



Low Loss and High Uniformity Multimode Interference Splitter Operating in a Wide Wavelength Band

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FHV RESEARCH

Motivation

In multimode interference (MMI) splitter the splitting of the optical signals is based on a self-imaging effect appearing inside of the multimode section. By cutting the splitter at a particular length, L_{MMI} ; N split output signals can be obtained.

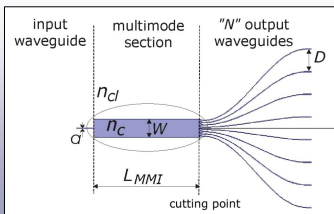
Advantages: (1) MMI splitters feature a large splitting number and stable splitting ratio ensuring good uniformity over all the output signals; (2) good fabrication tolerance since the splitting is performed in the multimode section.

Disadvantage: length of the multimode section is wavelength dependent, i.e. the MMI splitters are designed solely for one wavelength and can only operate in a narrow wavelength band.

Solution

Exponential taper placed in front of the multimode section has an impact on the multimode interference conditions of the MMI splitter leading to the **great improvement** of both the **uniformity** and **insertion loss** of split signals. Furthermore, such splitter is able to operate in a **wide wavelength range**.

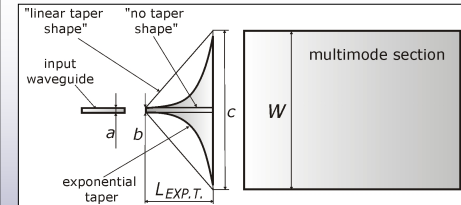
Design of Conventional MMI Splitter



Design parameters:

- $\lambda = 1550 \text{ nm}$ - operating wavelength
- $n_c = 1.4561$ - refractive index of the core
- $n_{cl} = 1.445$ - refractive index of the cladding
- $N = 8$ - number of output signals
- $a = 6 \mu\text{m}$ - width of the input/output waveguides
- $W = 200 \mu\text{m}$ - width of the multimode section
- $L_{MMI} = 4730 \mu\text{m}$ - length of the multimode section

Design of MMI Splitter with Exp. Taper



Design parameters:

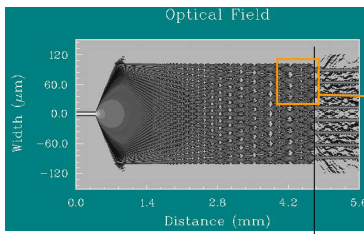
$L_{MMI} = 4506 \mu\text{m}$ - length of the multimode section

Taper design parameters:

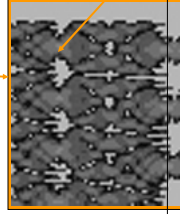
- $a = b, c = W, L_{EXP.T} = 400 \mu\text{m}$
- α - exp. parameter \Rightarrow taper side wall curvature lies halfway between "linear taper shape" and "no taper shape"

Simulation Results

Multimode interference pattern – conventional MMI



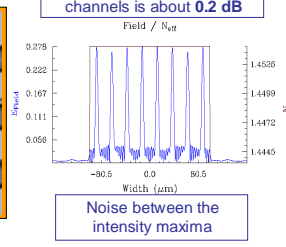
bright spot points



8-fold splitting point

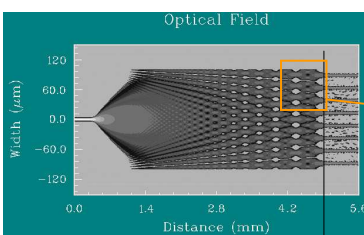
Field distribution at 8-fold splitting point

Uniformity over all the output channels is about **0.2 dB**

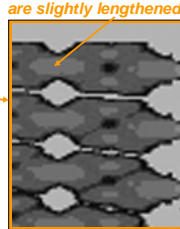


Noise between the intensity maxima

Multimode interference pattern – MMI with exp. taper



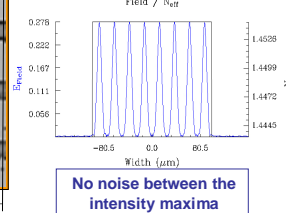
bright spot points are slightly lengthened



8-fold splitting point

Field distribution at 8-fold splitting point

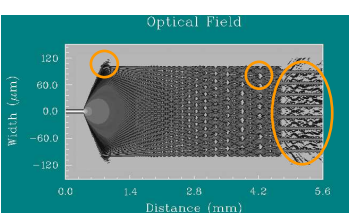
Uniformity over all the output channels is about **0.027 dB**



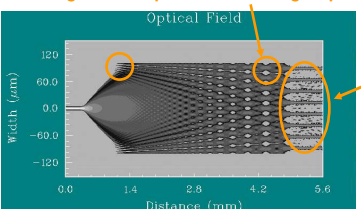
No noise between the intensity maxima

Impact of the Exponential Taper on Multimode Interference Conditions

Exp. taper placed in front of the multimode section has an impact on the multimode interference conditions, i.e. **the multimode interference pattern becomes smoother**. As a result: (1) the bright spots are much better separated from each other, i.e. there is no noise in the valleys between the intensity maxima improving the coupling conditions, (2) the intensity of the split output signals is more homogeneous leading to the improvement of the uniformity, (3) the bright spots are slightly lengthened leading to the strong increase of the usable operating wavelength band.



homogeneous separation of the bright spots



better coupling conditions

Discussion

MMI splitter with an exponential taper can operate in a much wider wavelength range than the conventional MMI (going from 1511 nm up to 1630 nm). This range covers the whole C-Band.

