Planar waveguide coupler based on tilted Bragg gratings and a discrete cladding mode

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Abstract
A new type of planar waveguide to waveguide coupler is presented based on two parallel single-mode waveguides written in the same ridge structure. Identical tilted gratings are used to couple light between the waveguide using the modes of the ridge. The bandwidth of the device can be controlled by varying the length. A transfer efficiency approaching 100% is shown to be possible in this system.

Introduction

• We have recently developed tilted Bragg grating technology for use in planar photonics [1].
• Can be used to couple light efficiently between waveguide and radiation/cladding modes.
• An integrated coupler based on two 45° tilted gratings has already been demonstrated [2], but with large losses due to leakage into radiation modes.

We simulate a new device that overcomes this limitation:
• Single ridge structure containing two parallel waveguides.
• Identical tilted gratings in each waveguide to couple to cladding modes.
• Parameters chosen to couple to a single backward propagating cladding mode.
• Power transfer between waveguides forms a coupler.
• Bandwidth controlled by grating parameters.

Results

Waveguide output power vs wavelength

*H = 34 μm, n_{sub} = 1.4398,
*α = 10 μm, α = 2.0 μm,
*Δn = 0.01, Δn = 0.001,
*λ_0 = 1.55 μm, λ = 586.6 nm,
*θ = 17.19°, L = 20 mm

Coupled to mode 35

Power at bottom (blue) and top (red) waveguide outputs.

- With one cladding mode, eigenvalues are \(Y_0, Y_z = \pm \sqrt{2} \Delta K^2\) 
- Photonic bandgap found in region where \(\Delta K < \sqrt{2} \Delta K\)
  - One quarter of the light in each waveguide,
  - Remaining half in cladding mode (exponential behaviour).

Inside bandgap  
Outside bandgap

Power in top waveguide for different device lengths

Top waveguide: points at which power does not depend on device length.

High fabrication tolerance with device length

Coupling strength between waveguide and cladding mode vs tilt angle

Peak at tilt angle expected by geometric optics.

Highest bandwidth at peak

That’s why we need tilted gratings!

Conclusions

We presented a new type of waveguide coupler that can couple light very efficiently between two waveguides. The use of tilted gratings allows for bandwidth control of the coupler which adds a new functionality in planar photonics. This could therefore be used as a flexible platform for the fabrication of new wavelength division multiplexers (WDM) or frequency filters.