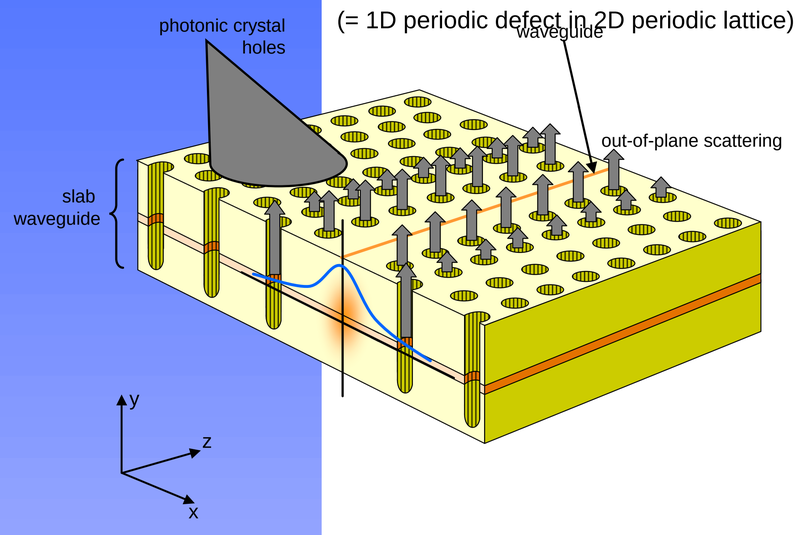
Ph

How to reduce out-of-plane scattering losses

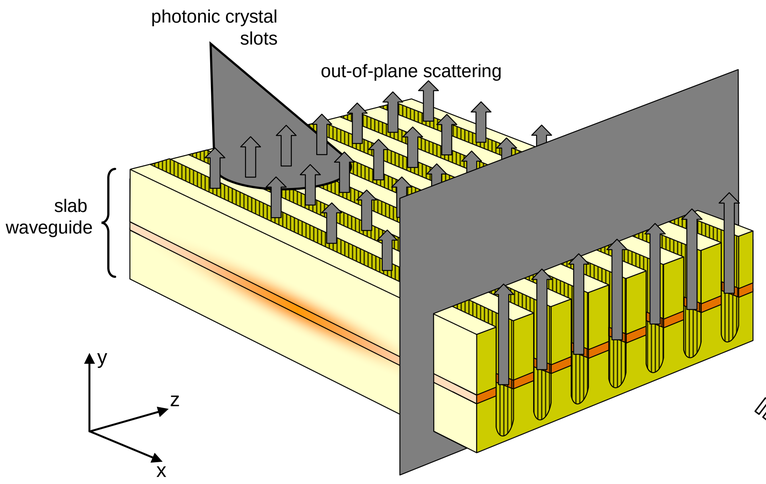
Wim Bogaerts, Peter Bienstman, Dirk Taillaert, Roel Baets

Photonic Crystal Slab waveguide

(= 1D periodic defect in 2D periodic lattice)



1D Periodic approximation

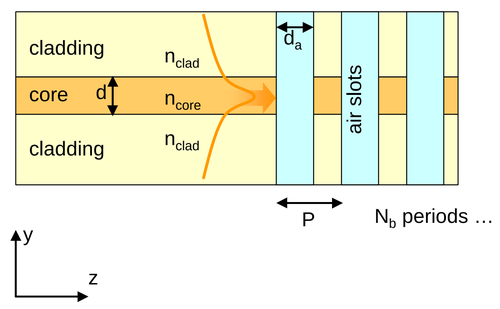


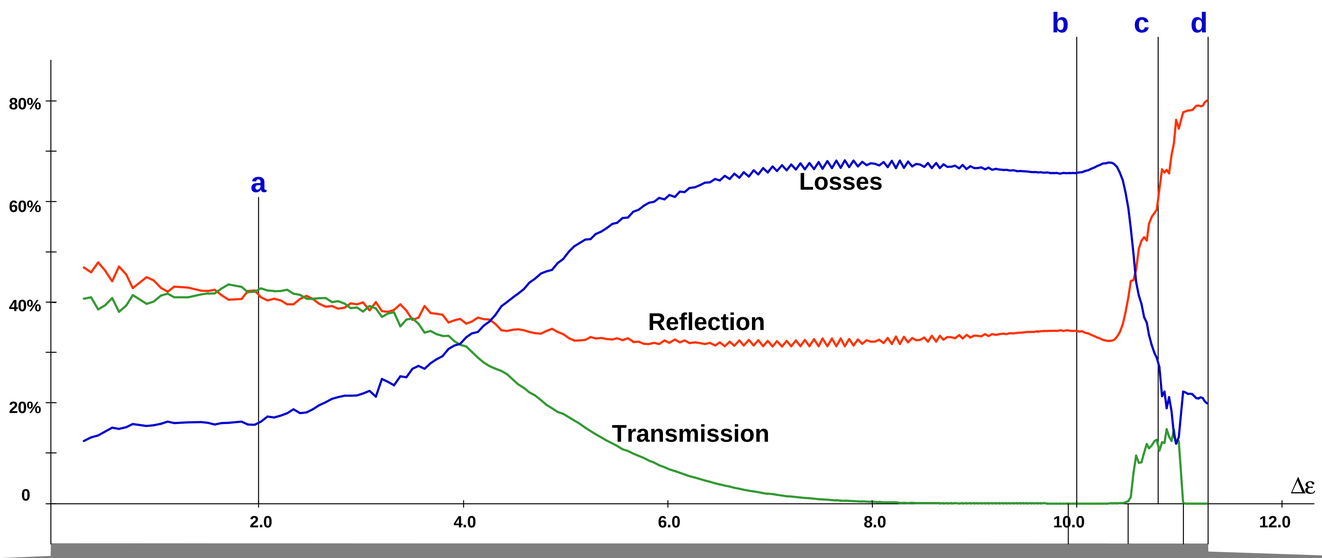
Problem

Reduce the scattering losses

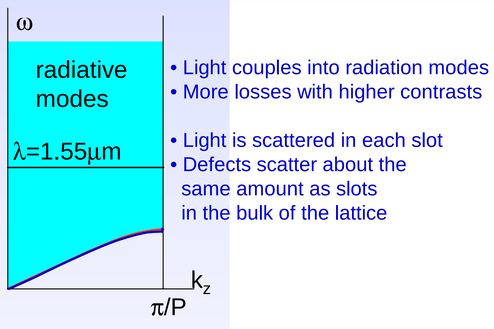
- **Optimal layer structure**
- **Optimal periodic structure**

Simulated structure

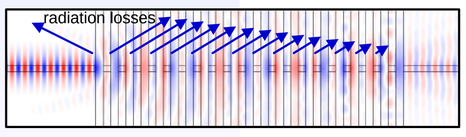




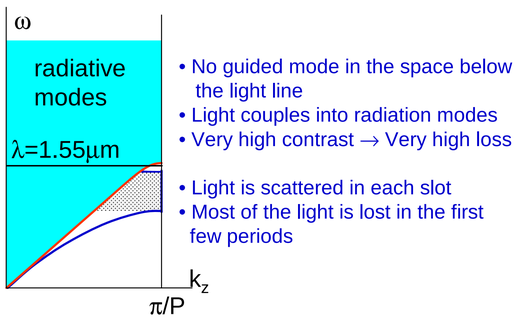
Above the light line:
Light couples into radiative modes



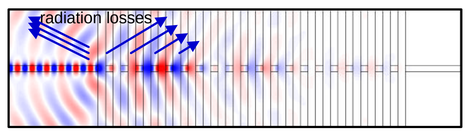
- Light couples into radiation modes
- More losses with higher contrasts
- Light is scattered in each slot
- Defects scatter about the same amount as slots in the bulk of the lattice



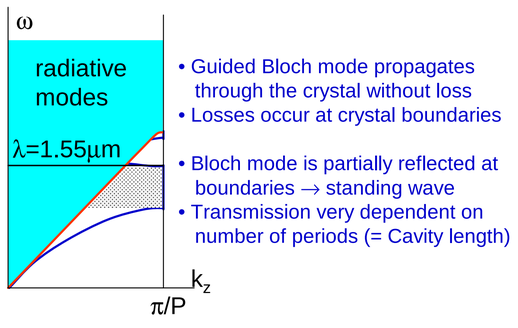
Below the light line:
Light couples into radiative modes



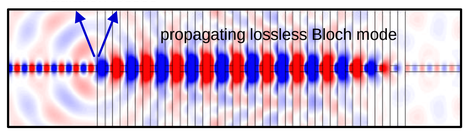
- No guided mode in the space below the light line
- Light couples into radiation modes
- Very high contrast → Very high loss
- Light is scattered in each slot
- Most of the light is lost in the first few periods



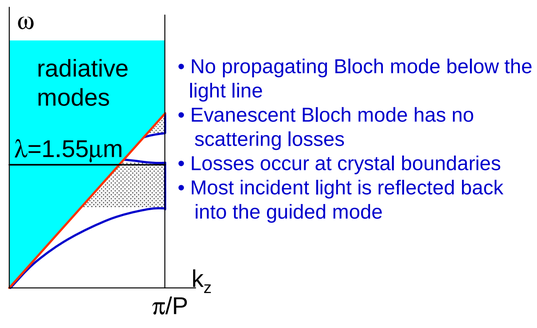
Below the light line:
Light couples into guided mode



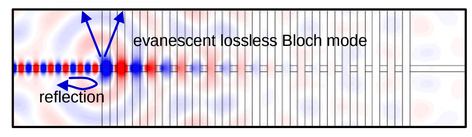
- Guided Bloch mode propagates through the crystal without loss
- Losses occur at crystal boundaries
- Bloch mode is partially reflected at boundaries → standing wave
- Transmission very dependent on number of periods (= Cavity length)



Below the light line:
Light is reflected in the photonic band gap



- No propagating Bloch mode below the light line
- Evanescent Bloch mode has no scattering losses
- Losses occur at crystal boundaries
- Most incident light is reflected back into the guided mode



Conclusion

What choice of layer structure is optimal for reducing out-of-plane scattering losses?

Low index contrast (case a)

- For lattices with much defects (bends, cavities)
- Not-too-extensive lattices
- Slab mode not well confined
- Deep etching technology required

Guided Bloch mode (case c)

- For large homogeneous lattices
- Few, widely separated defects
- Very tightly confined slab waveguide mode
- Oxide or air cladding required (no active devices)

Abstract

In photonic crystal slabs an in-plane photonic crystal is combined with a slab waveguide. Light is then confined in plane by the photonic crystal and out-of-plane by the slab waveguide. The etched structures will cause light to scatter out of the waveguide plane. We studied the out-of-plane scattering losses of these holes using a 2D approximation of this 3D structure, with etched slots instead of holes. We show that the losses increase with higher index contrast, but that with very high index contrasts light can be coupled into lossless Bloch modes.

References

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