

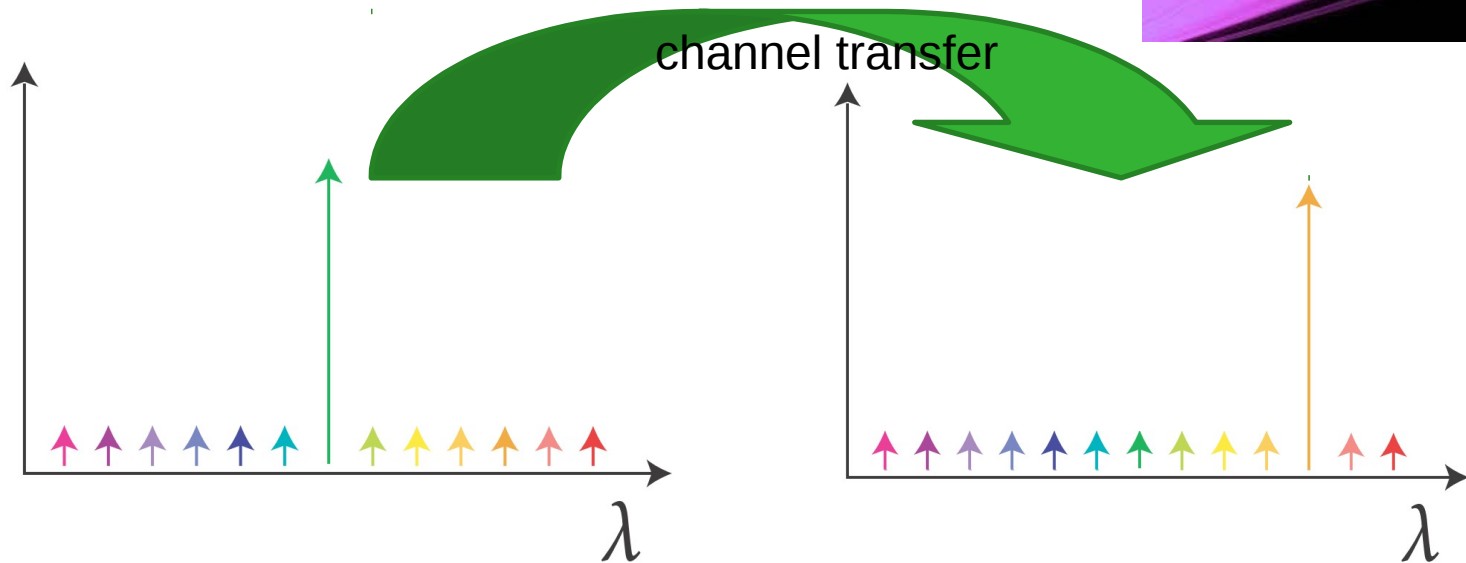
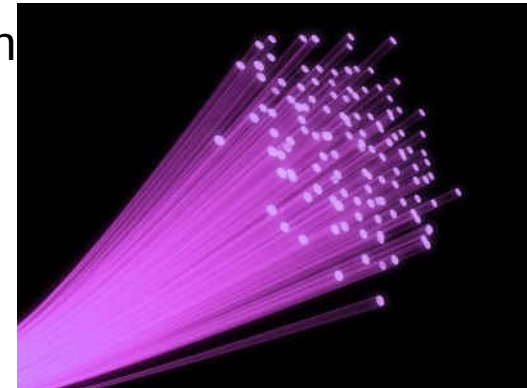
Bringing Nonlinear Optics Into Glass Chips

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Applications

- § Possible: spectroscopy, display, telecommunication
- § All-optical wavelength conversion on a chip
- § Routing a signal in telecommunication
- § Every channel in a different wavelength

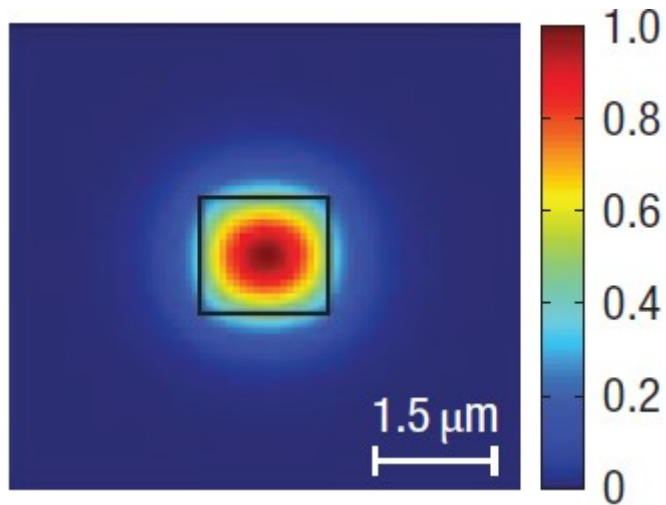


Outline

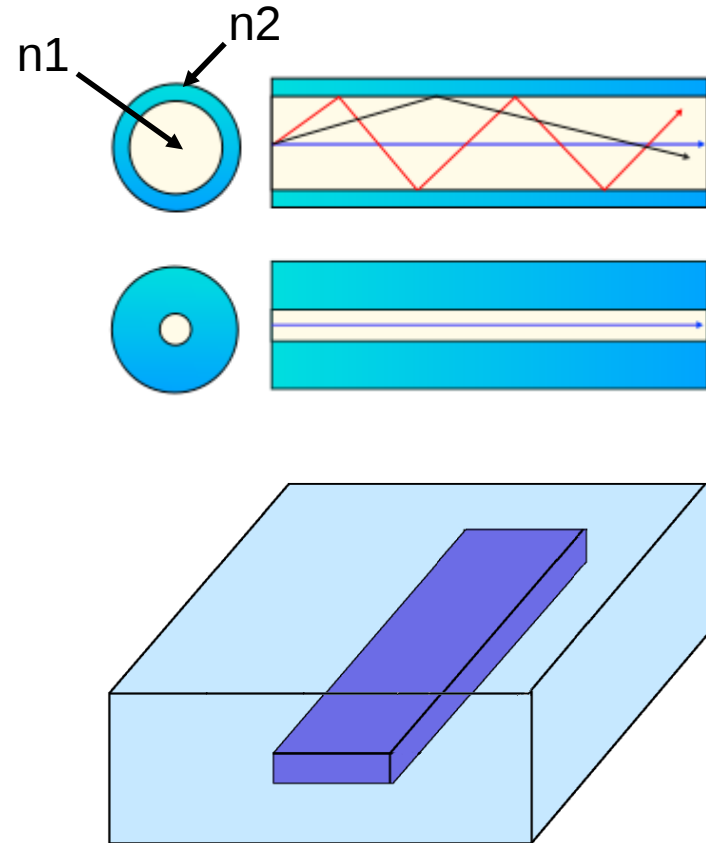
- § Optical waveguiding?
- § Basic building blocks of optical circuits
- § Example: waveguide
- § Nonlinear generation of light
- § Nonlinear generation in glass waveguides

Optical waveguiding

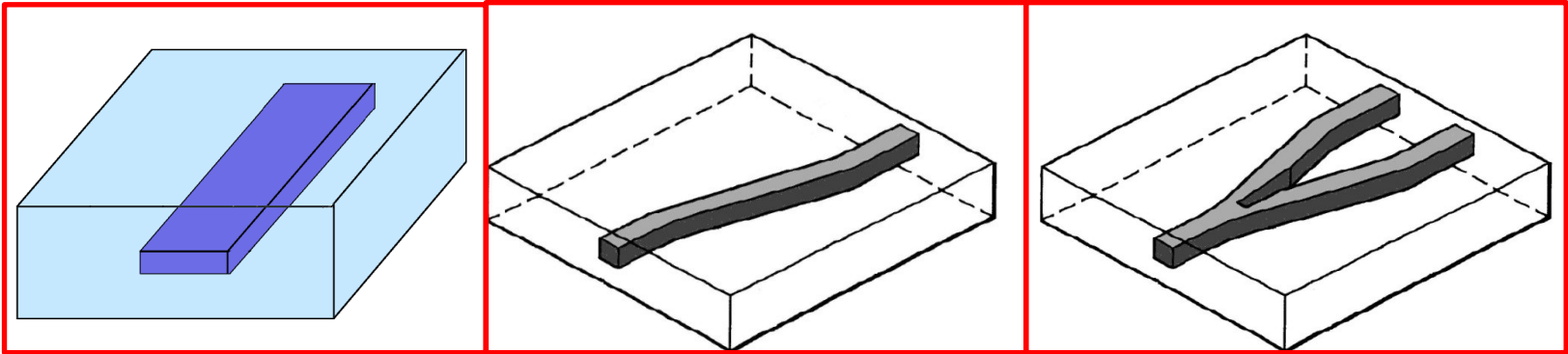
- § Light is guided by total internal reflection
- § Use of silicon nitride ($n_1 \approx 2.0$) in silica ($n_2 \approx 1.5$)



Mode field with evanescent field



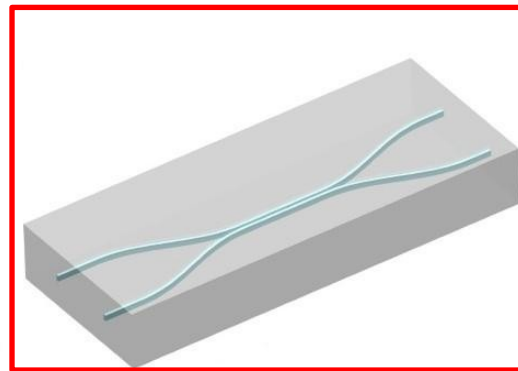
Basic building blocks



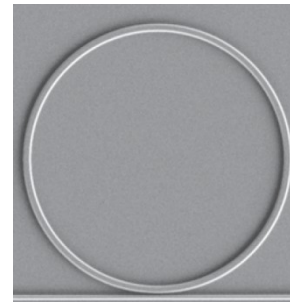
straight

curve

Y branch

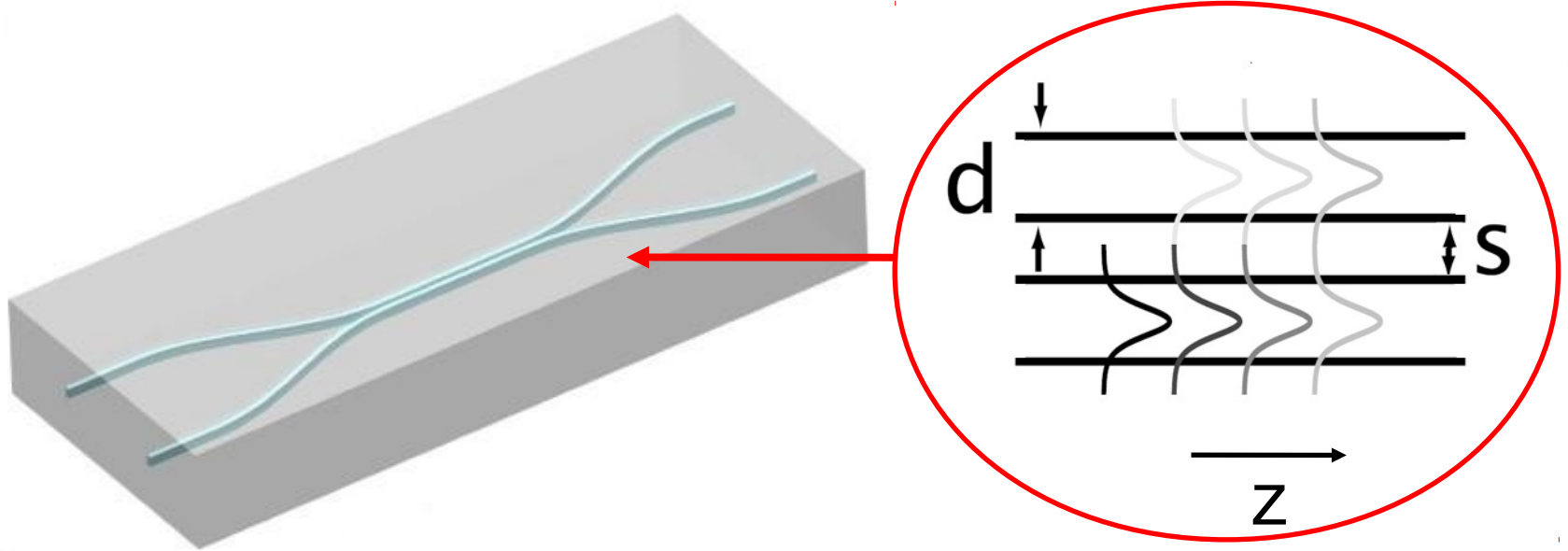
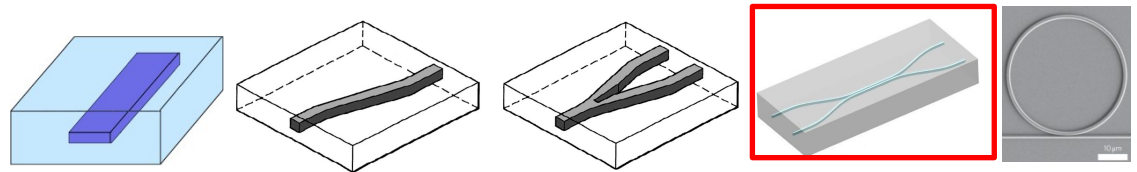


coupler



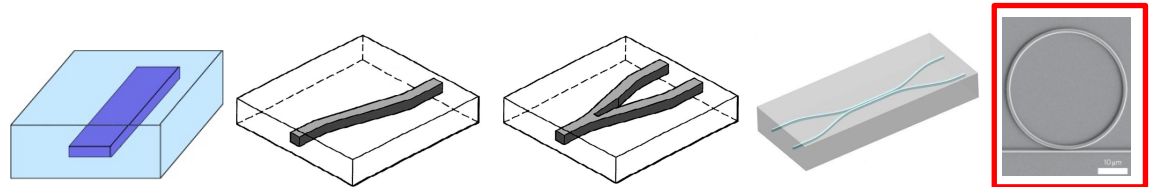
ring

Coupler

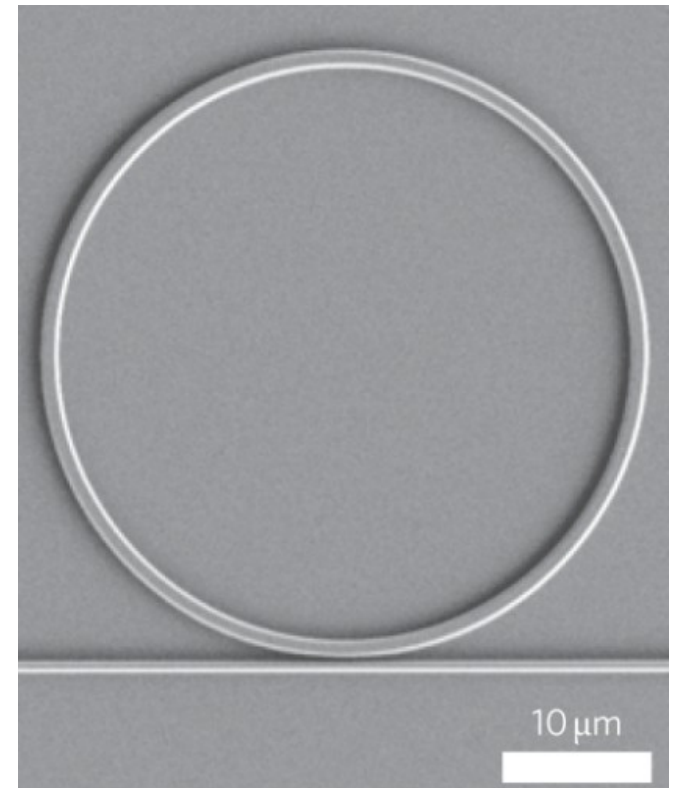
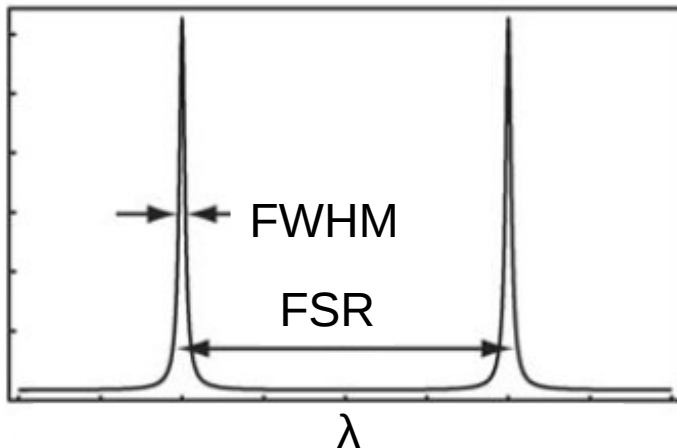


- § Evanescent field can couple into nearby waveguide
- § Coupling: $\sim \sin^2(c \cdot z)$

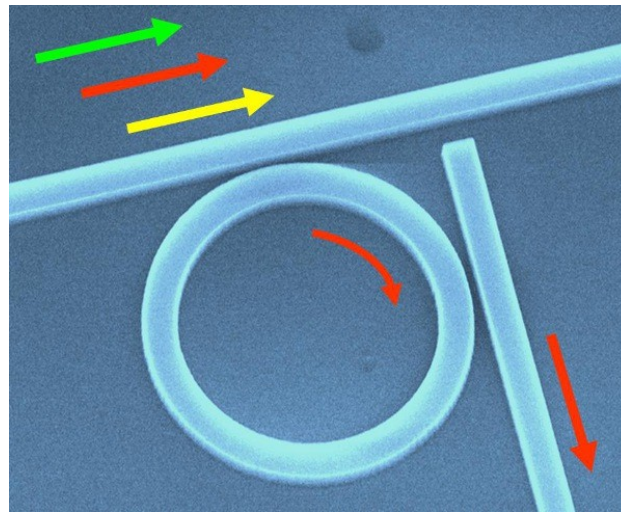
Ring



- § Light is coupled into a ring
- § Ring is resonant for particular wavelengths
- § At resonance: intensity is enhanced within the ring (int = F·I_{ext})



Example: Optical drop filter



- § Wavelength selective filter
- § Reroute a single channel

Range of functions can be improved by nonlinear optics!

Nonlinear generation of light

- § Typical generation of light by
- § Spontaneous emission
- § Stimulated emission



Nonlinear generation of light

- § New waves are generated at every spot of the waveguide
- § Phase velocities have to fit

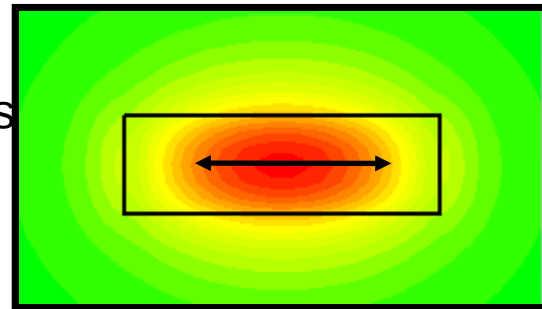


Fitting phase velocities are called phase-matching
 $k_1+k_2=k_3+k_4$

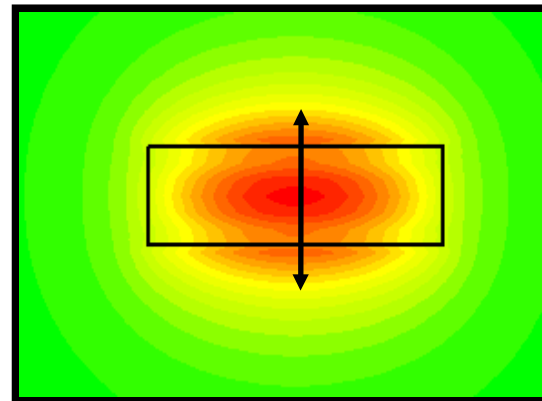
Phase-matching in a waveguide

- § Rectangular cross section
- § Polarization dependent phase velocities
- § Waves with different wavelengths can be phase-matched

TM polarized (slower)

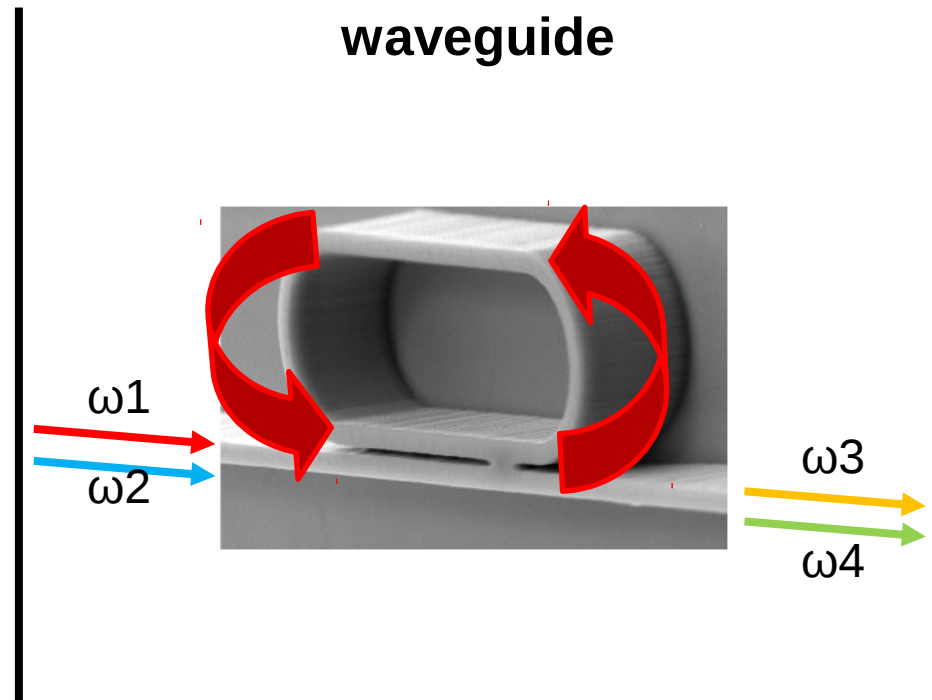
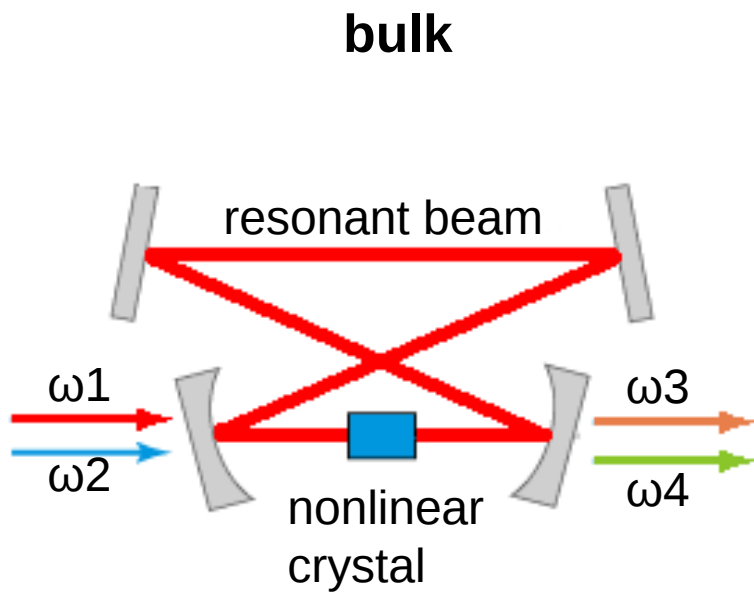


TE polarized (faster)



High intensities in a waveguide

- § Using ring resonators
- § New frequencies are generated within the resonator



Future steps

- § Numerical modeling on phase-matching conditions
- § Experiments on straight waveguides
 - Use of high power laser
- § Experiments on ring resonators

