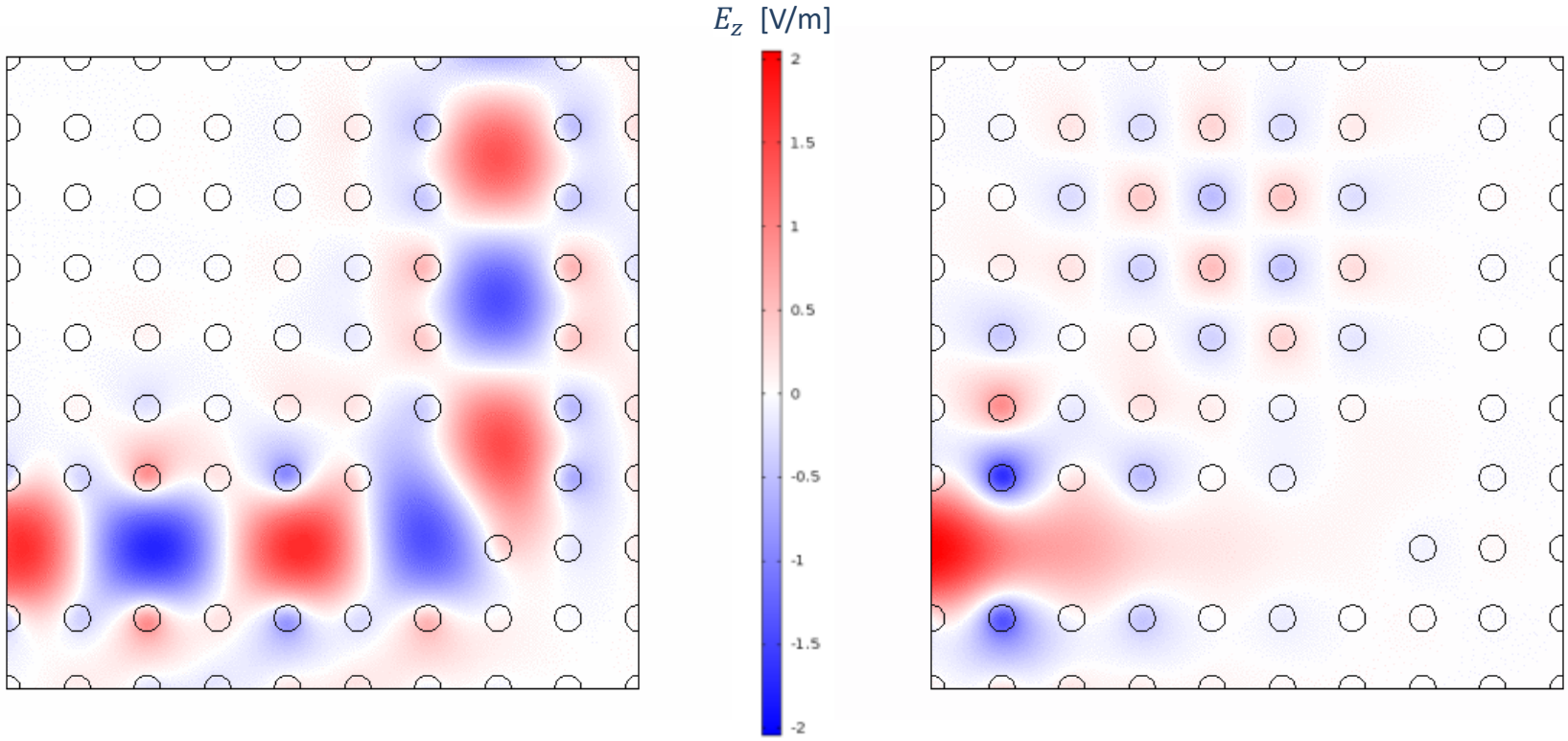
FEM Calculations

a = 368 nm

2D photonic crystal waveguide bend

$\lambda = 1033$ nm

$\lambda = 1234$ nm

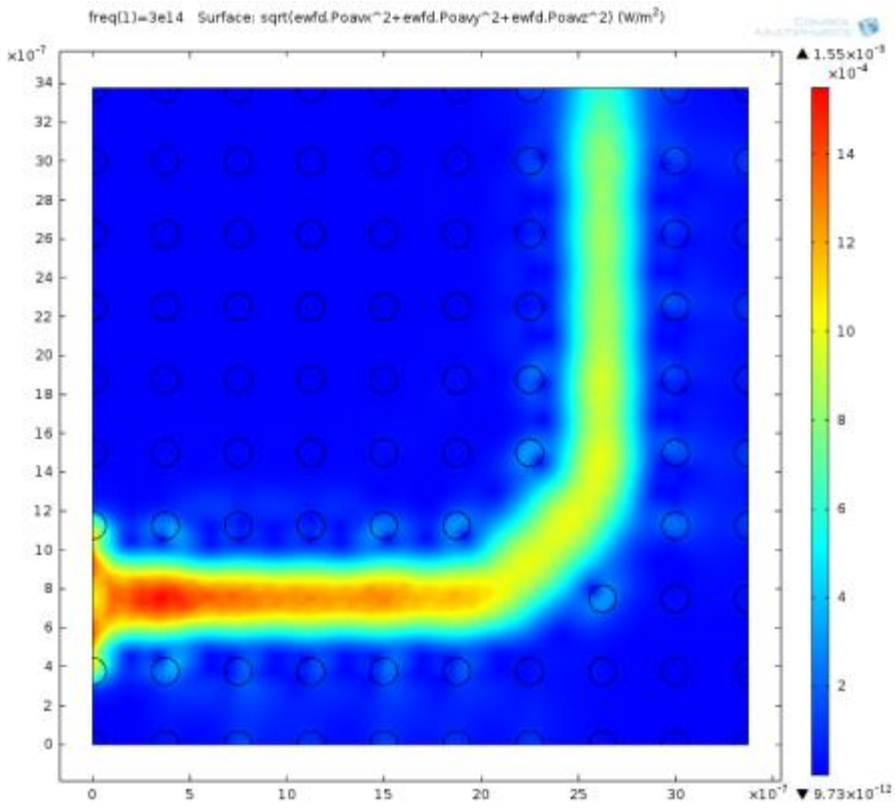


GaAs $\quad n(\lambda) = A - B\lambda = 3.503 - 3.33 \times 10^{-4}\lambda[nm]$

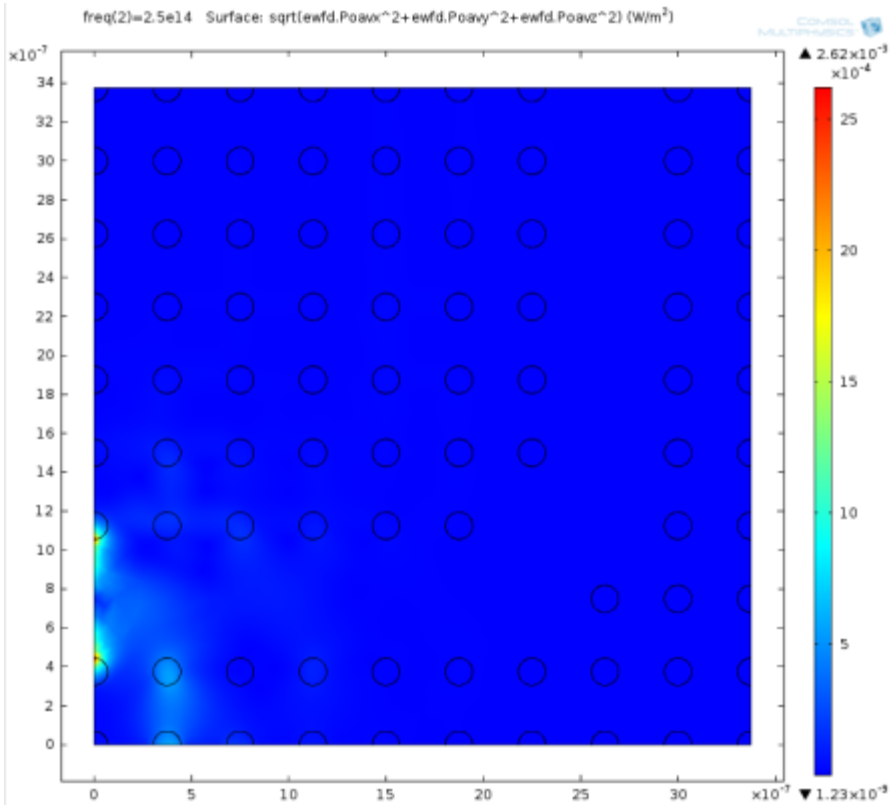
2D photonic crystal waveguide bend

Poynting Vector modulus $\boldsymbol{S} = \boldsymbol{E} \times \boldsymbol{H}$

$\lambda = 1033$ nm



$\lambda = 1234$ nm

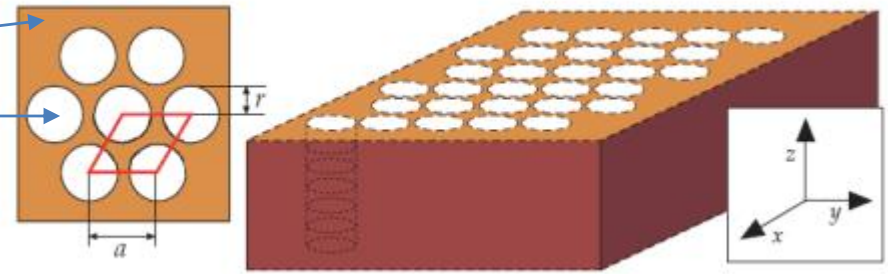


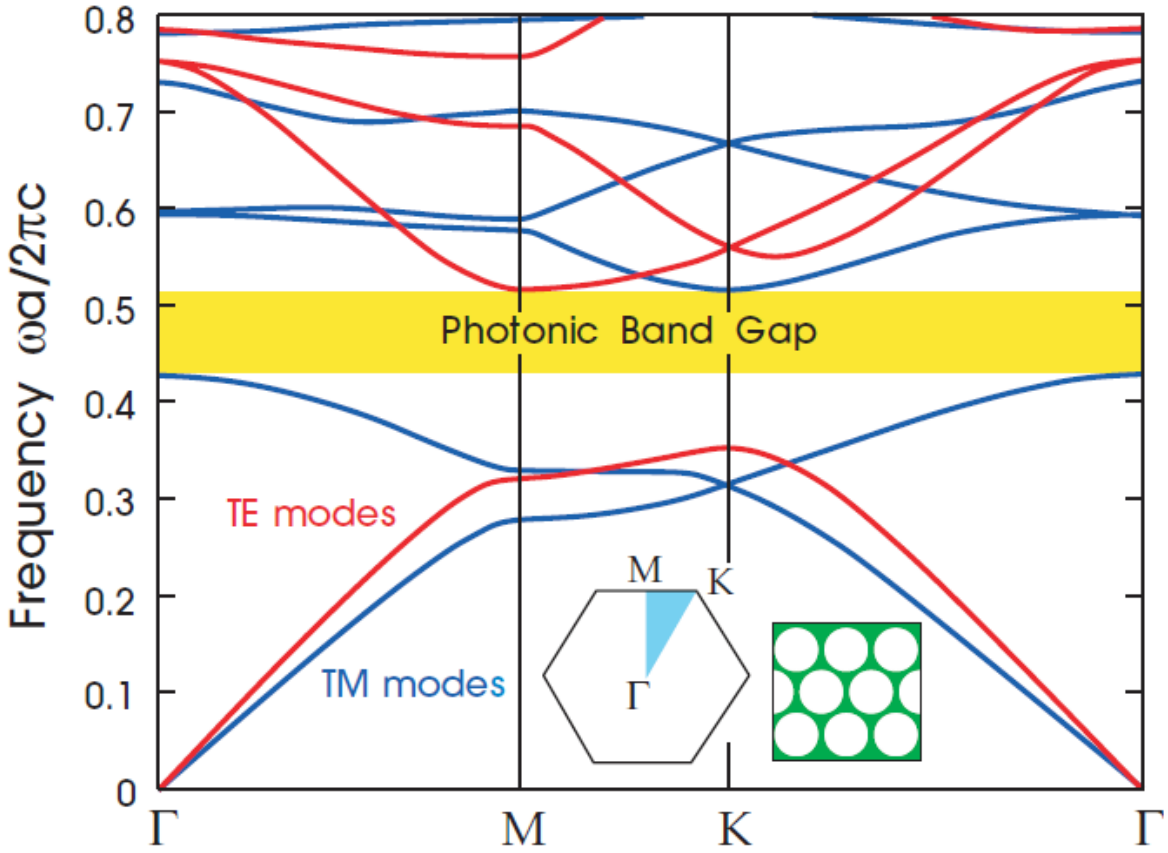
GaAs $n(\lambda) = A - B\lambda = 3.503 - 3.33 \times 10^{-4}\lambda[nm]$

2D photonic crystal bandgaps

$\varepsilon_1 = 13\ (GaAs)$

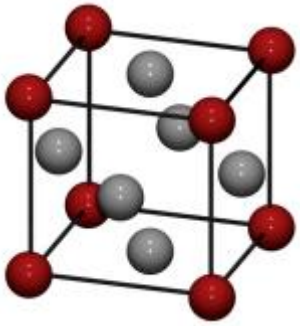
$\varepsilon_2 = 1$



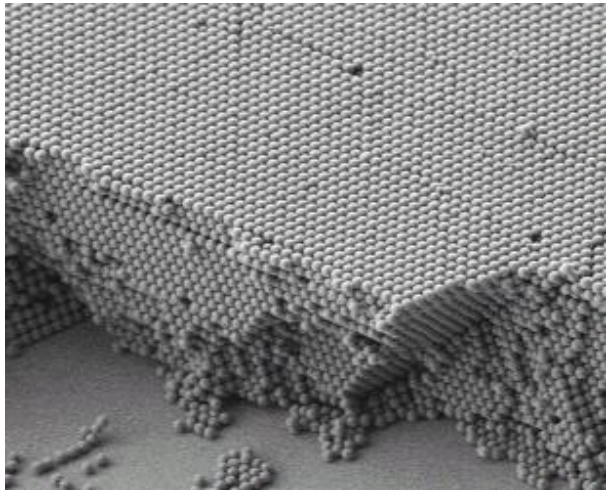


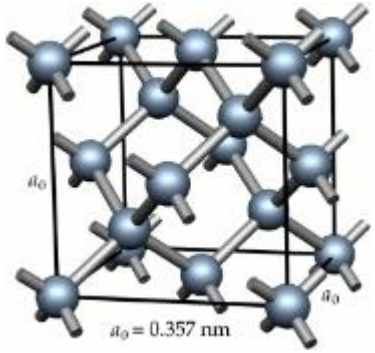
Photonic Bandgap for both TE and TM modes

3D photonic crystal

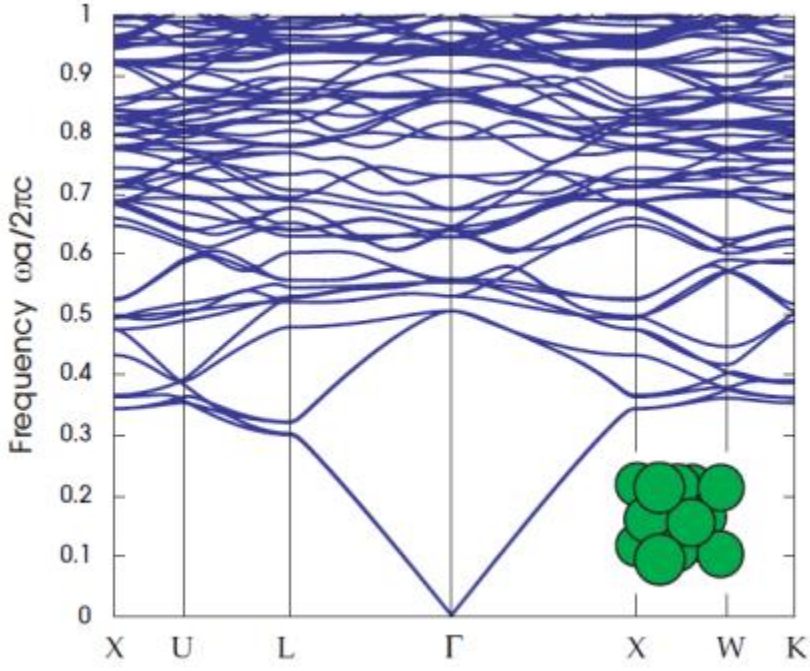


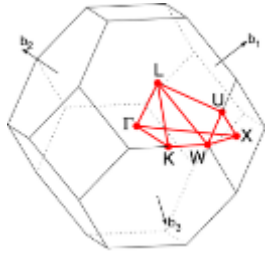
fcc

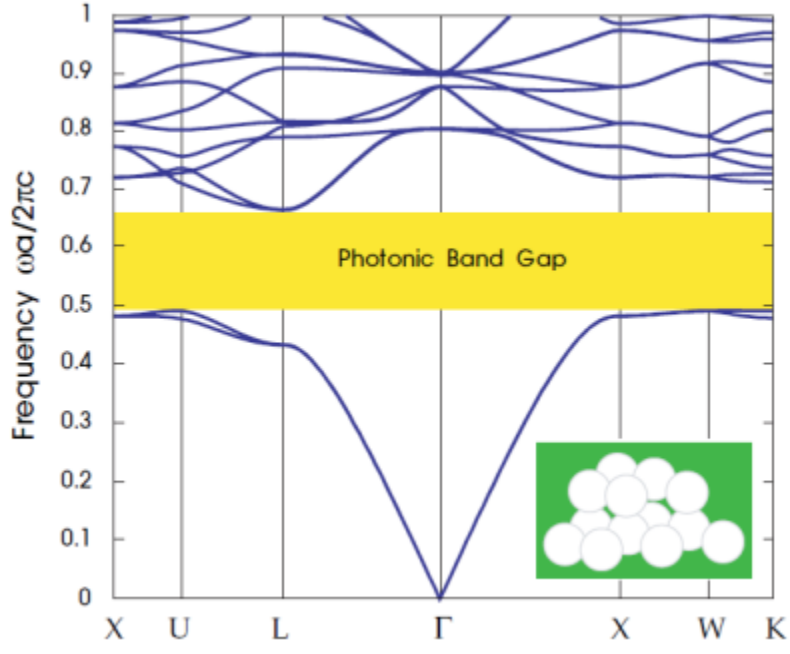




diamond

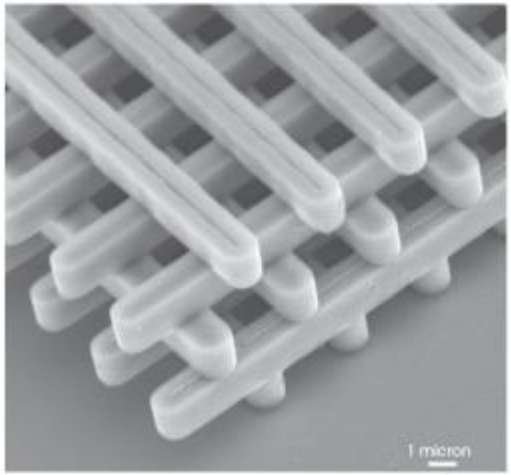


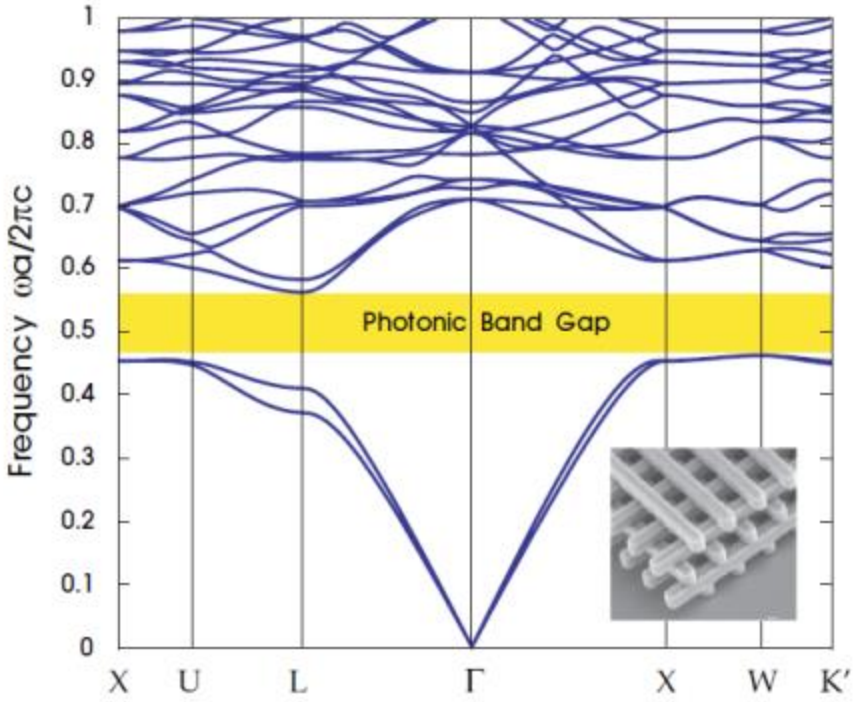




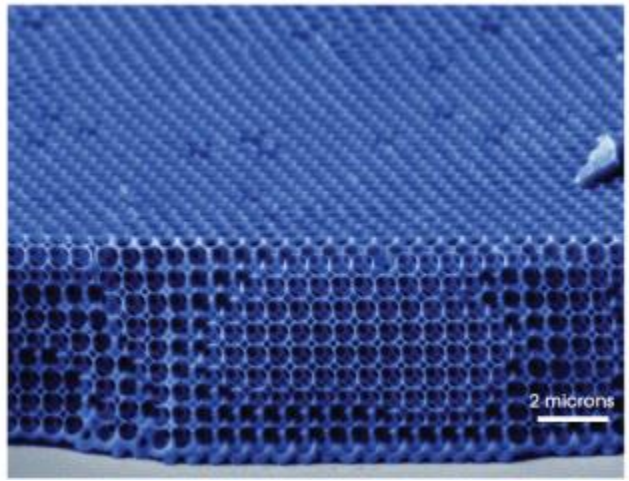
3D photonic crystal

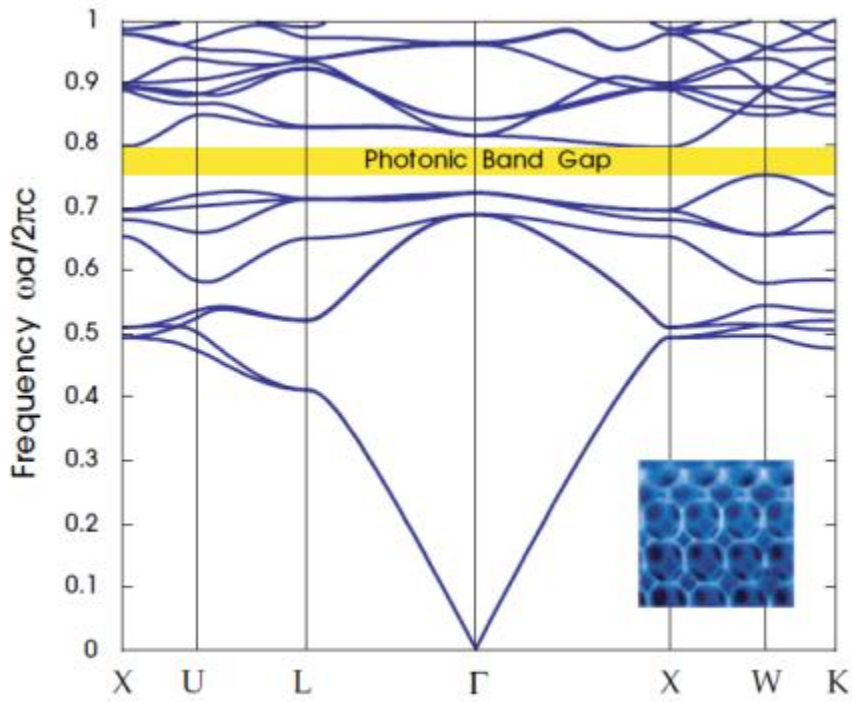
Woodpile



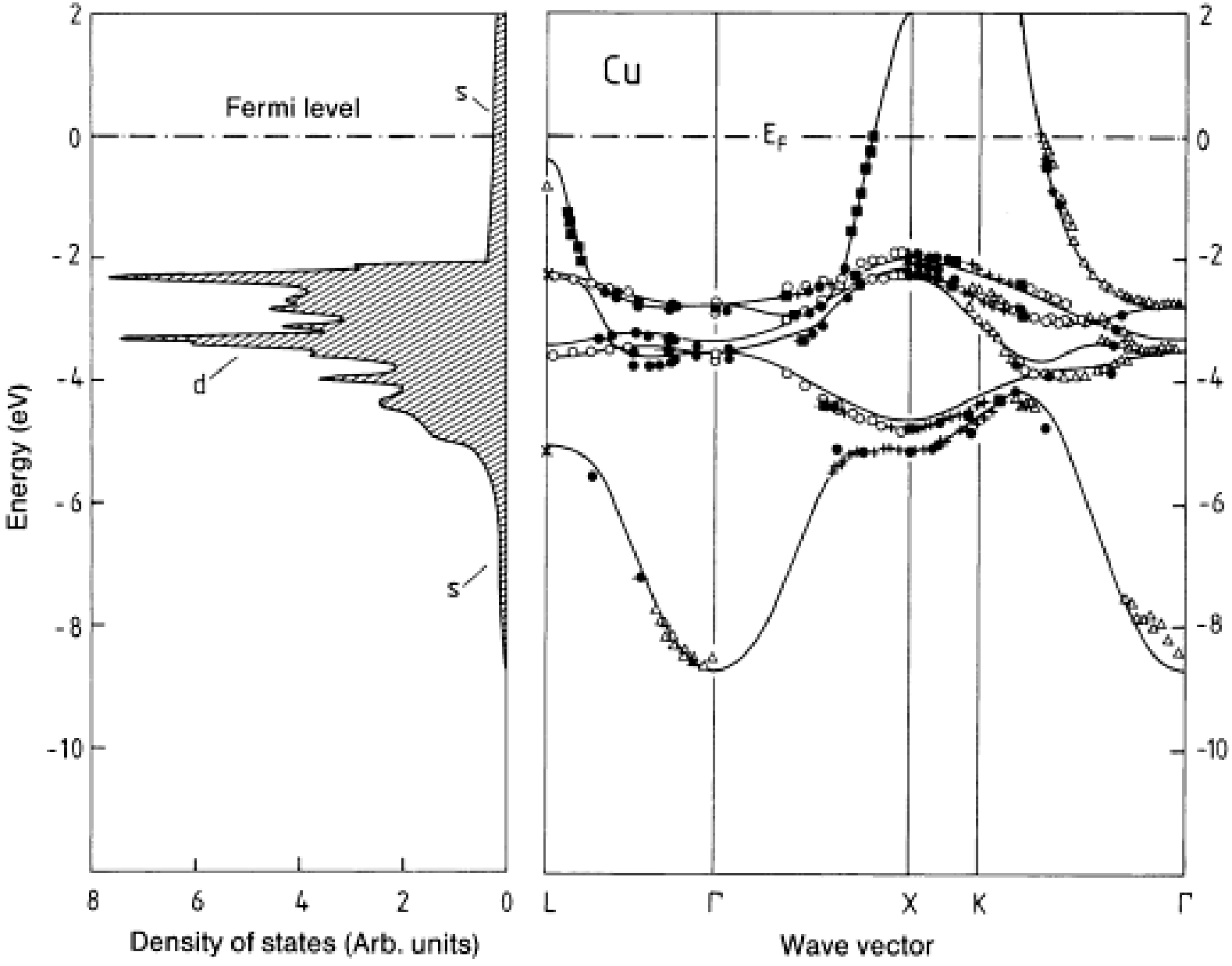


Inverse opal





Cu band structure



Ge band structure