SOI 1D and 2D photonic crystal structures for polarization independent fiber-to-chip coupling and duplexing operation

D. Vermeulen, G. Roelkens, D. Van Thourhout, R. Baets

Ghent University – IMEC, Photonics Research Group, Ghent, Belgium

Introduction The high refractive index contrast that can be obtained in a silicon-on-insulator waveguide structure enables large scale integration of optical functions, which allows targeting low-cost, high volume applications. In earlier work we have shown that one-dimensional and two-dimensional [1] photonic crystal structures can be used to efficiently interface an SOI waveguide circuit with an optical fiber, and that it even allows for a polarization diversity approach to tackle the problem of polarization independent operation in high index contrast waveguide structures. This fiber-to-chip coupling using photonic crystal structures so far has been limited to a single wavelength band operation. Also, polarization independent fiber-to-chip coupling was only possible using a two-dimensional grating structure. In this paper we demonstrate for the first time the use of both one-dimensional and two-dimensional photonic crystal structures for polarization independent fiber-to-chip coupling in two distinct wavelength bands, while at the same time providing the duplexing operation for both wavelength bands. As a demonstration, we work with the 1300nm and 1550nm wavelength band, due to its practical use for Fiber-to-the-Home (FTTH) integrated optical circuits.

Devices Figure 1a shows a two-dimensional square lattice photonic crystal structure with four access waveguides. The photonic crystal is designed to support a Bloch mode around 1550nm and 1310nm, both lying above the light line and diffracting light in the air cladding in the same direction. By tilting the fiber under this angle, both Bloch modes can be excited from the fiber and collected in the access waveguides, thereby efficiently coupling light into the chip in both wavelength bands. Since the group velocity of both Bloch modes is in opposite directions at the same time duplexing of both wavelength bands can be achieved. Due to the symmetry of the square lattice, both orthogonal fiber polarizations can be efficiently coupled to the SOI waveguide circuit for both wavelength bands. In figure 1b, a one-dimensional grating structure is used to achieve an efficient interface between chip and fiber in two distinct wavelength bands, while accommodating the polarization independent coupling of a single wavelength band (1310nm band in this case). Both types of structures have been fabricated in a CMOS pilot line using 193nm DUV lithography. We report an insertion loss of -6dB/-8dB for 1300nm and -6dB/-7dB for 1520nm/1580nm in respectively the one-dimensional and two-dimensional photonic crystal configurations. The measured fiber-to-fiber polarization dependent loss (PDL) ranges between 0.4dB and 1.8dB within a bandwidth of 100nm around 1300nm in the one-dimensional structure, as shown in Figure 1c.

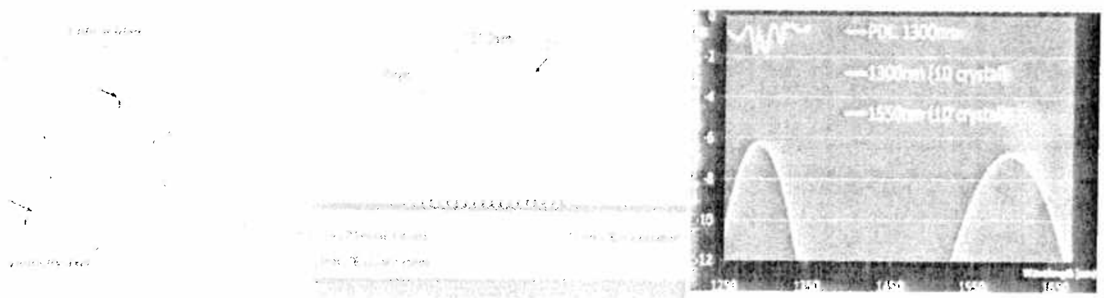
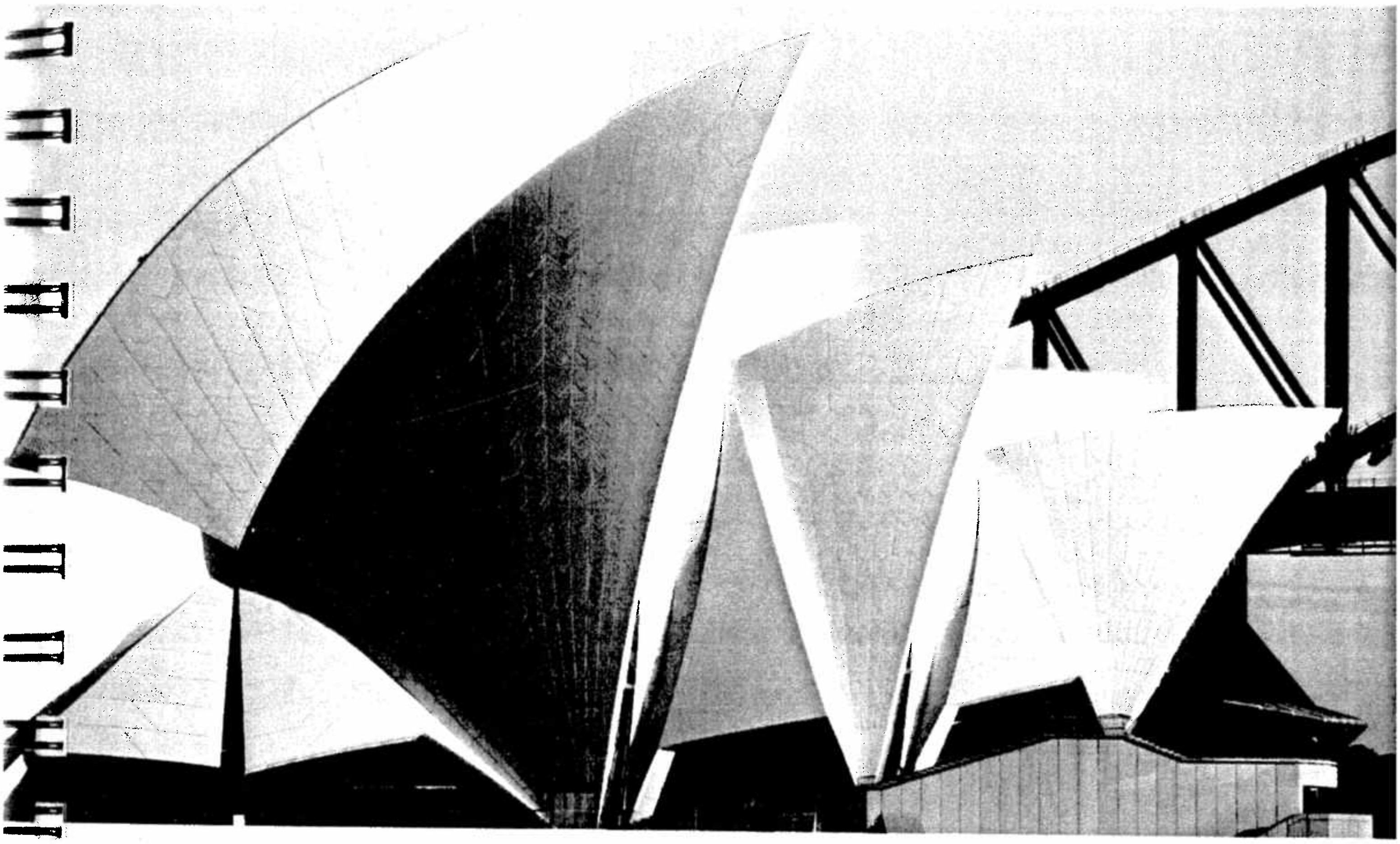


Fig. 1: 2D grating duplexer (a) and 1D grating duplexer (b) with polarization diversity and measurement (c)

References

[1] D. Taillaert *et al., Jap. Journ. Appl. Phys. 45(8A), p. 6071-6077 (2006)*



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