The Hong Kong University of Science and Technology

Department of Electrical and Electronic Engineering
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Title: Micro-Systems II: Optical Wave-guides

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Nowadays, integrating many functions such as light function (camera, TV...), gas function (smell, alcohol...) etc into very tiny system (micro-system or chip) is a very important trend in EE technology and in the market. It is because the data traffic on the Internet has been growing at an astonishing rate of 400% per year over the last 3 years. The demand for data bandwidth has already surpassed the data transmission capacity of the current telecommunication infrastructure. Realizing the importance of optical wave-guide of micro-systems will have a significant impact on industry and society. This EE technology will revolutionize new consumer and industrial products, and provide new directions in instrumentation and in many other areas.

A Dielectric Slab Wave-guide

Wave-guides are "wires" that carry light. A dielectric wave-guide guides light by total internal reflection, which requires that light trapped in a high refractive index region (core), surrounded by a low refractive index region (cladding).

\[ \Theta_i \] is the angle of incidence and \( \Theta_{ic} \) is the critical angle of incidence.

The light is confined in the core of the dielectric wave-guide when two conditions are met:

1) The core index, \( n_{core} \), is larger than the cladding index, \( n_{cladding} \),

\[ n_{core} > n_{cladding} \]

2) The incident angle of the light impinging on the core/cladding interface, \( \Theta_i \), is larger than the critical angle, \( \Theta_{ic} \),

\[ \Theta_i > \Theta_{ic} = \sin^{-1}\left(\frac{n_{cladding}}{n_{core}}\right) \]
Micro-resonator OADM

Results

Laser light was lens-coupled into the input wavelength, and then it traveled through the channel. When the beam reached the ring shape couple, light wave with certain wavelength extracted out and traveled through the ring to output of drop filter. The remaining light wave traveled to the output of main channel. After dropping certain wavelength, the channel of this frequency was empty, another signal could be added from the add filter end to reuse the channel. When the wavelength is off resonance with the resonator, the light is ‘reflected’ and exits through the throughput when the wavelength is on resonance, the light is transmitted through the resonator and exits through the drop port. Both the resonance wavelength and the coupling factor depend on polarization and the shape of the resonator. I have focused on the rectangular shaped resonator.

Overview layout of the mask

(a) Ray trajectories of square cavities with incident angles \( \theta \) and \( 90 - \theta \). The trajectories do not close upon themselves after one round trip, which is defined as the wave front (dashed line) meeting itself.

(b) Closed rectangular trajectory with \( \theta = 45 \degree \). All rectangular orbits (solid and dashed lines) have the same path length and therefore the same cavity mode.

Square-shaped \( \mu \)-cavities provide a long evanescent coupling length of potential add-drop filters. The advantages of this method are twofold:

1. The entire flat square sidewall allows a longer interaction length, and therefore a wider gap distance for evanescent coupling between the cavity and the straight waveguides.

2. The optical path length is identical for rays having the same input coupling angle along the sidewall, and hence the same cavity mode.
can be coupled anywhere along the flat sidewall. Square-shaped $\mu$-cavities allow design flexibility of coupling to either cross-grid or parallel wave-guides.

The reflection and transmission spectra with orders pattern

The overview of the experimental setup