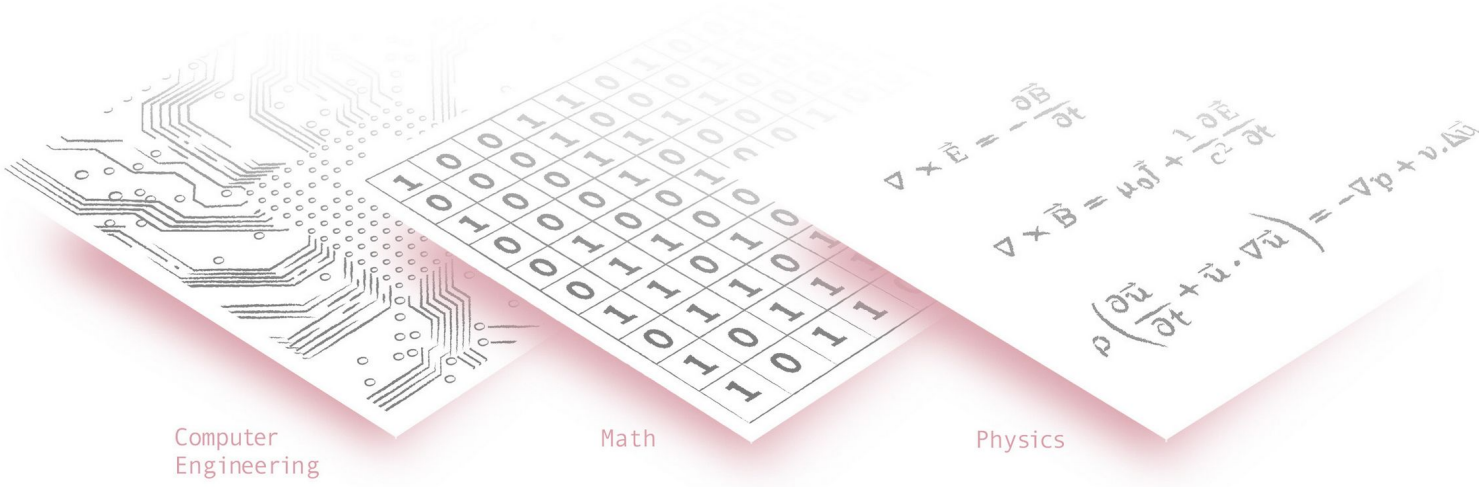


Inverse Design in Photonics

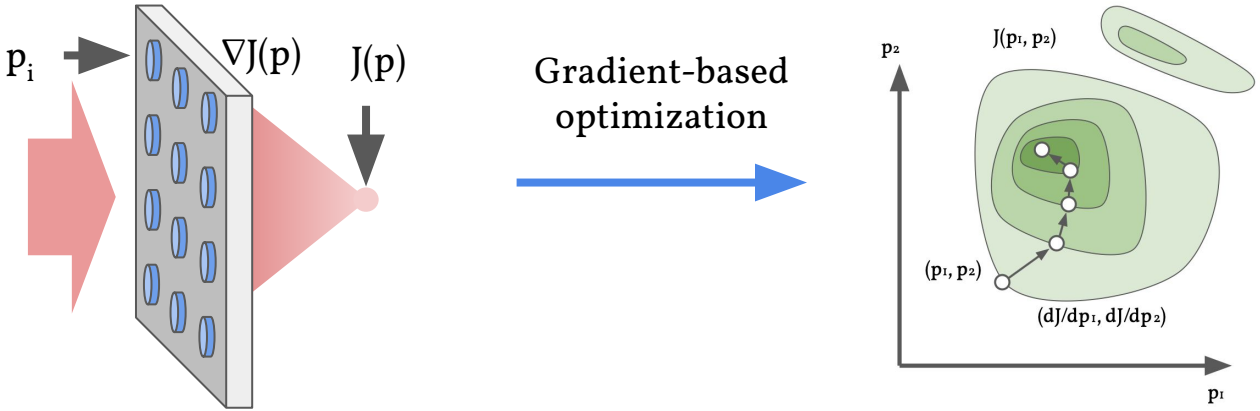
Tutorial 3: Adjoint Optimization

FLEXCOMPUTE

Tidy3D

Review: Design Procedure

- Goal: optimize objective function over design parameters J(p).
- Approach (repeat until convergence):
  a. Start with parameters.
  b. Compute gradient using adjoint method.
  c. Update design parameters a small amount in gradient direction.

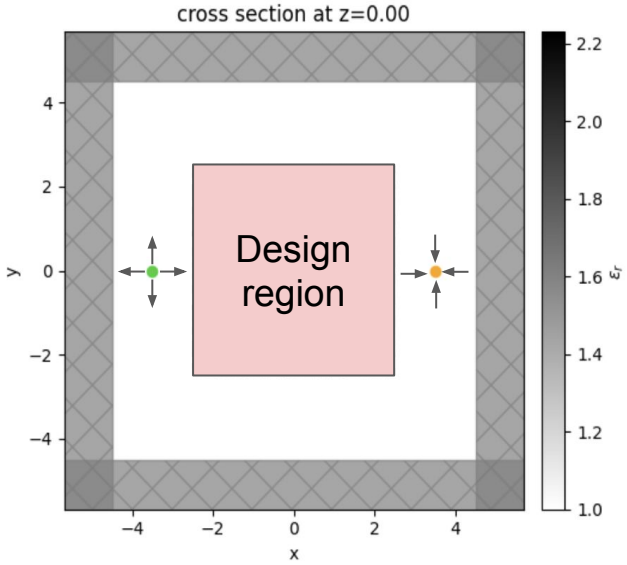


Simple Example: Design Lens

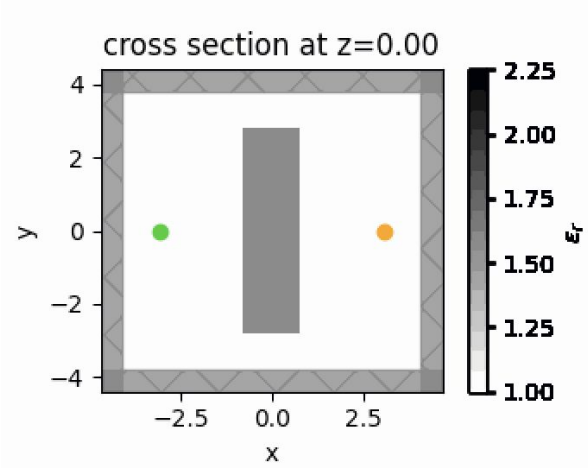
Goal: design a device to focus light.

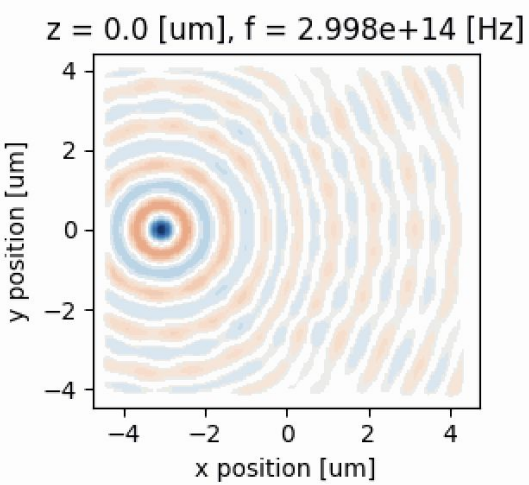
- Point dipole (green)
- Field monitor (orange)
- Region containing design parameters (red)

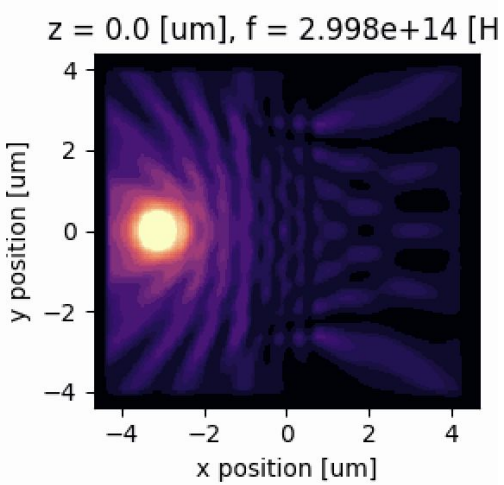
Objective function: maximize electric intensity at the field monitor compared to vacuum.



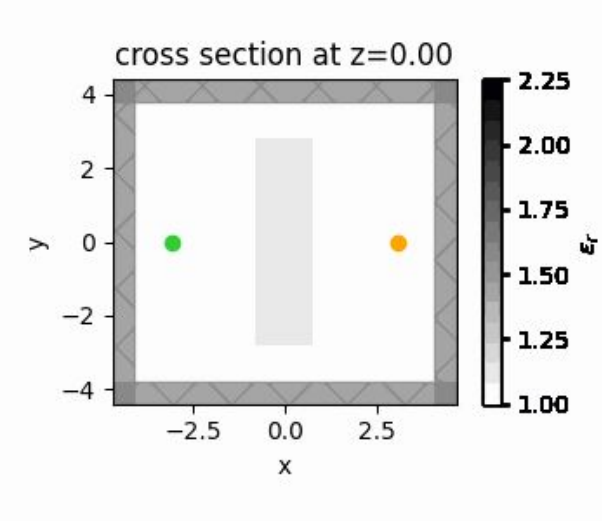
Starting point of the optimization

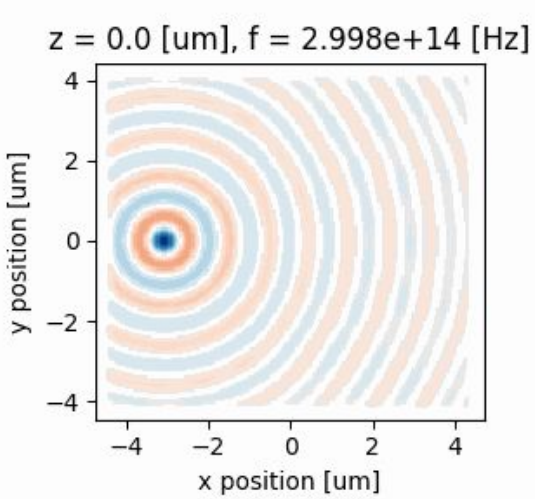


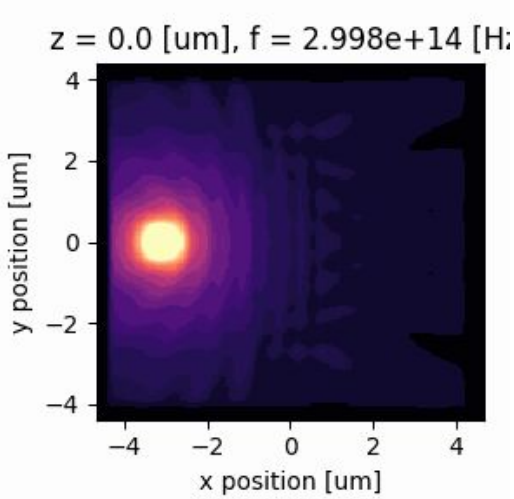




Optimization process

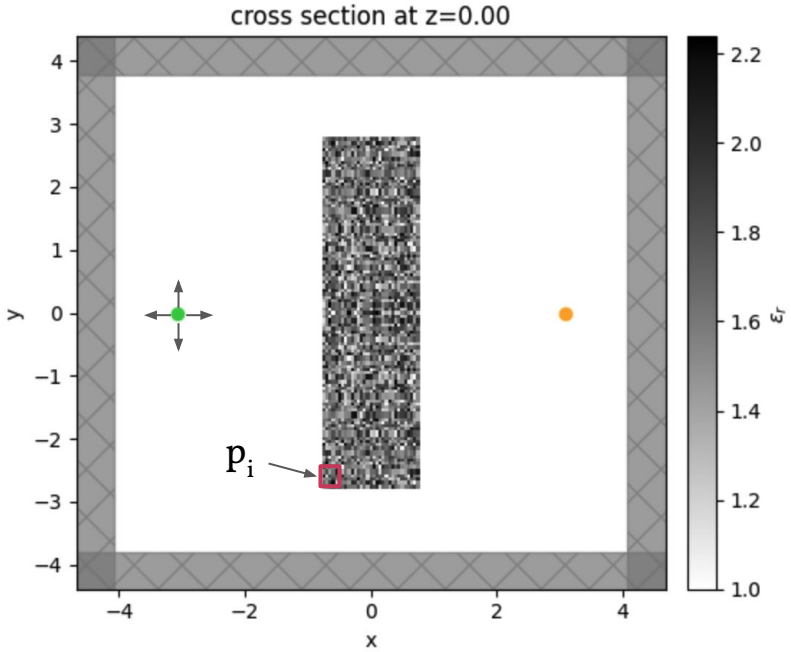






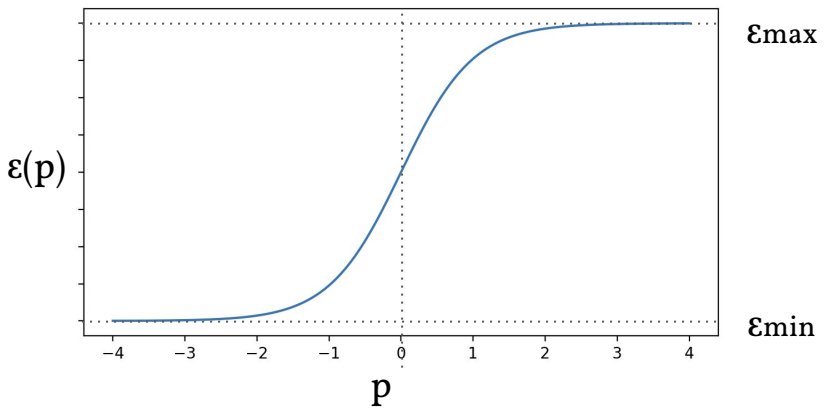
Design parameters

- Break design region into several sub wavelength “pixels”.
- Relative permittivity of pixels are independent parameters.



Parameterization

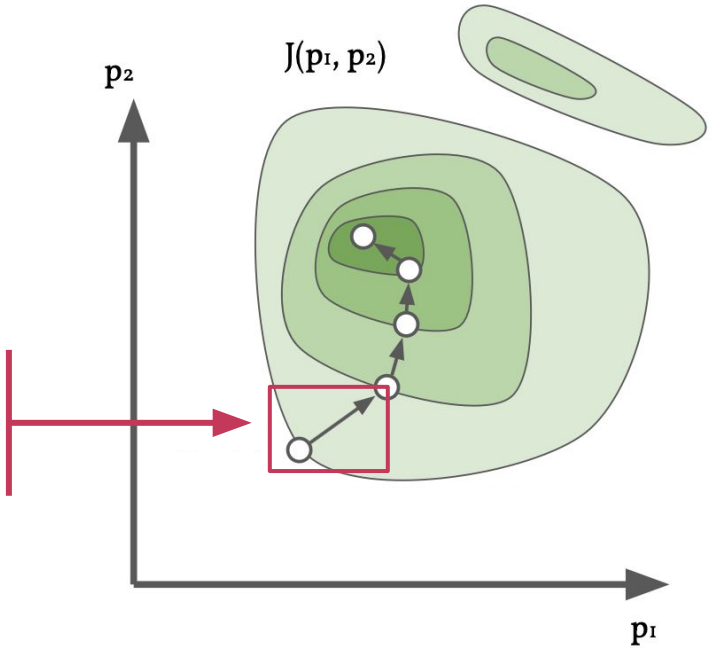
- Want to constrain permittivity of each pixel to between 1 (vacuum) and a material.
- Define function that maps parameter “p” between $(-\infty, \infty)$ to a permittivity between $(1, \varepsilon_{max})$.
- Can freely update “p” and keep permittivity in bounds.



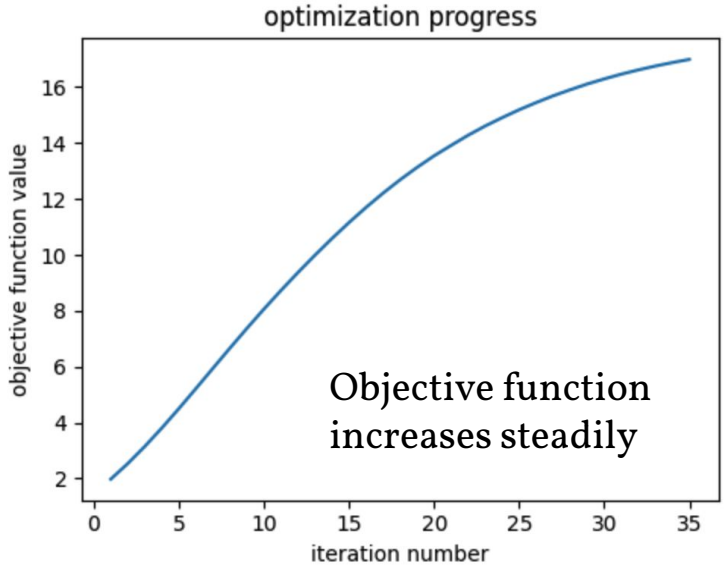
Optimization

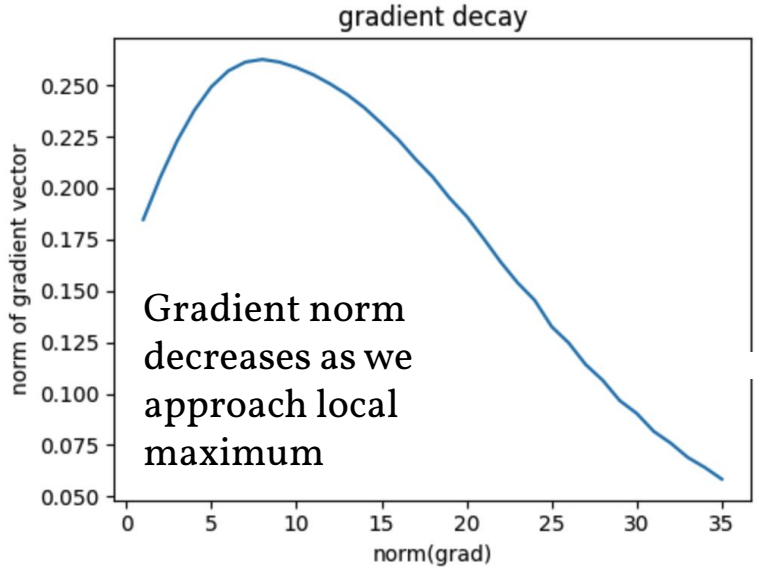
Algorithm:

- Define starting parameters
- In each step
  - Compute J(p) and dJ/dp.
  - Update p = p + α dJ/dp

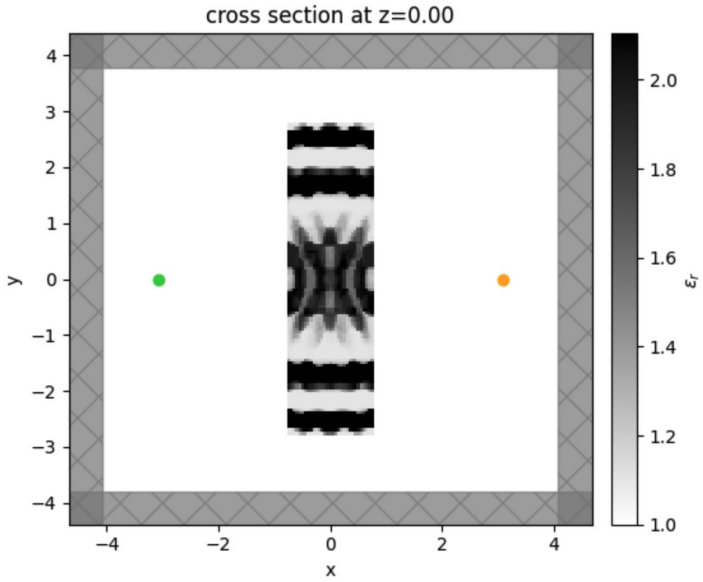


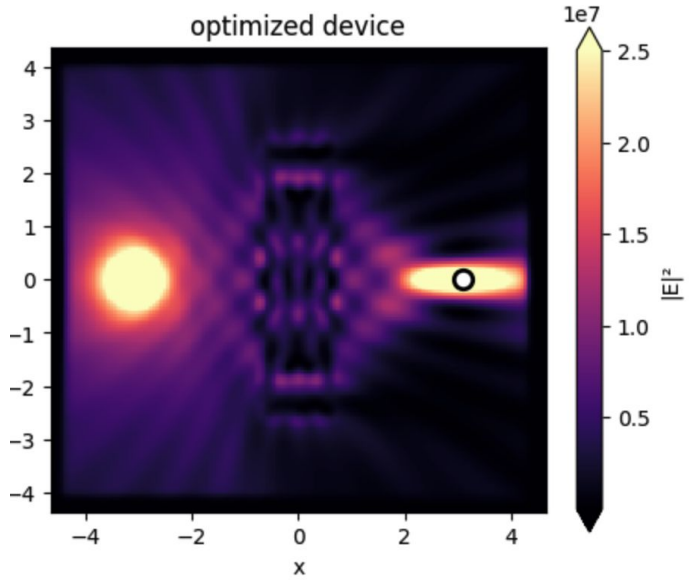
Optimization Progress





Final Device





Design can be further improved to incorporate fabrication constraints.