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Roland Circle Based OAM Mode Demultiplexer Device Design

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Abstract
Orbital Angular Momentum (OAM) has been researched for mode division multiplexing recently. One of the ways to create OAM modes is to utilize Roland circle as it realizes proper OAM mode phase profile. So far, several OAM demultiplexer results have been demonstrated by using Roland circle, however, the reported crosstalk was around -10 dB implying the difficulty of optical demultiplexing. In this work, Roland circle for OAM mode demultiplexer is studied in terms of crosstalk improvement. As a result, crosstalk improvement of up to 16 dB is achieved with enhancing the number of arrayed waveguides connected to the Roland circle.

1. Introduction

Oribital Angular Momentum (OAM) is an attractive alternative mode for space division multiplexing (SDM) since it has infinite orthogonal eigen states [1]. OAM has a ring-shaped intensity front with a phase distribution of $2\pi n$ where n is an integer determining the OAM mode number. The target of this work is to suppress crosstalk for OAM de-multiplexing.

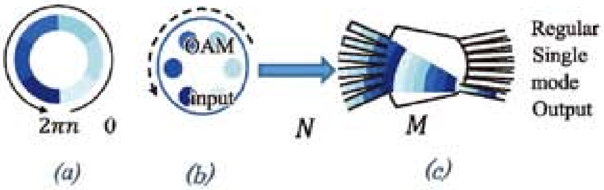

Fig. 1 Schematics of OAM mode (a) Field profile, (b) quasi-field profile, and (c) OAM de-multiplexer.

2. Demultiplexer device design

The OAM demultiplexer device that is used in this work is based on arrayed waveguide Roland circle [2] and basically has three primary parameters; Roland radius Rout, number of channels M, and number of arrays N. Rout is designed depending on the value of M since the value of M will determine the number of different OAM modes that the OAM demultiplexer has to support. Different path lengths between the channel

ports and the array ports create phase delay in the array causing different phase distributions making it possible to generate and propagate OAM mode in

free space [3] as well as in fiber [4]. Design wavelength is 1.55 µm. Rout is the radius of the array curvature (Roland circle radius), whereas Rin is the radius of the channel curvature as shown in Fig. 2. The device is 1500 µm long and 456 µm wide. Device material consists of SiO2 cladding and Si core. xa is the spacing between the array waveguides, while xin is the spacing between the channel waveguides. In this context, i is the channel index and j is the array index. Lij is defined as the optical path length. θa is defined as the tilt angle for the array waveguides while θin is defined as the tilt angle for the channel waveguides.

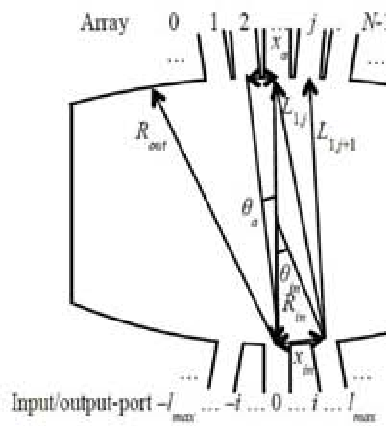

Fig. 2 Roland circle device design for multiplexer/ demultiplexer.

3. Results and discussion

Different crosstalk values were obtained for different values of N. Coupling OAM mode to MCF creates non-orthogonal quasi-fields, and therefore the crosstalk in that case is not as low as with the ideal case. Therefore, increasing the number of arrays N can create quasi-fields that more accurately represents the ideal OAM mode, which is the reason why increasing N decreases crosstalk. Noteworthy is to mention that N is not the only parameter that has impact on crosstalk. As shown in Fig. 3, increasing the value of M increases the crosstalk. This perspective makes it important to not only investigate N, but also M for identifying the criteria for optimally low crosstalk OAM demultiplexer.

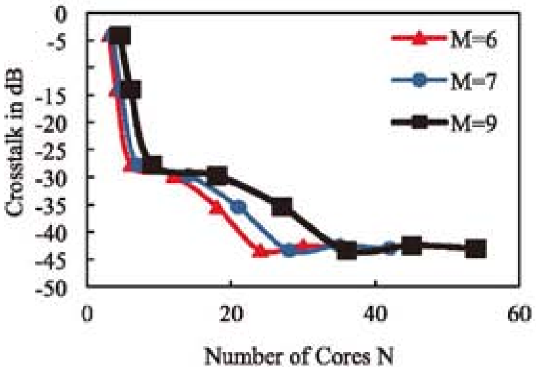

Fig. 3. Crosstalk of OAM mode demultiplexer as a function in N, for various values of M

As shown in Fig. 3, various values of M were investigated to observe the behavior of the crosstalk in the OAM demultiplexer. Therefore, it was concluded that modifying the x-axis in Fig. 4 from number of cores N to the ratio between N and M can provide for a more insightful understanding of the low crosstalk OAM mode demultiplexer.

The crosstalk is presented in Fig. 4 as a function in N/M for various values of M. As shown in Fig. 4, different values of M have no effect on the pattern of crosstalk as a function in N/M, and therefore low crosstalk OAM mode demultiplexer design criteria are perceived.

As shown in Fig. 4, a very low crosstalk for the OAM mode demultiplexer of -43 dB is achieved at a ratio of N/M=4. The independent value of N itself is not a predictable factor for the crosstalk, and so is the independent value of M. It is noteworthy to mention that at N/M>4, the crosstalk value saturates, which makes it redundant to increase the ratio of N/M to a much higher value than 4 given that the OAM mode demultiplexer device complexity will increase without any direct impact on the crosstalk.

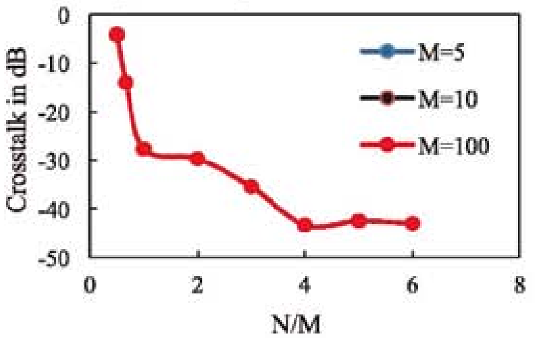

Fig. 4. OAM mode demultiplexer as a function in the ratio of N/M for various values of M

4. Conclusion

Increasing the value of N improves the crosstalk, however, increasing the value of M degrades the crosstalk performance.

Increasing the ratio of N/M improves the crosstalk regardless of the value of each parameter.

A ratio of N/M = 4 provides for the minimal crosstalk value of -43 dB for the OAM mode demultiplexer device.

Increasing the ratio of N/M to more than 4 does not help with the crosstalk improvement, as increasing the ratio of N/M to more than 4 saturates the crosstalk improvement.

5. Acknowledgement

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6. References

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