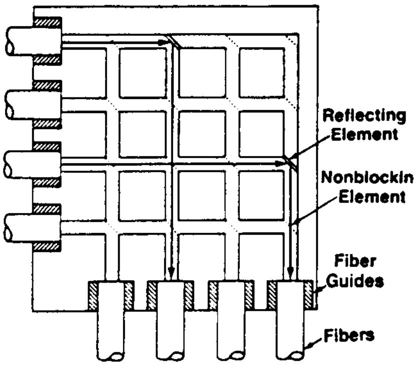

Fig. 2. Bubble switches can be incorporated into a matrix of crossing waveguides. Bistability permits matrix addressing.

(Poster Paper)

TuD9 In-line flexural wave optical modulator, filter, and frequency shifter in dual-core fiber

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A component vital to the successful implementation of single-mode fiber signal processing and communications systems is an integrated in-line Bragg cell that can function as a modulator, SSB frequency shifter, and tunable WDM tap. A number of reported devices[1,2] go toward achieving this goal, the most efficient to date being the flexural-wave modulator in a dual-mode single-core (DMSC) fiber developed by Kim *et al.*[2] In their device the LP_{11} and LP_{01} normal modes (NMs) of the DMSC structure are coupled together by an acoustic flexural wave whose wavelength matches the intermodal beat period. Launching light into the even mode results in a frequency-shifted signal in the odd mode. In practice, however, it is difficult to excite just one NM, and a frequency-shifted signal in the LP_{11} mode is not appropriate for efficient pigtailing to a single-mode fiber. The dual-core (DC) device we have developed avoids these problems by permitting low-loss fusion splicing of a single-mode fiber to either core and having negligible intrinsic coupling. This is achieved by designing the DC to be phase velocity mismatched to such a degree that the NMs of the DC coupler are almost identical to the modes of each core in isolation. Provided that there is sufficient overlap of the modal fields, distributed feed-forward NM (and hence intercore) coupling will be achieved[3] in the presence of a flexural wave at the correct frequency. We fabricated two different DC fibers, DC1 and DC2, with experimentally determined beat lengths of 0.43 mm and 1.205 mm, respectively at $\lambda = 1\,\mu m$. Flexural waves were excited by using fused silica horns bonded to the DC fibers with glass solder. The intrinsic coupling in DC1 was too small to measure with our setup, and 8.5% acousto-optical coupling was obtained at 4.6 MHz and 962.5 nm. The instrinsic coupling of the DC2 was approximately 4%, and 100% (and beyond) acousto-optical coupling was achieved at 560 kHz and 1.064 μm. The length of DC fiber in each case was 30 cm. Both devices were widely tunable. The results of a heterodyne experiment with DC2, illustrated in Fig. 1, are presented in Fig. 2. The high intrinsic coupling of DC2 meant that the carrier was not fully suppressed, and the 9 cm of fiber on the opposite side of the horn meant that sideband suppression was not perfect. We believe that with additional development the modulator has considerable potential as a practice device.

References

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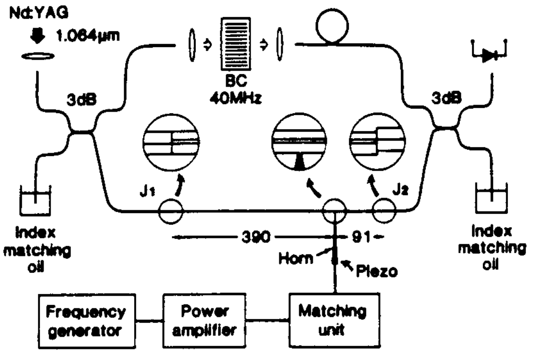

Fig. 1. The heterodyne experiment. Light from a Nd:YAG laser at 1.064 μm is split at a 3-dB coupler, one half is frequency shifted 40 MHz in a Bragg cell (BC), and the other launched into the central core of DC2 (spliced joint J1). At the opposite end of DC2, a second single-mode fiber is butt-coupled (J2) to the off-axis core, both signals are recombined in a second 3-dB coupler, and the heterodyne signal is detected at a Si photodiode.

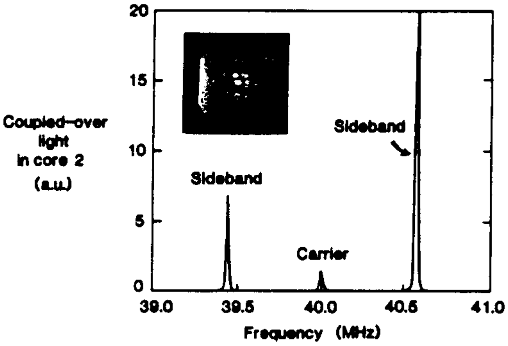

Fig. 2. Resulting frequency spectrum around 40 MHz with modulator running at 560 kHz at 1.064 μm. Carrier suppression is not 100% because of the intrinsic 4% coupling in DC2. The inset is a photograph of the cross section of DC2 (outer diameter 100 μm).

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