Inverse design

of novel Nanophotonic Structures

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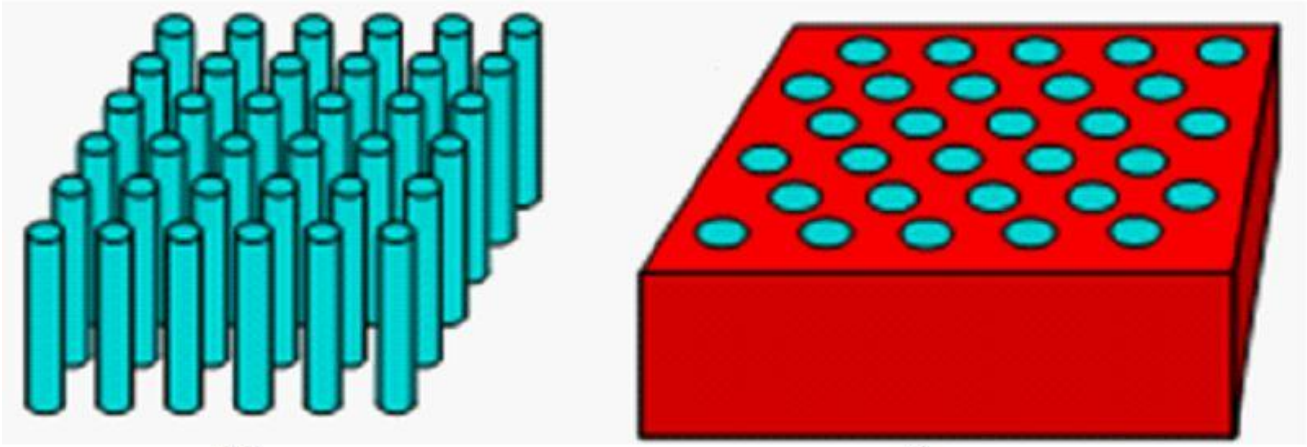
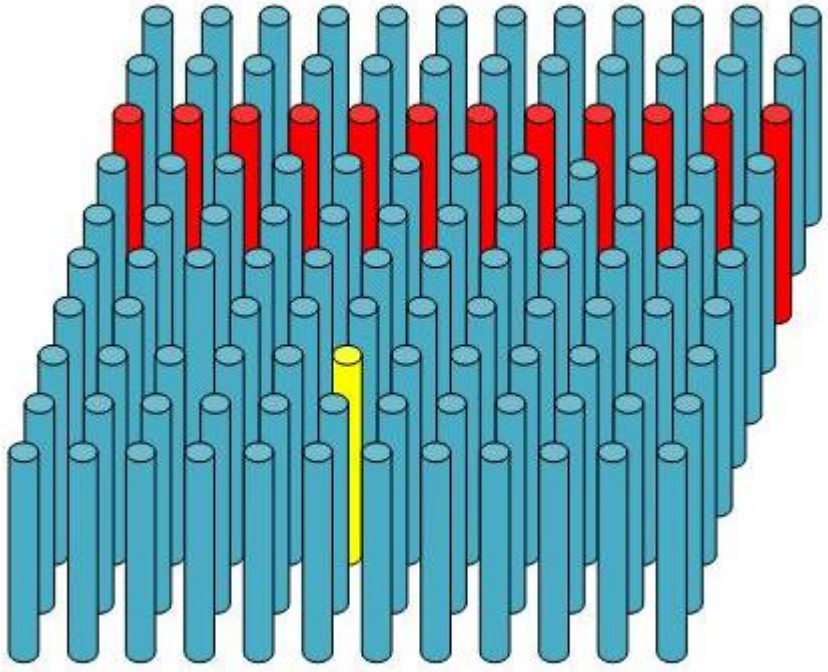
Photonic Crystals

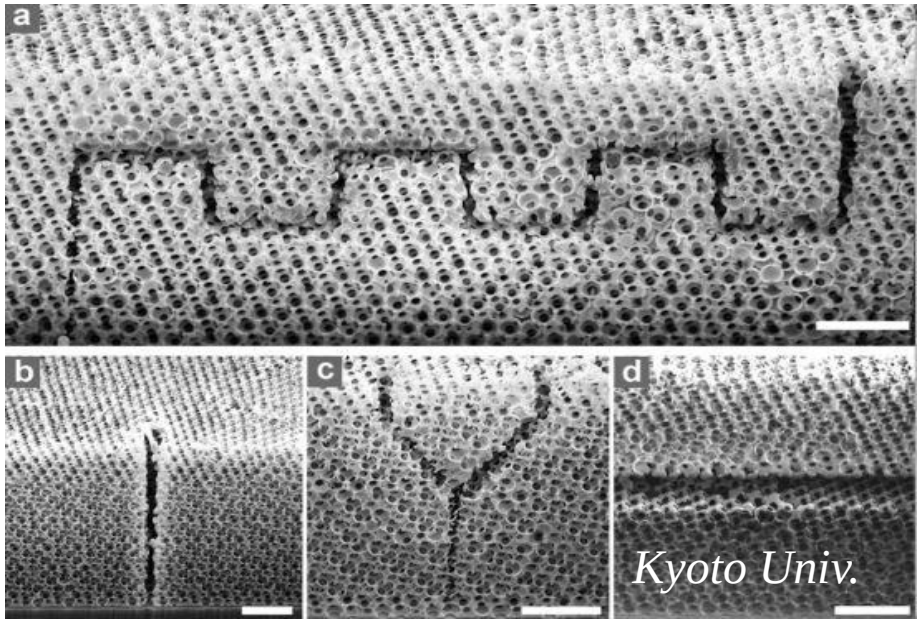


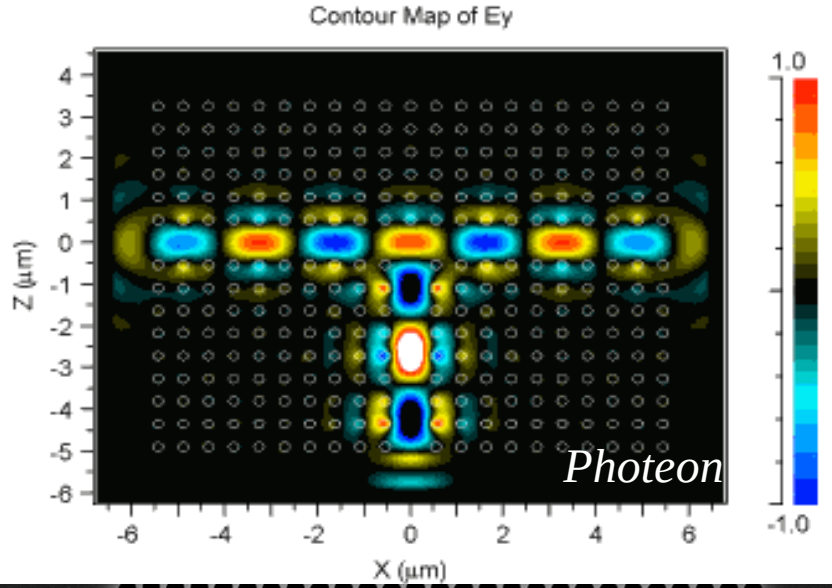


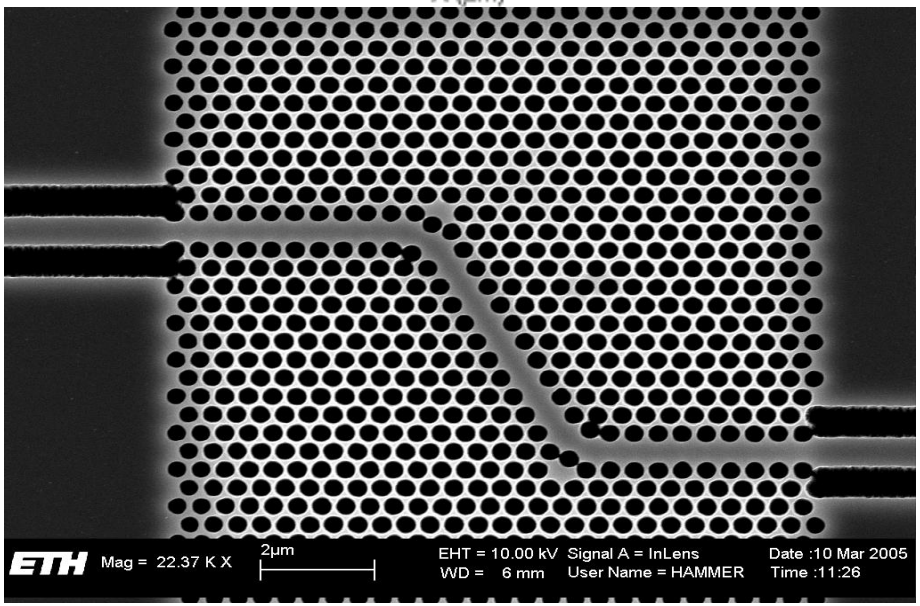
Photonic Crystals

Passive devices:

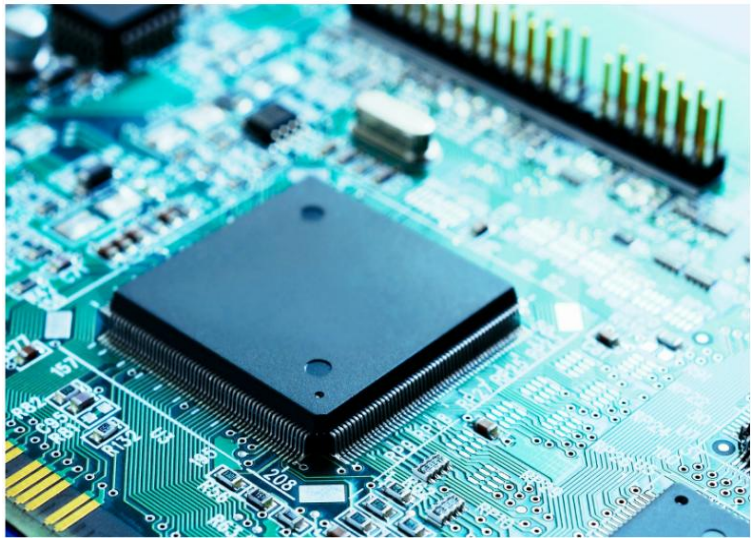
- Low loss waveguides supporting :
  - Bends.
  - Power splitting.
- Control the flow of light.

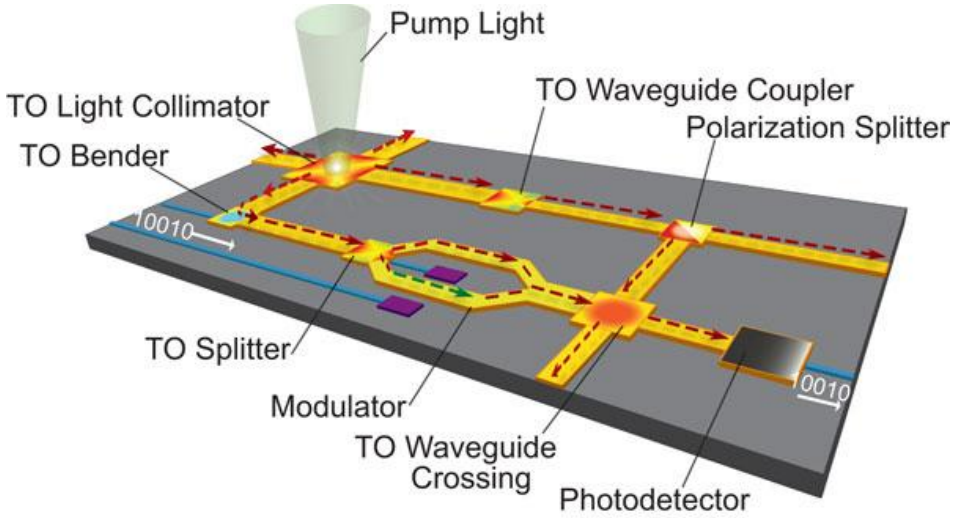






Motivation





(Q. Wu et al., LSA., 2012)

Integrated Circuits:

- Easy replacement.
- CMOS technology.
- VLSI, 3D-IC.

Photonic Integrated Circuits:

- Future networks.
- No electro-optic conversion.
- Large integration.

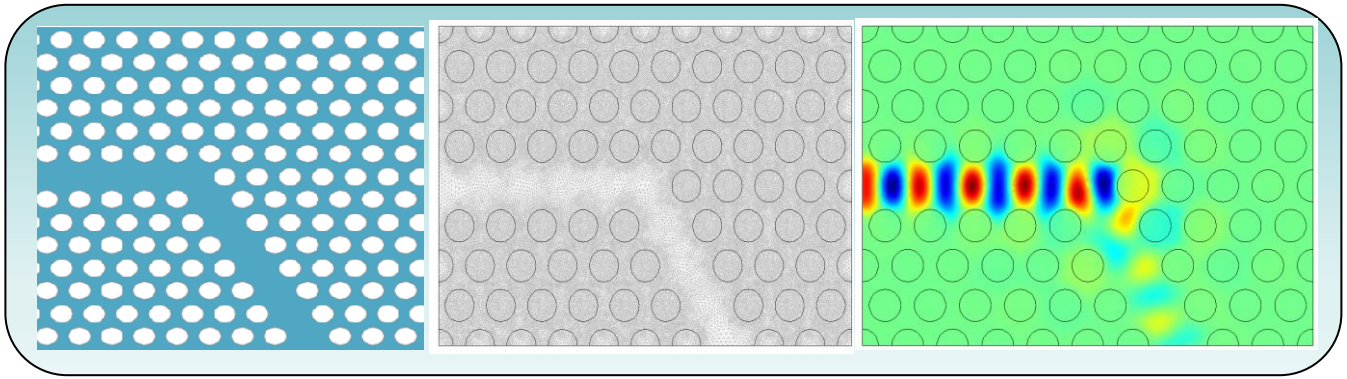
Photonic Crystals(PCs):

- Low losses, high efficiency.
- Lithography.
- Hard to design.

Complex PC devising: Milestones

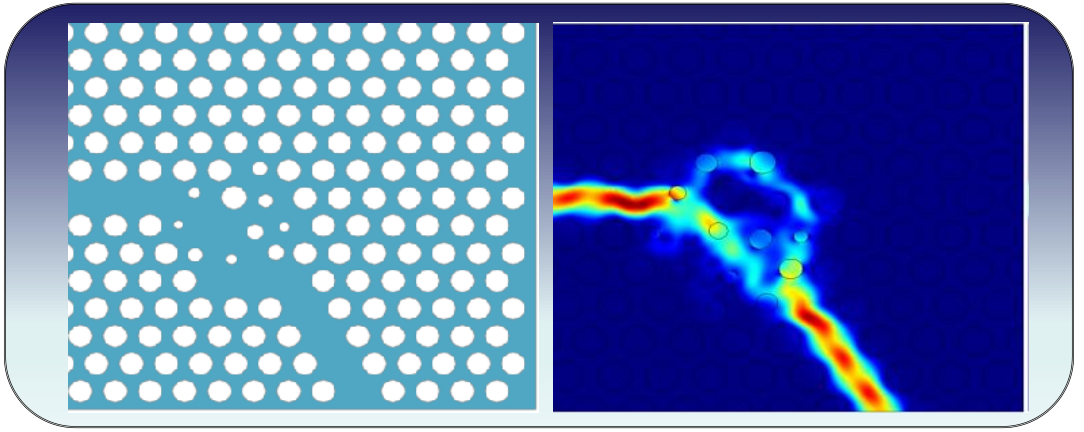
EM modelling

I. Andonegui, A.J. Garcia-Adeva
Optics Express, 2013

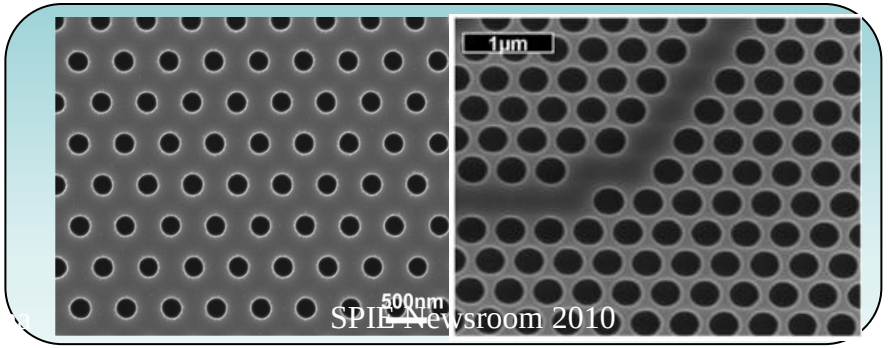


Design of new devices

I. Andonegui, A.J. Garcia-Adeva
Appl. Phys. A., 2013



Submicron manufacturing

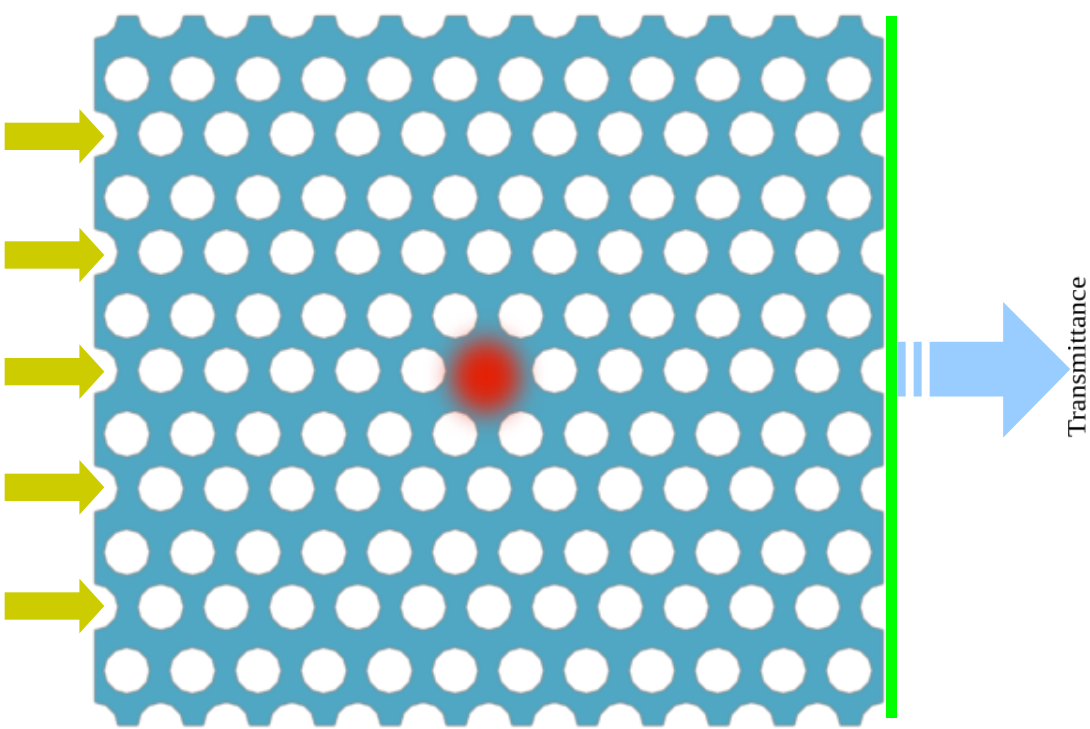


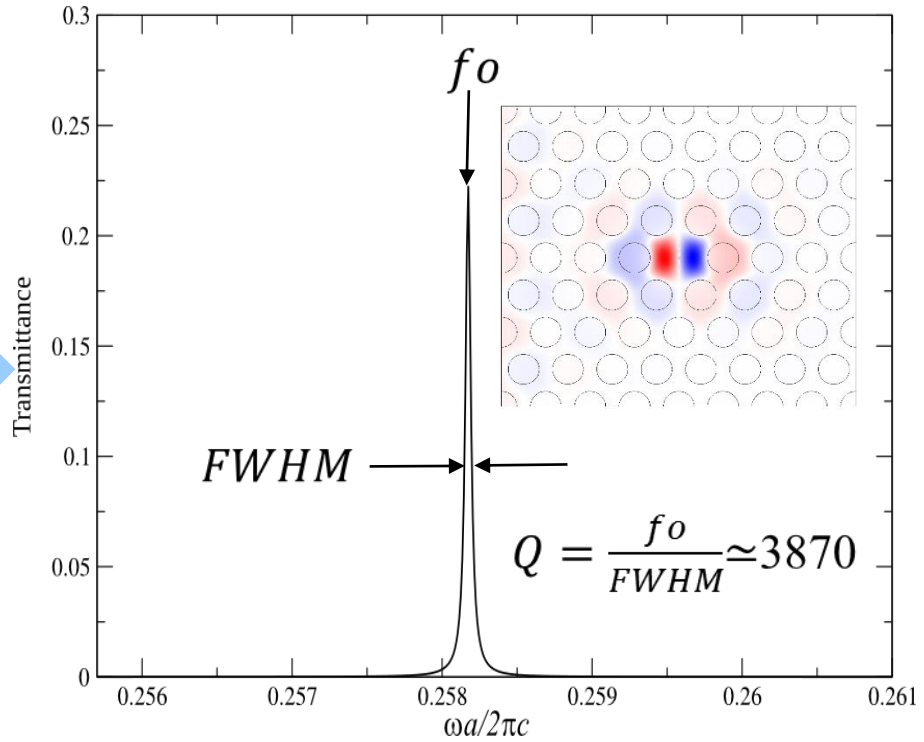
SPIE Newsroom 2010

Why use an Inverse Design method?

High Q cavity using traditional approach

1. Set starting geometry.
2. Compute fields.
3. Evaluate property.



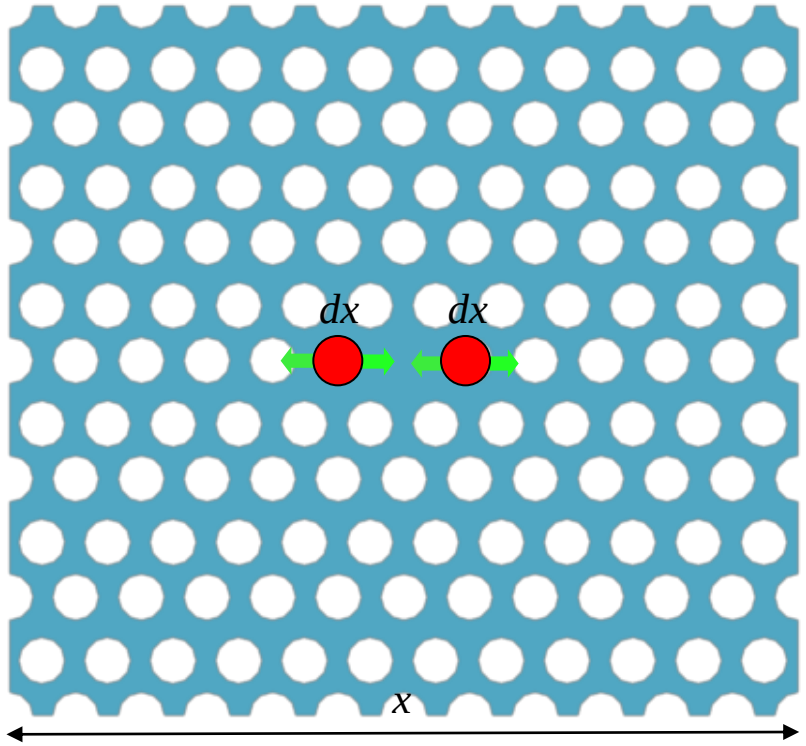


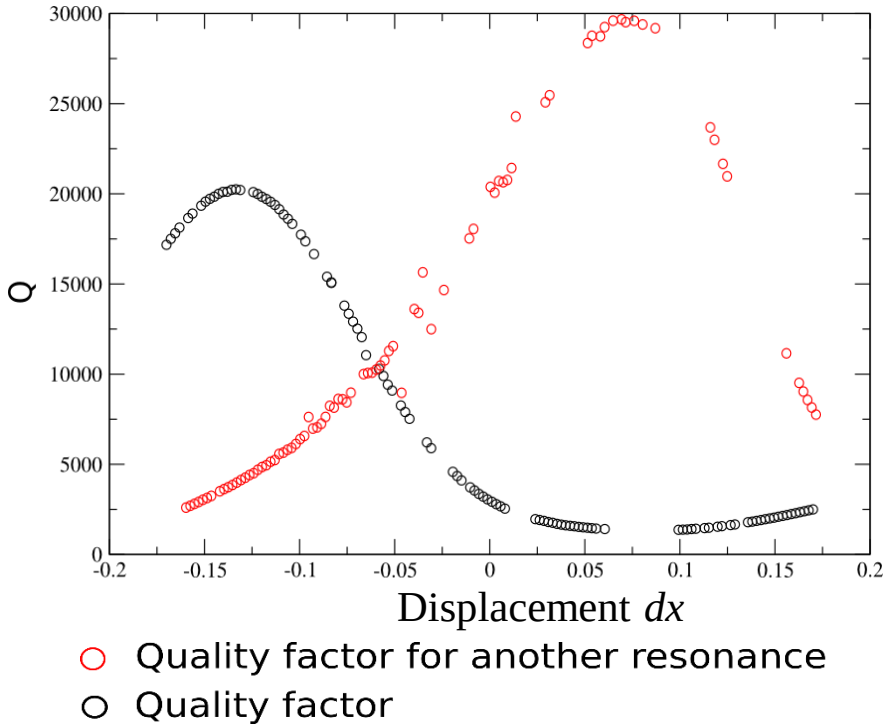
Direct approach

Direct Design

1. Compute fields.
2. Evaluate
3. Displace a hole.
4. Repeat steps 1-3.
5. Tune another hole.

- Time consuming
- Poor efficiency.
- Computationally HARD: D-dimension search NP-hard.
- Many resonances.
- N-objectives not feassible.





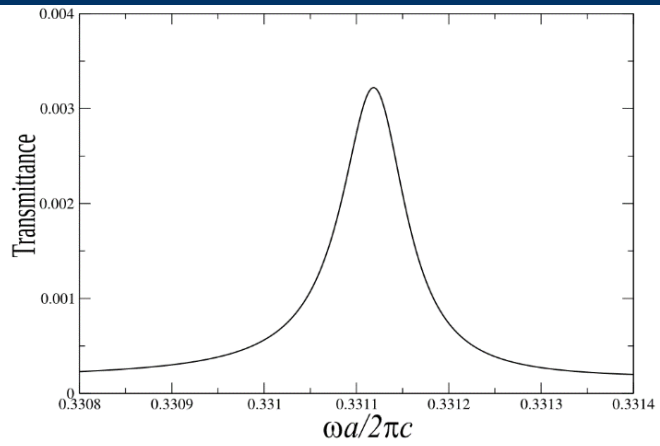
Inverse Design

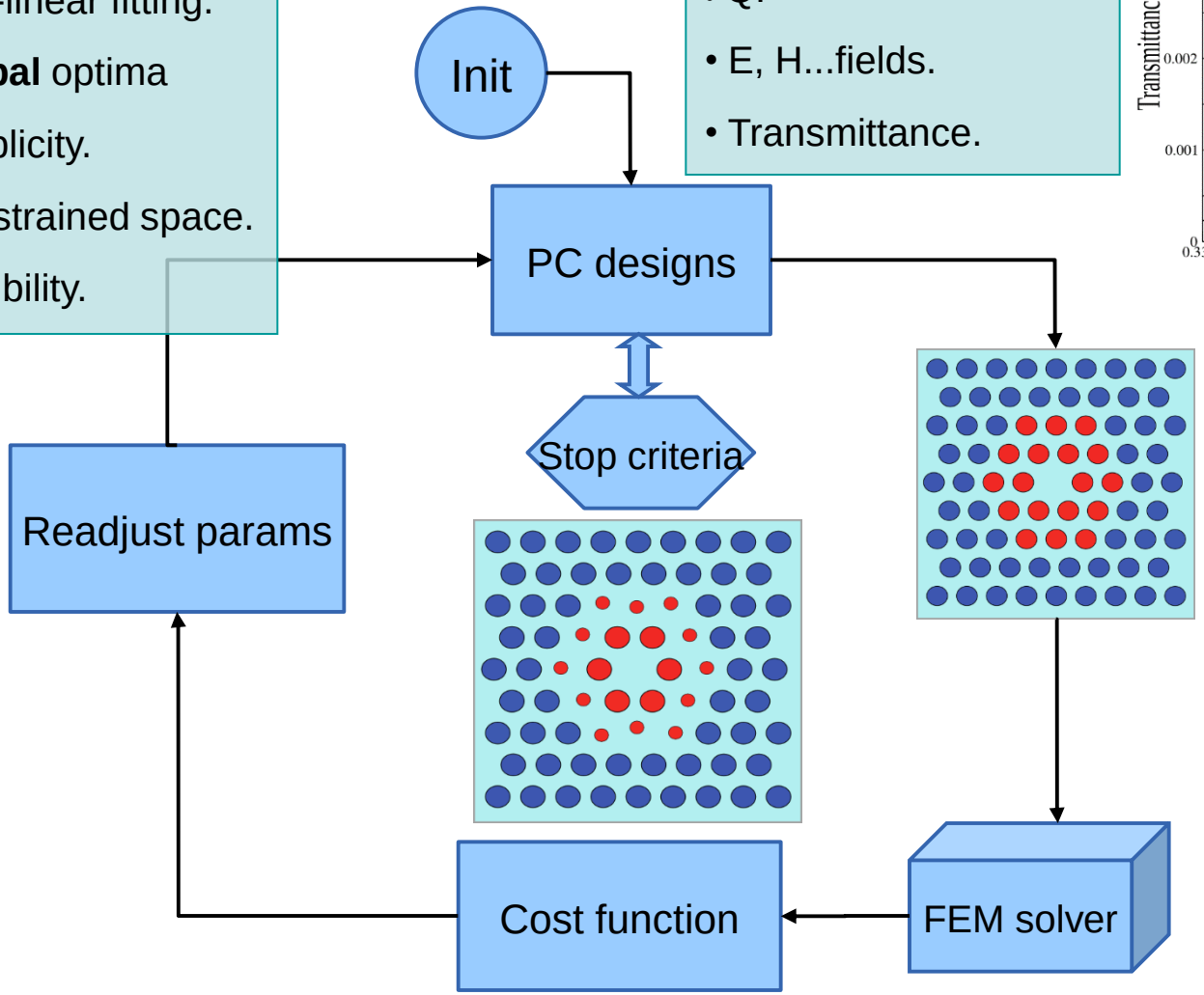
Heuristics

1. Non-linear fitting.
2. **Global** optima
3. Simplicity.
4. Constrained space.
5. Flexibility.

Objective function

- Q.
- E, H...fields.
- Transmittance.

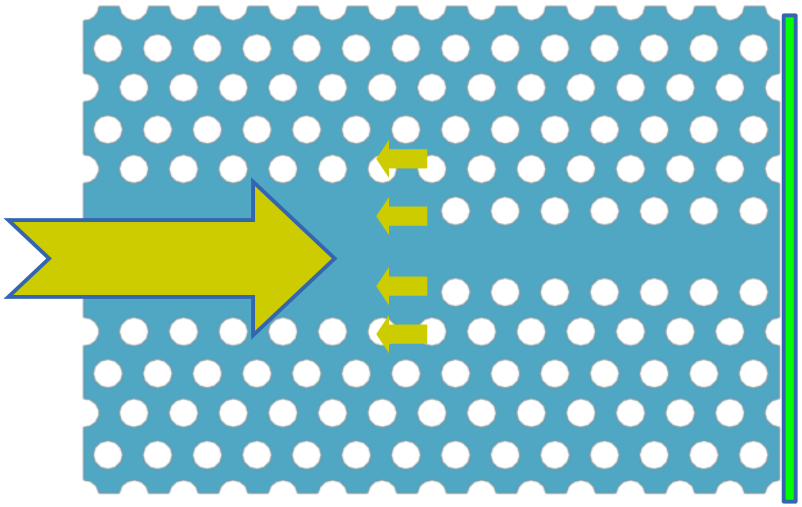


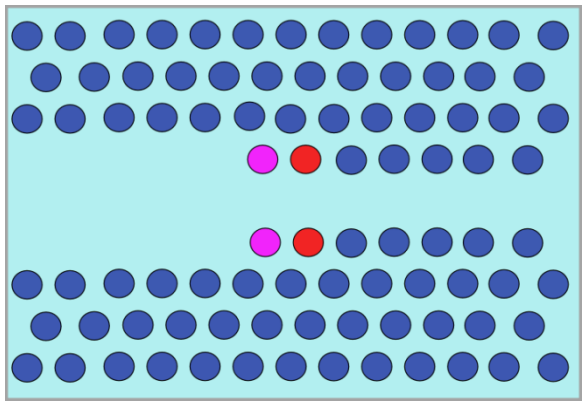


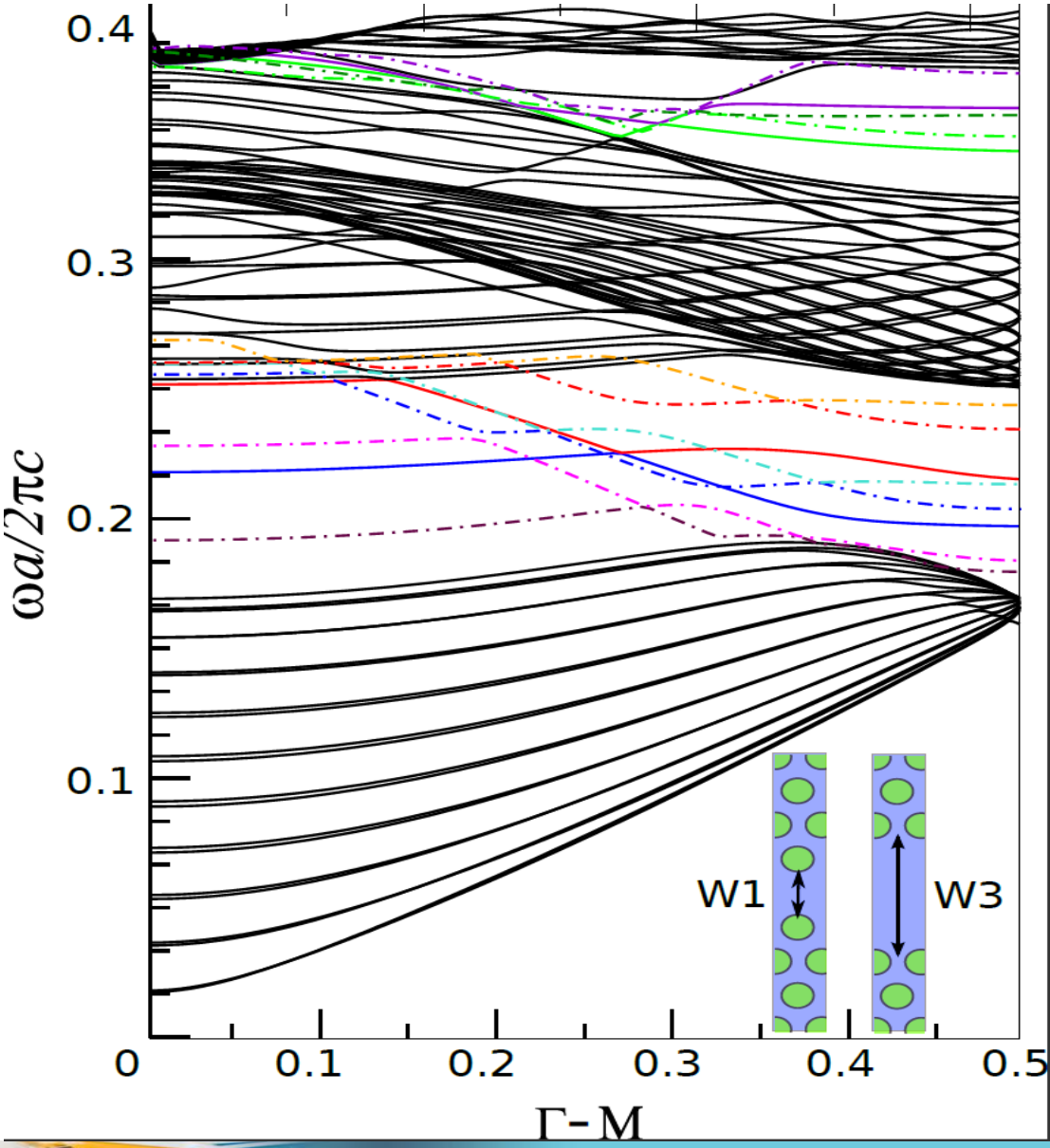
FEM

1. Stationary regime.
2. Fast, accurate.
3. Efficient.

A short tapering stage by Talneau et al.







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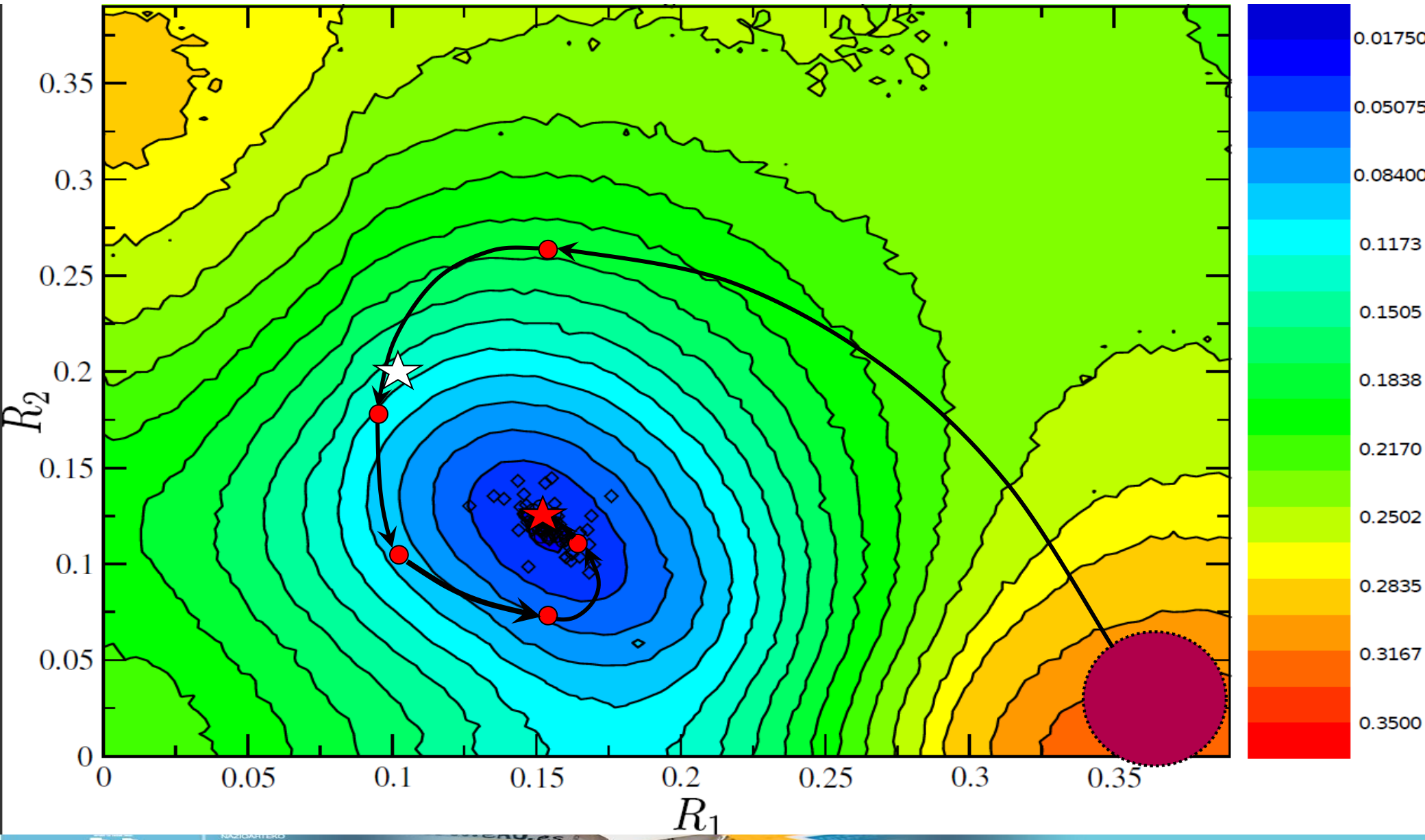

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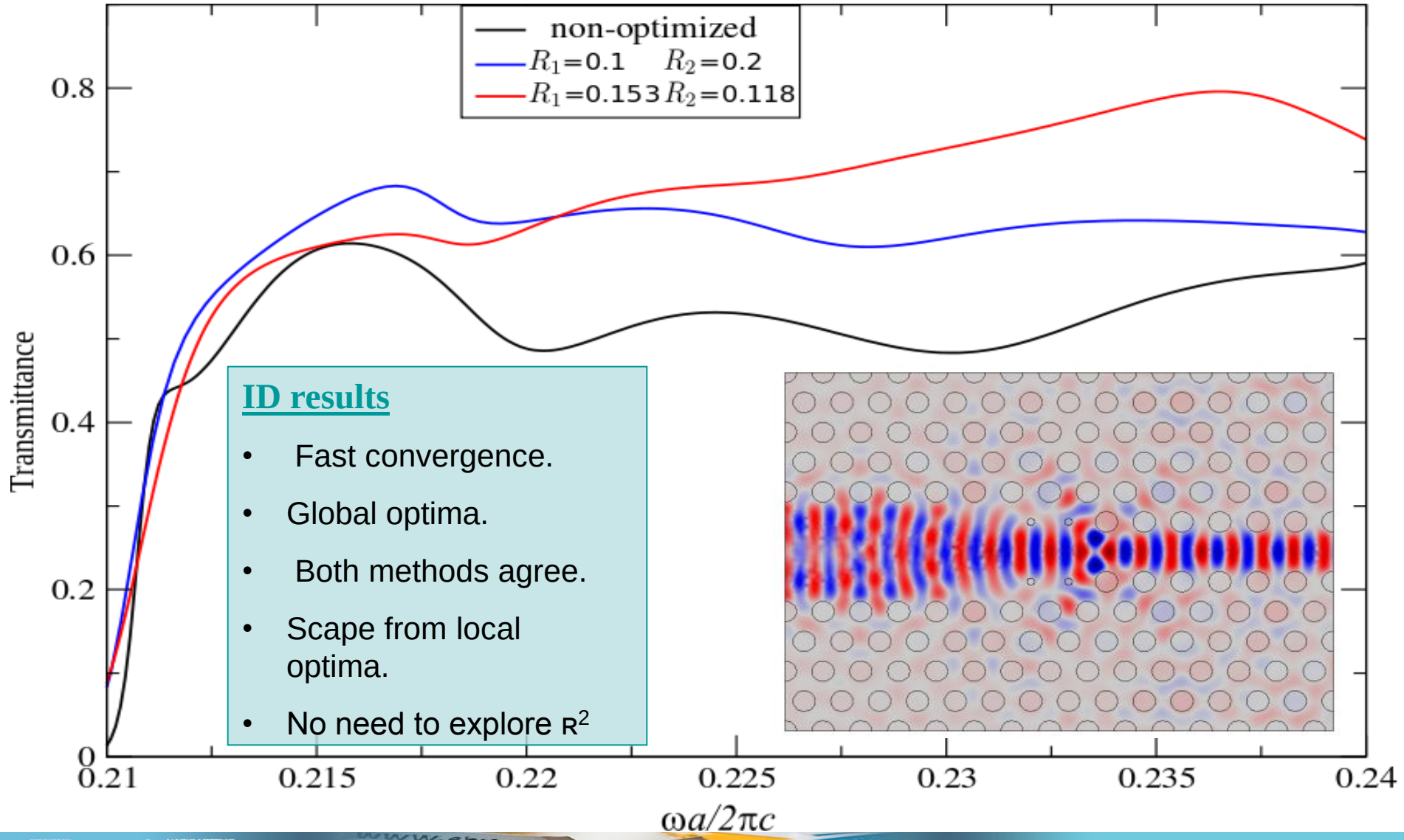
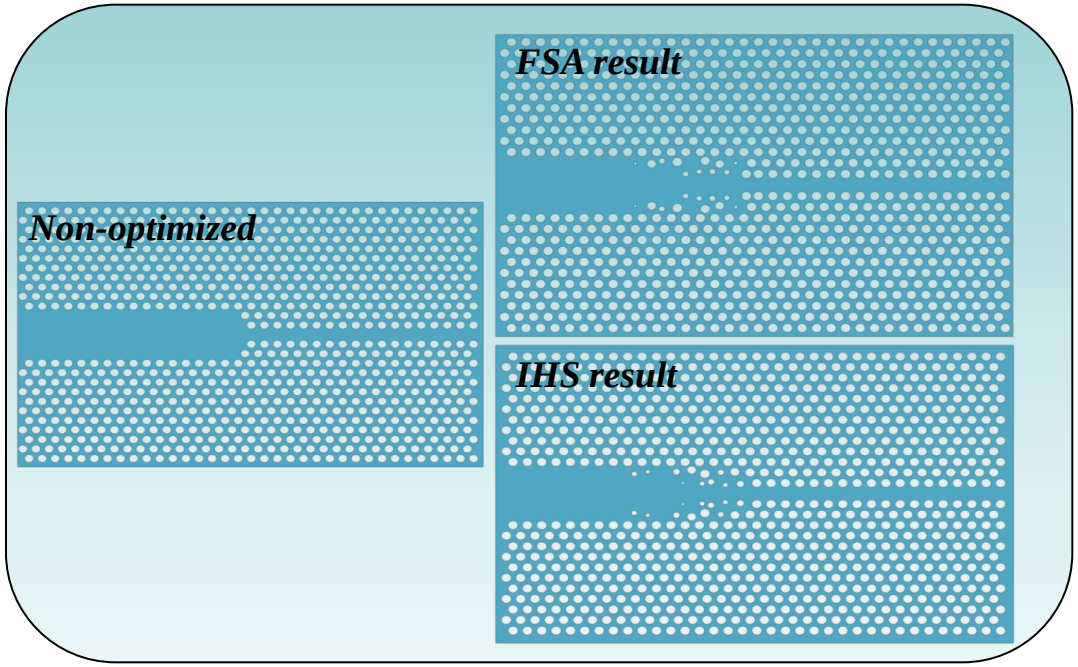
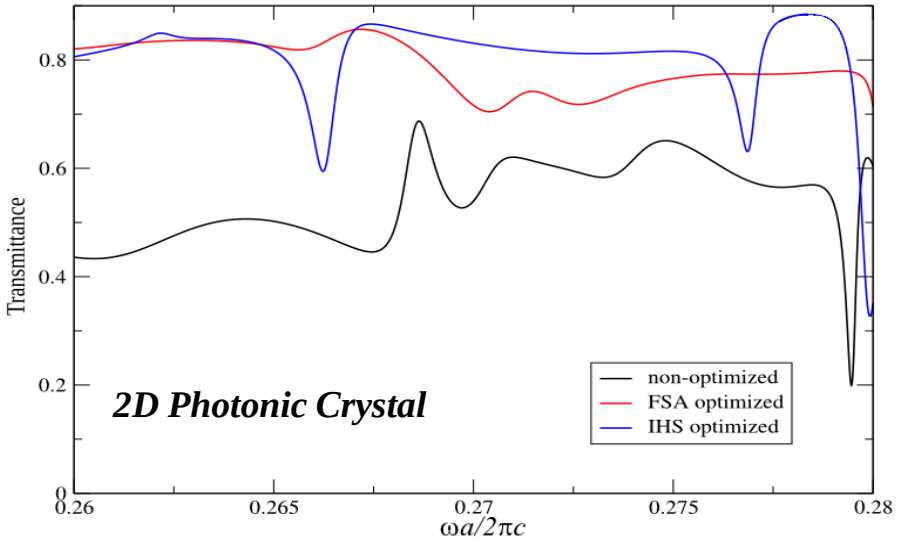


ID results

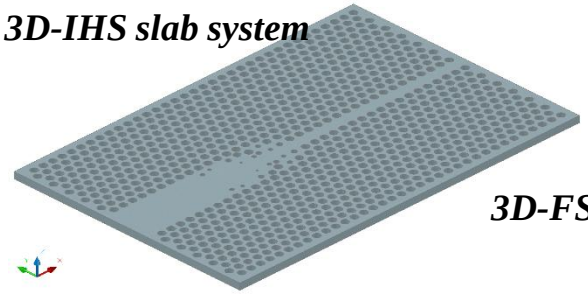
- Fast convergence.
- Global optima.
- Both methods agree.
- Scape from local optima.
- No need to explore R^2

Target cases: W5-W1 broadband mode couplers

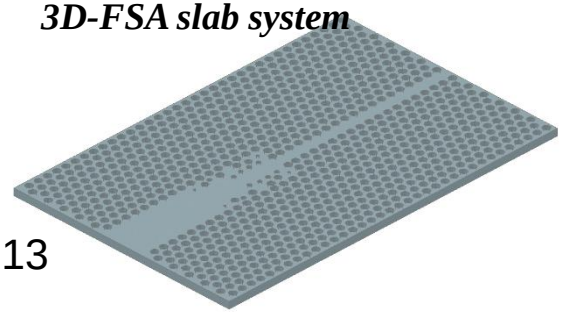


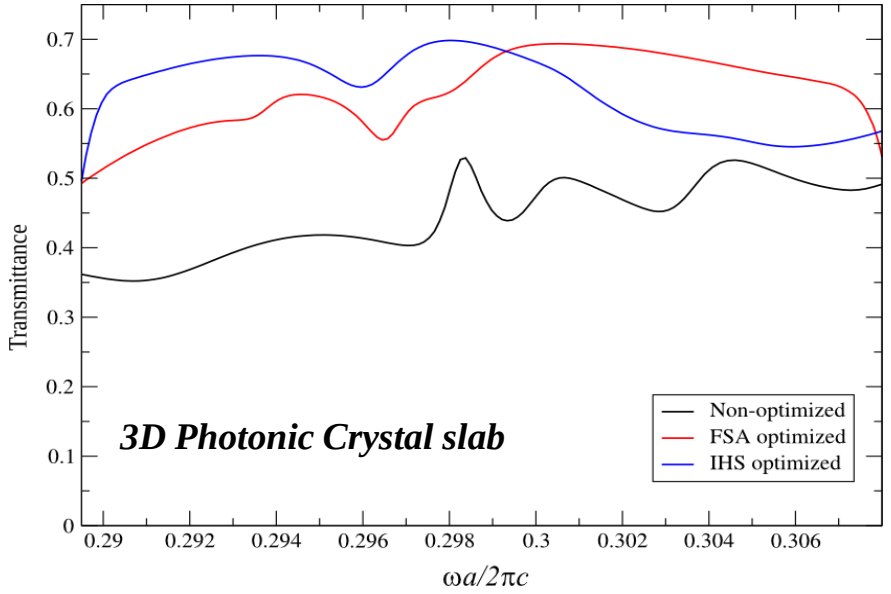


3D-IHS slab system



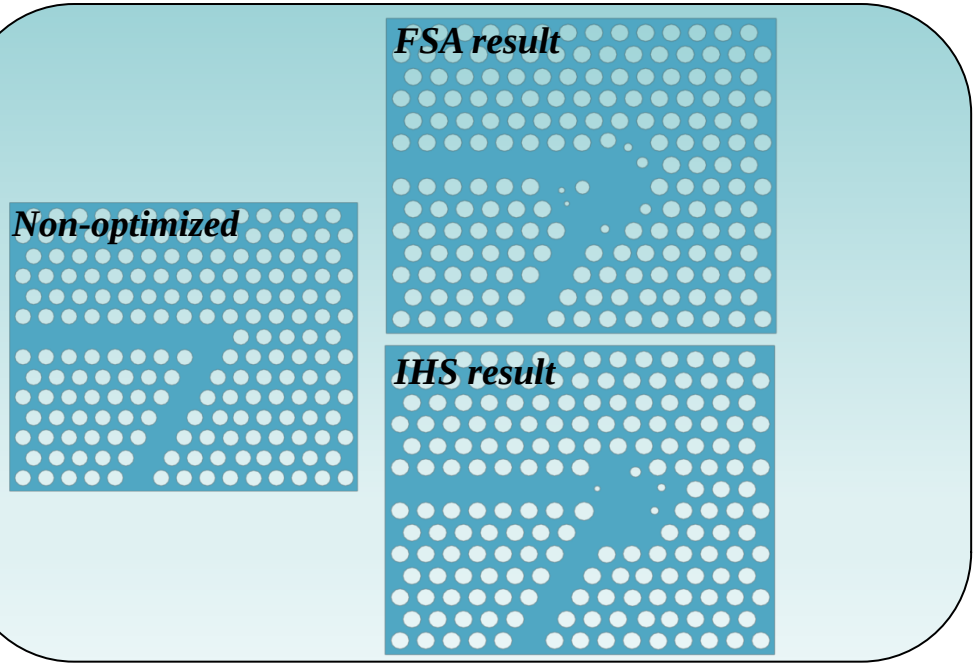
3D-FSA slab system

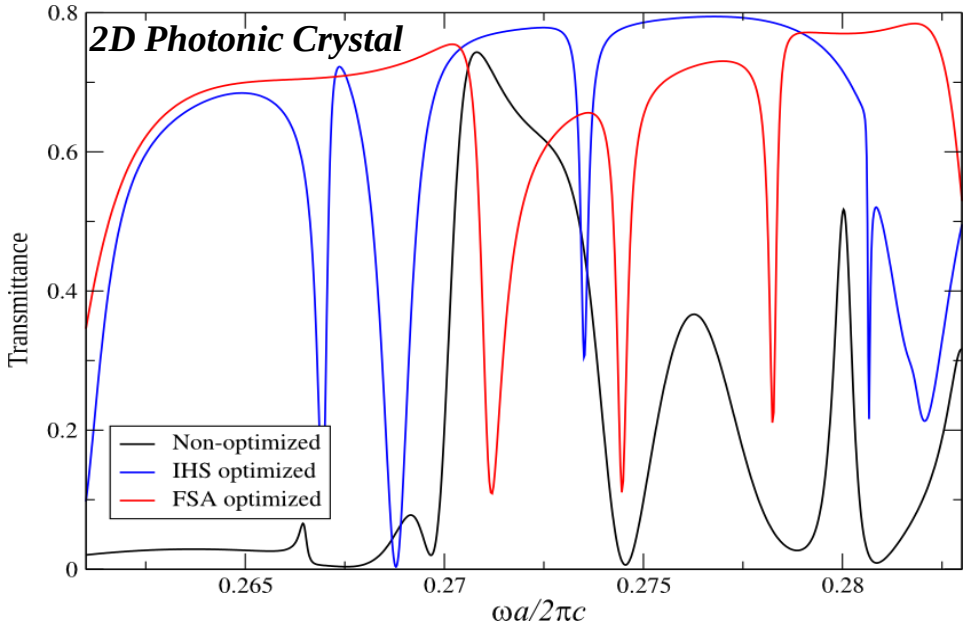




Appl. Phys. A., 2013

Target cases: 120º PCWG sharp bends





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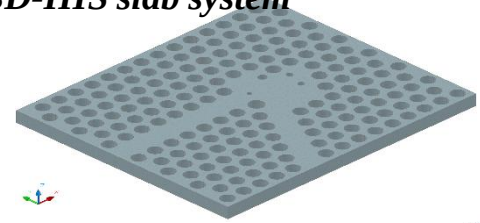
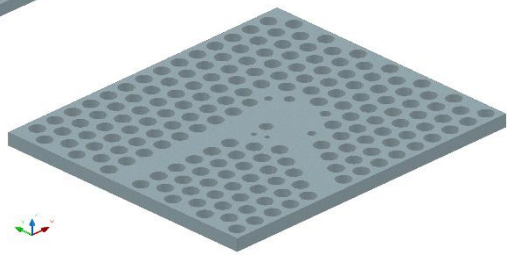
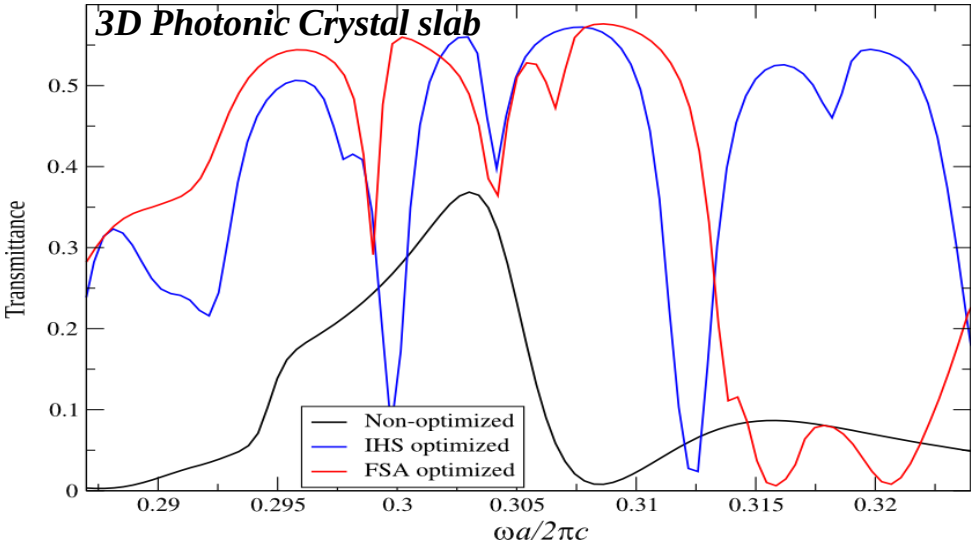
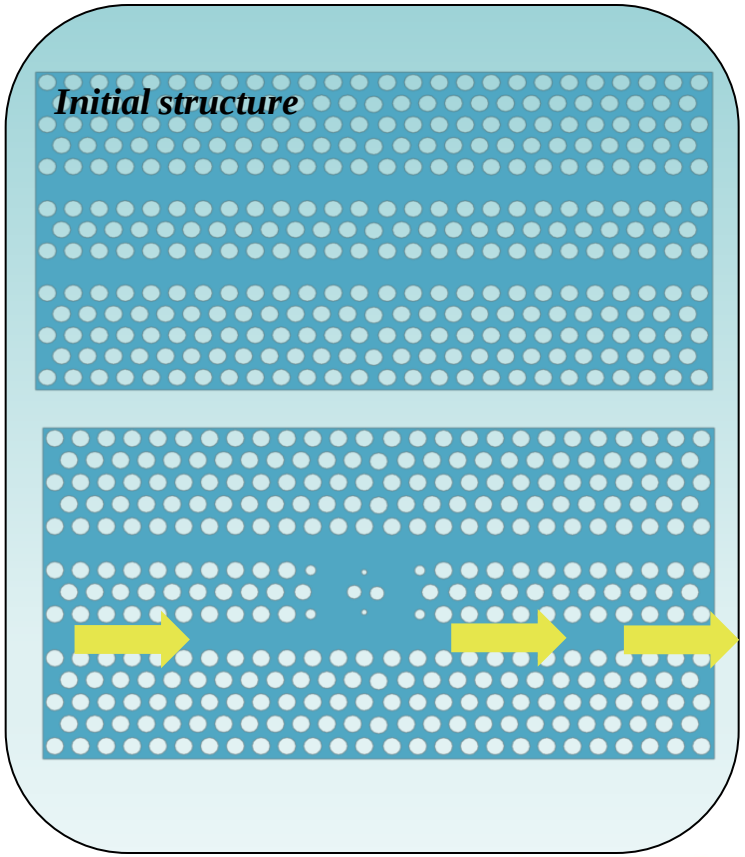


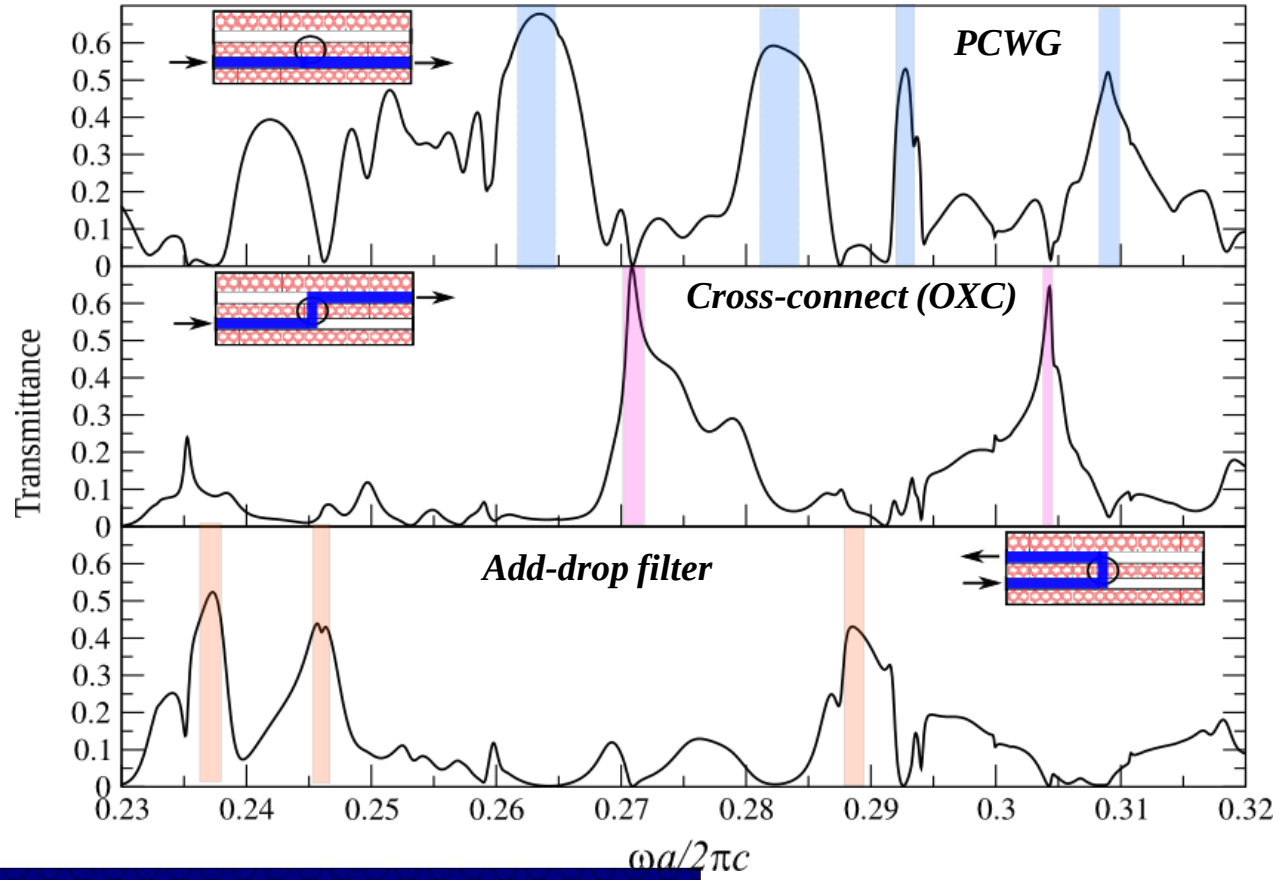
3D-FSA slab system

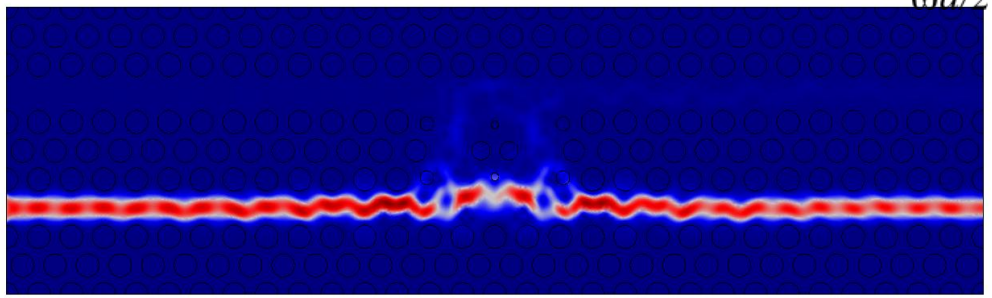




Target cases: reciprocal cross-connect







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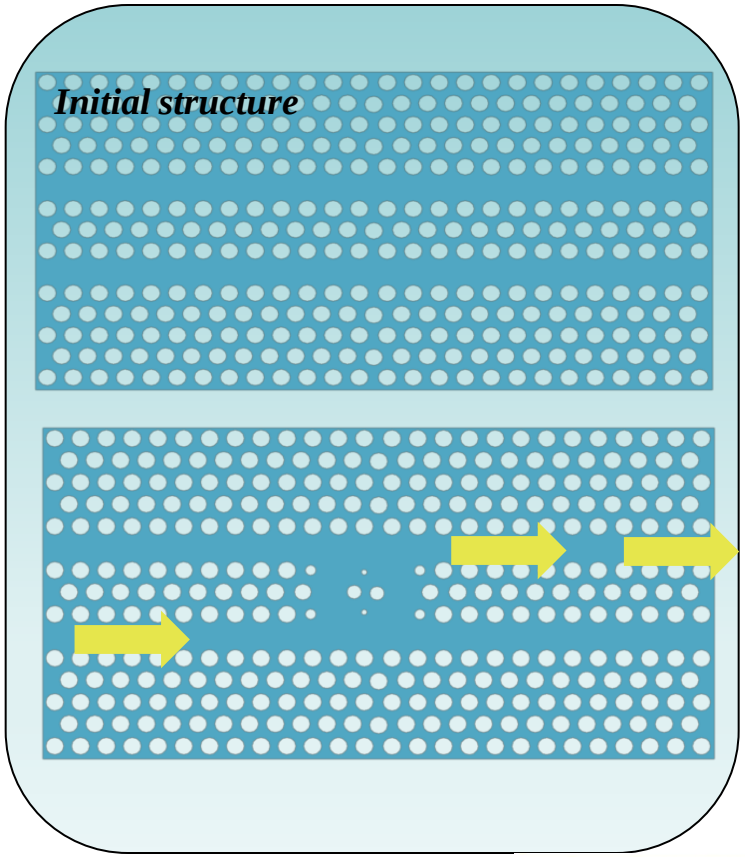

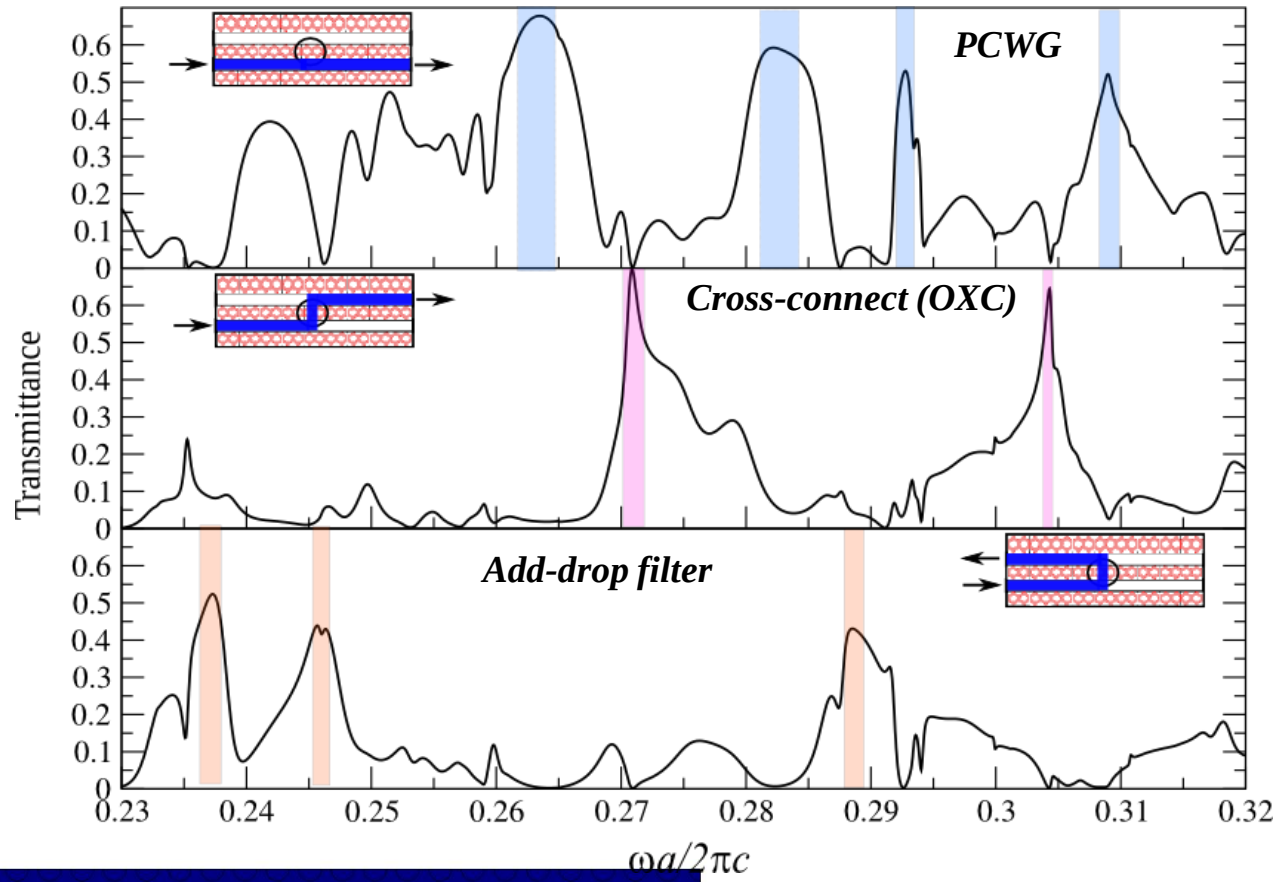

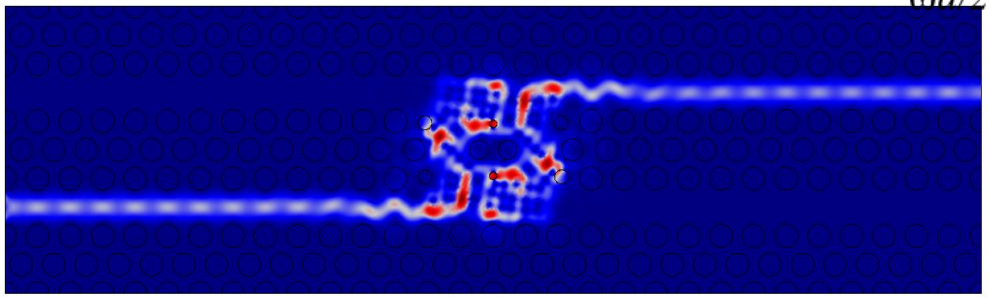

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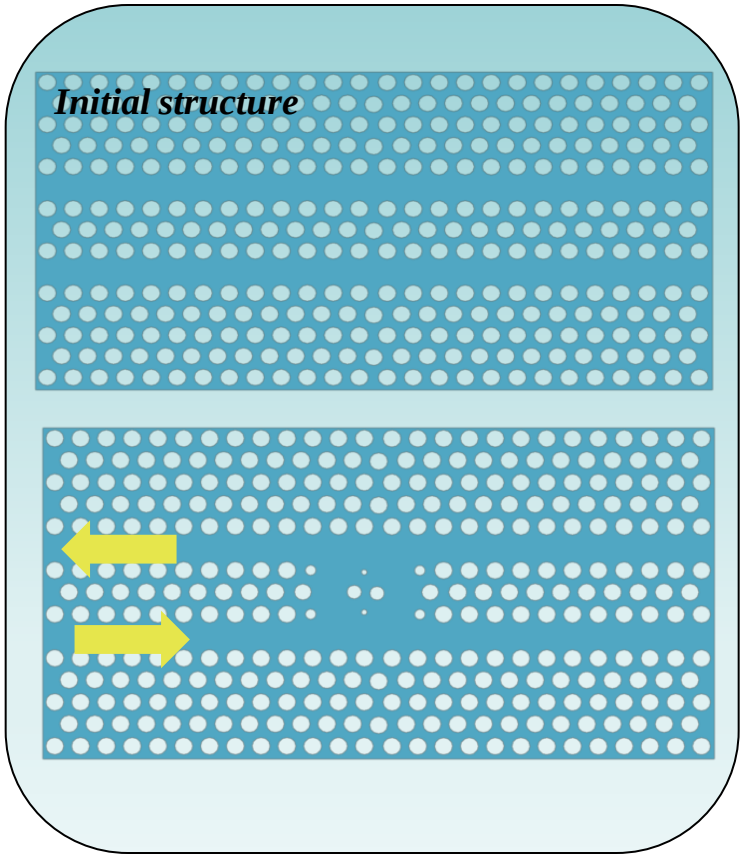
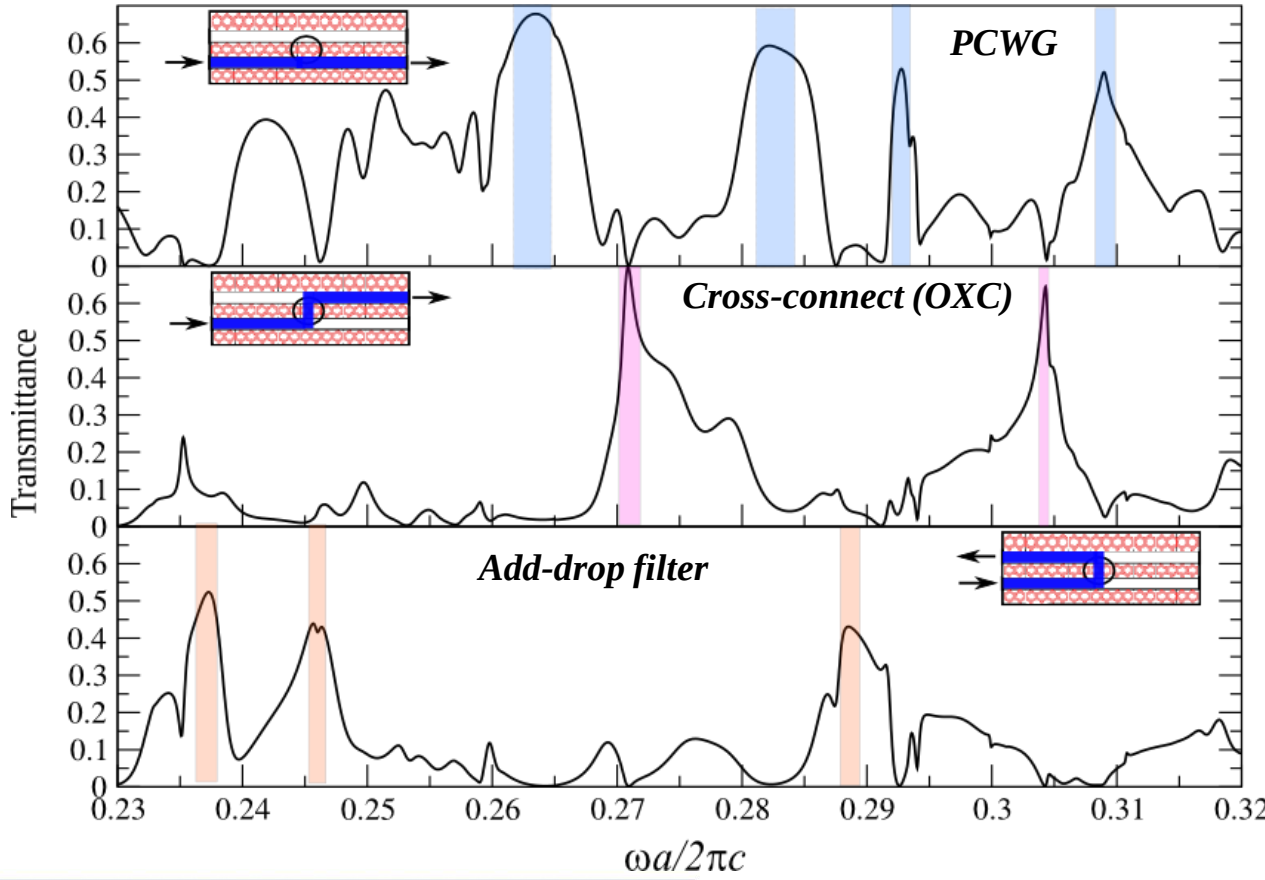
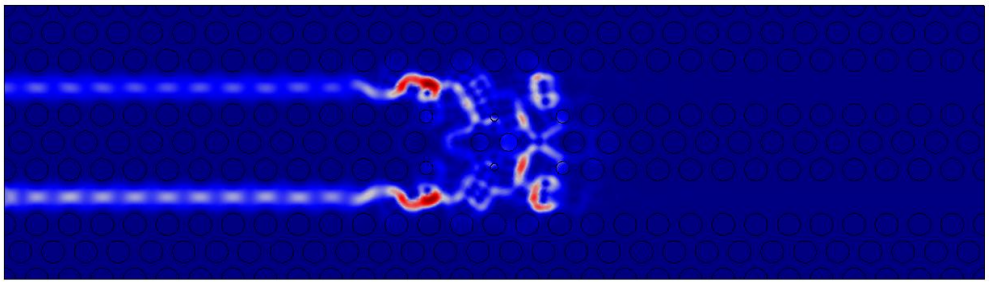
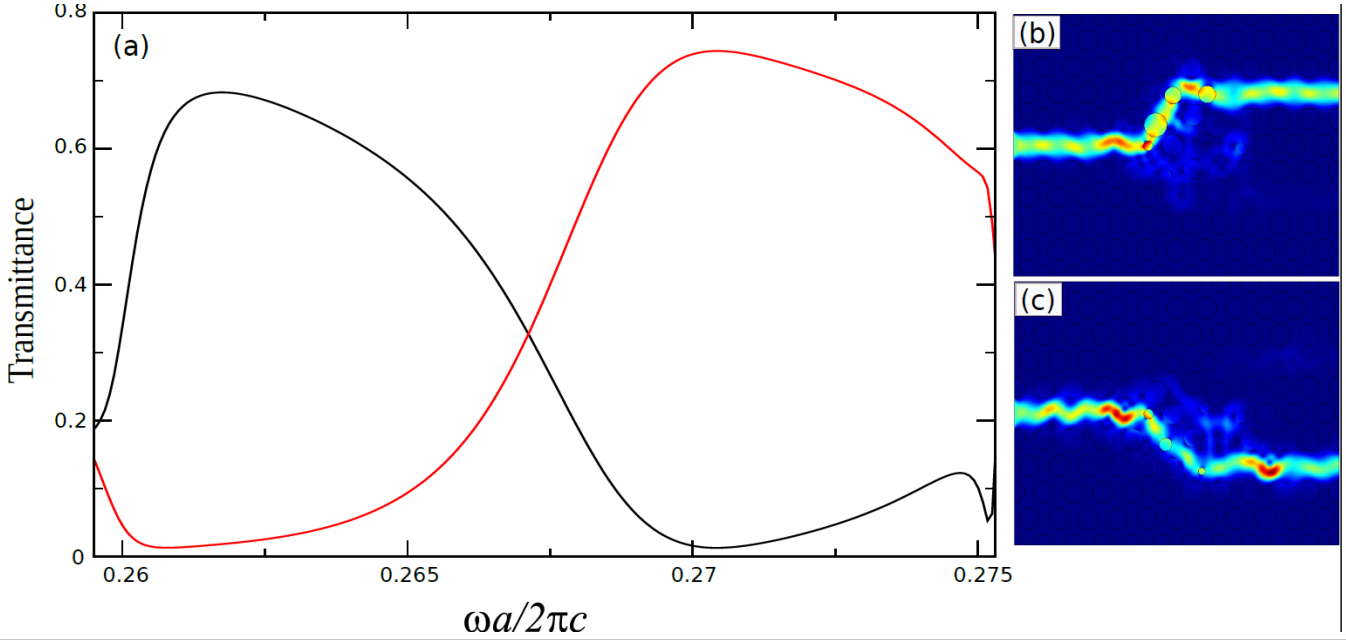
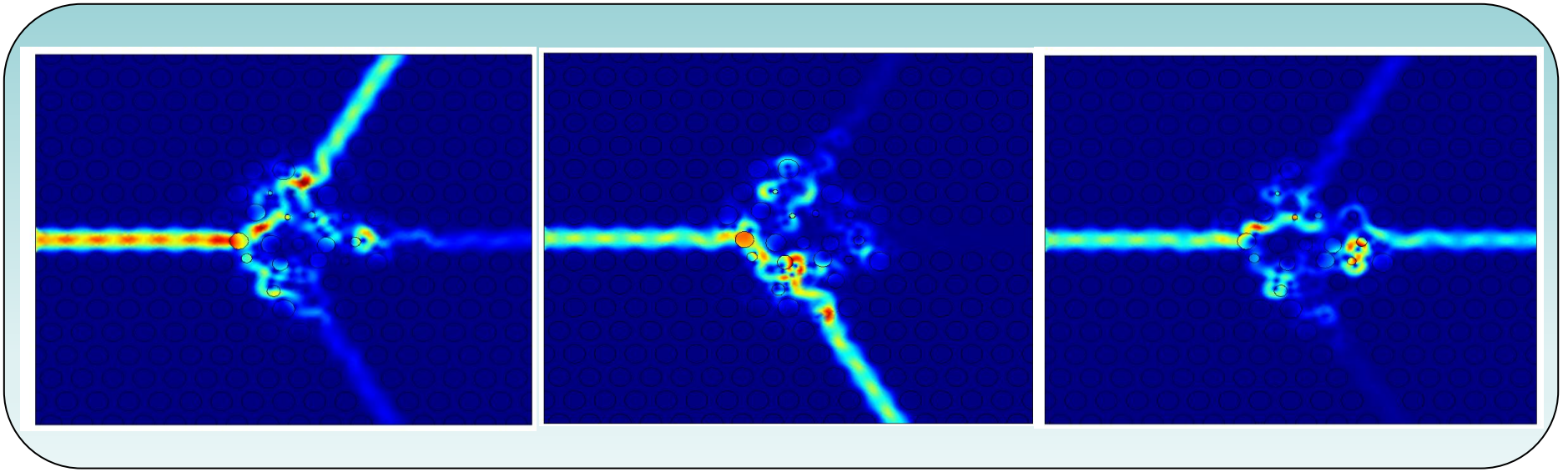




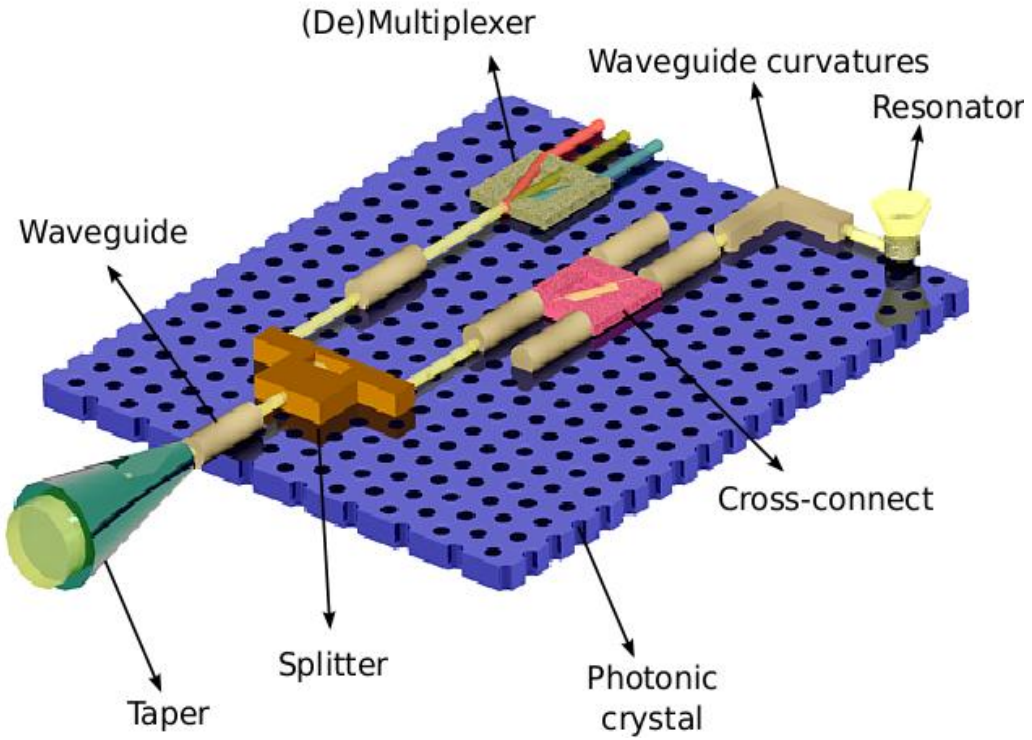


And many more applications…



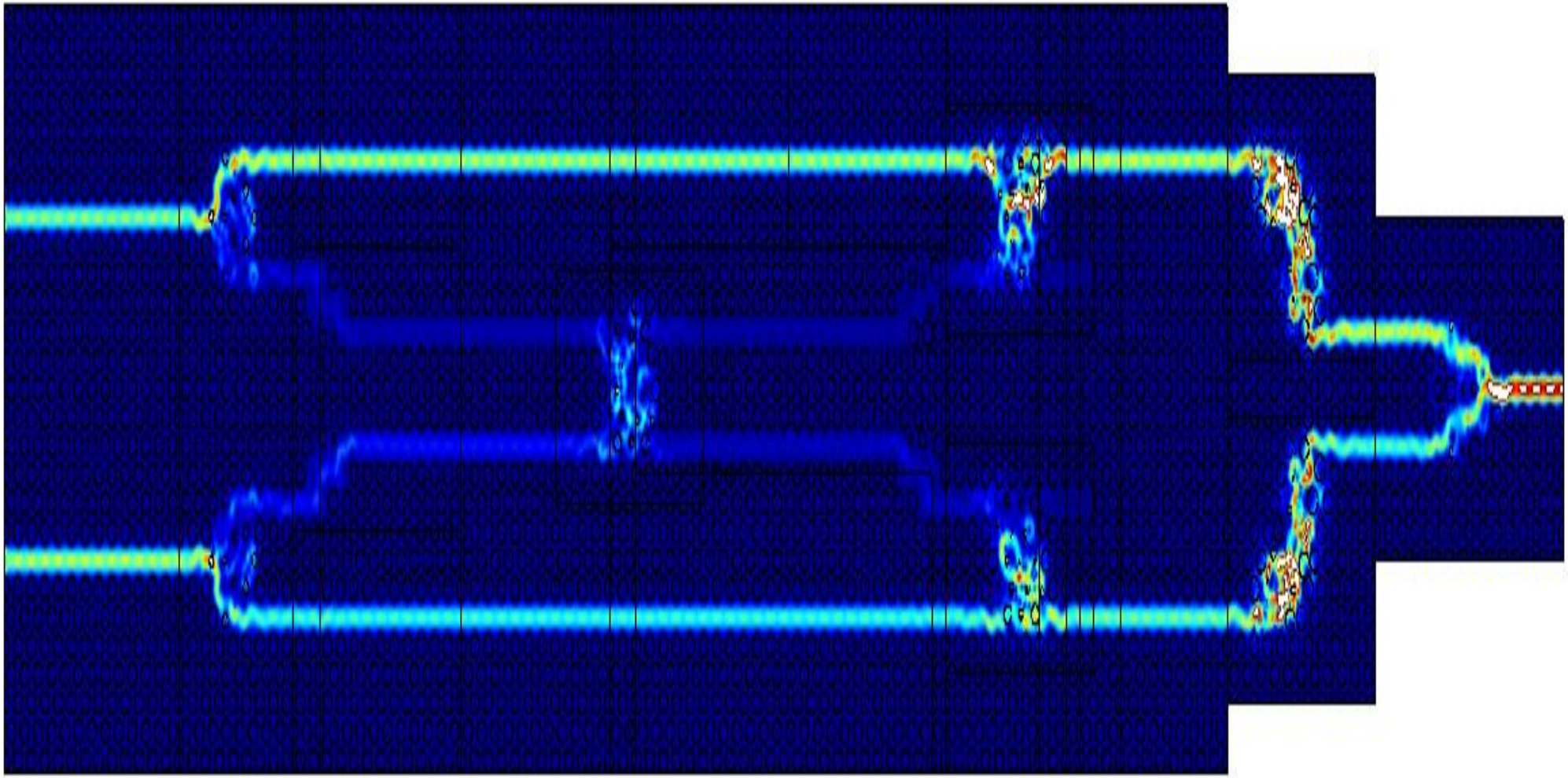


Photonic Integrated Circuit



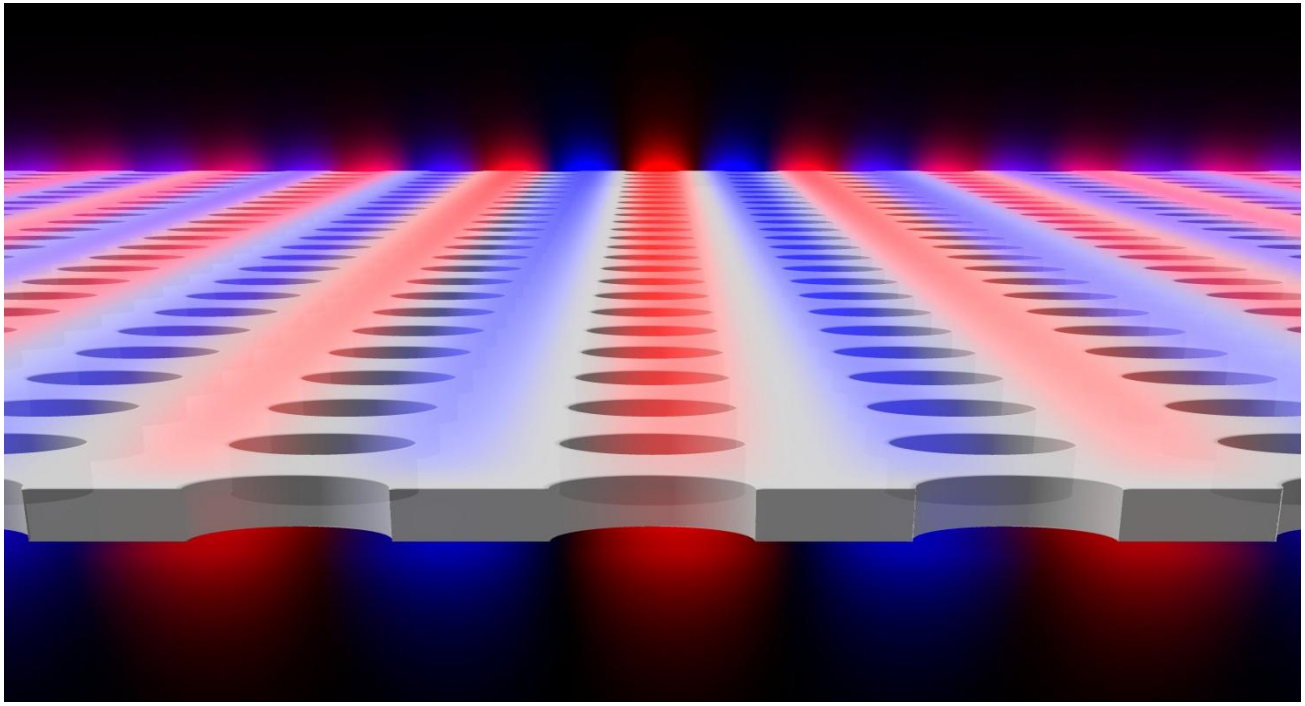
SPIE Newsroom, 2013

Photonic Logic Gates: AND gate



Future activities

- Include nonlinear materials such as As_2S_3.
- Study of active devices.
- Fabricate these structures by means of Direct Laser Writing technique (DLW).
- Characterize the response of manufactured devices.
- Include manufacturing error tolerances in the ID method.



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- Basque Country Government Research Groups.
- EHU/UPV PhD fellowship 2012.

Thanks for your attention!