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PERFORMANCE OF BOW-TIE POLARISING FIBRES

M.P. Varnham, D.N. Payne, R.D. Birch & E.J. Tarbox

Department of Electronics, The University, Southampton, UK.

Abstract: Differential bending loss between the two polarised modes is shown to be a necessary condition for truly single-polarisation operation in highly-birefringent fibres. The very high polarisation extinction ratios obtainable make the fibre ideally suited to many applications requiring transmission of polarised light.

Bow tie fibres(1) provide an ideal medium for the transmission of polarised light over long distances. The very high values of modal birefringence ($\sim 10^{-3}$) obtainable with the optimal Bow-Tie cross-sectional geometry minimises the polarisation coupling occuring at sharp bends and twists. In addition, recent developments(2) have resulted in a fibre with large differential leakage-loss between the two polarised modes, such that any power coupled to the unwanted polarisation is heavily attenuated. The fibres thus have very high polarisation extinction ratios. Furthermore, the primary polarised mode has been measured to have low loss in long lengths. The fibres are therefore ideally suited in both long and short lengths for the many applications requiring truly single-polarisation operation(2), namely coherent detection systems, fibre gyroscopes and a whole range of interferometric and polarimetric sensors, switches and modulators. Similar work has been reported by Simpson et al(3), who found a differential loss of 30dB between the two leaky modes in a short length of fibre having an elliptical leaky-cladding structure.

The present work demonstrates that differential bending-loss is the single most important mechanism for polarising operation of very highly birefringent fibres. Moreover, our measurements show that the orientation of the fibre in the bend affects the polarising properties, an effect which has not been previously reported.

The polarising properties of Bow Tie fibres are most readily understood by comparing the attenuation of each polarised mode separately, as shown in Fig. 1. At long wavelengths, each mode experiences the commonly-observed microbending attenuation edge, but, as a direct result of the high core anisotropy, the edges occur at different wavelengths. In the region between the edges the fibre can be used as a polariser, with a loss of only 5dB/km for the guided mode and 55dB/km from the suppressed mode. Reference to the figure shows that improved performance results when the fibre is rewound from the 15cm radius drum (represented by the solid curves) to a 6cm radius drum (represented by the dashed curves). The greater extinction ratios obtainable with a smaller bend radius are evidenced by the very much sharper attenuation edges.

Figure 2 shows the extinction ratios versus wavelength measured in a single loop of Bow Tie fibre. Each curve represents a different bend radius and the results have been extrapolated to dB/m in the bend. The wavelength at which the fibre polarises light varies by about 100nm and an extinction ratio of 100dB/m occurs for the smallest bend. This is an incredibly high extinction ratio which may in longer lengths be limited by small amounts of mode coupling. Similar results have been observed in a wide variety of fibres having different geometries, index difference and birefringence. In all cases no polarising performance was detectable in short lengths of index-matched fibre kept very straight ($R=\infty$). We conclude therefore that although a polarising mechanism is predicted to exist in straight fibres[4] the differential bend loss observed here is by far the dominant contribution to the single-polarisation behaviour of Bow Tie fibres.

Finally, Figure 3 shows the not altogether surprising result that the orientation of the fibre axis of asymmetry in the bend affects the measured extinction ratio. The wavelength at which polarising behaviour commences is seen to vary with orientation. For each orientation angle Θ , inset (a) shows the wavelengths λ at which the fibre experiences 15dB extinction in a single loop of 20mm radius, while inset (b) defines Θ. The phenomenon has interesting implications and can clearly be used to tune the operating wavelength of a fibre polariser.

Further work on the design, fabrication and development of Bow Tie polarising fibres will be presented at the Conference. This will include numerical analysis of the polarising phenomena and some simple applications of the fibres which highlight their properties.

REFERENCES

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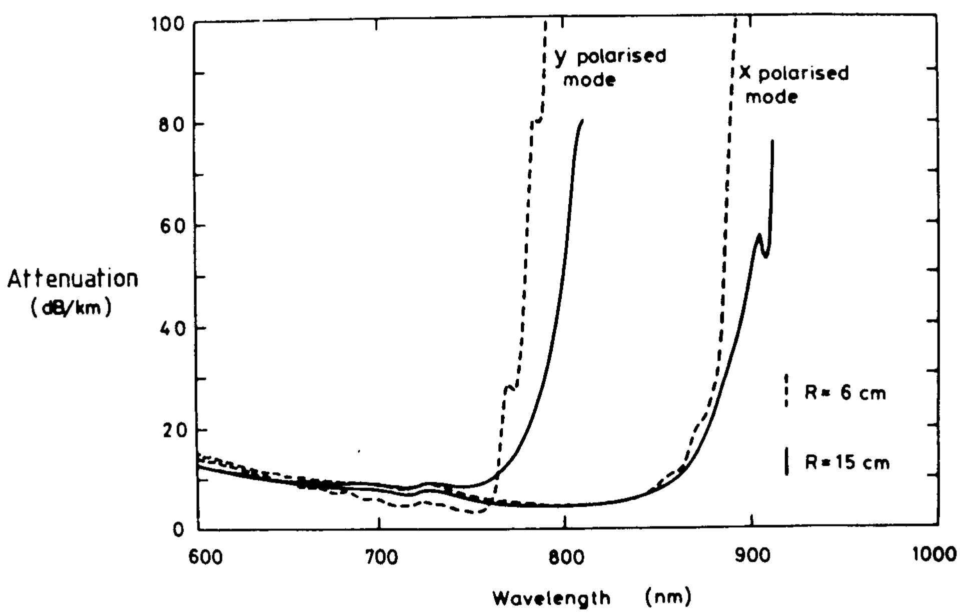

Fig. 1 Spectral attenuation plot of Bow-Tie fibre for two bend radii showing different loss edges for X and Y polarised modes.

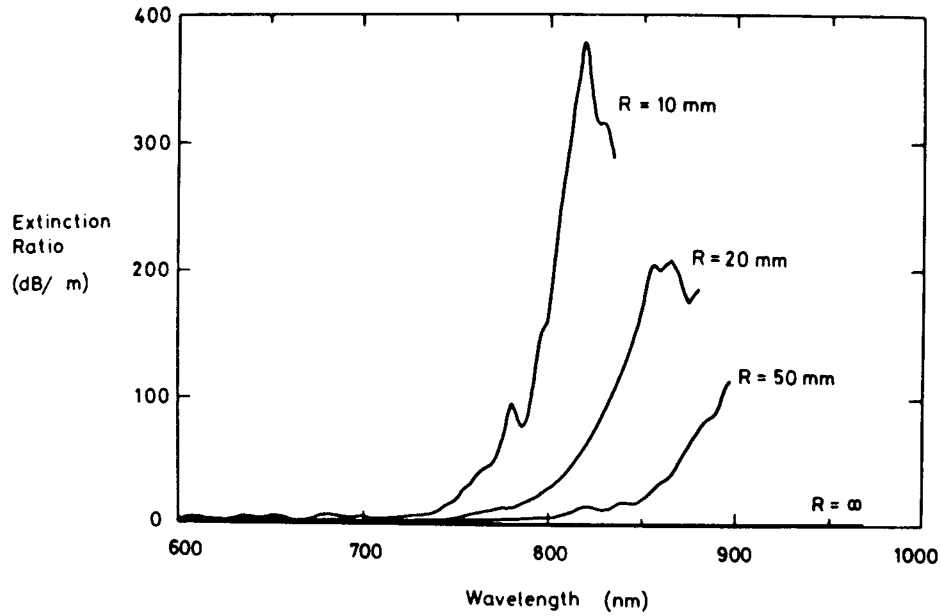

Fig. 2 Spectral extinction ratio for Bow-Tie fibre plotted for 3 bend radii shown.

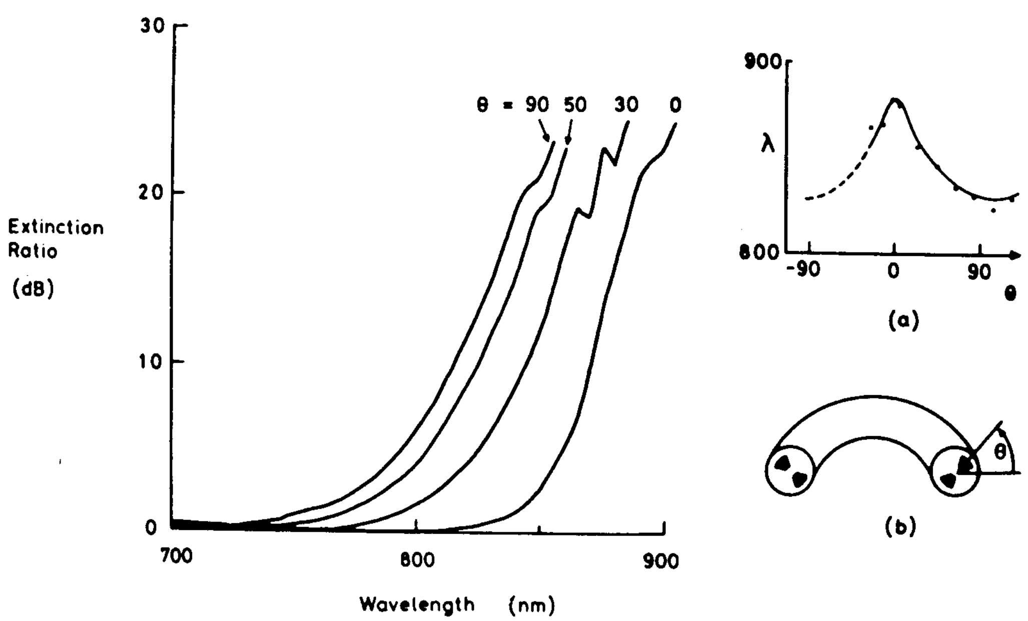

Fig. 3 Spectral extinction ratio for a single 20mm radius loop of Bow-Tie fibre as a function of bend orientation Θ (see inset (b)). Inset (a) shows wavelength variation with orientation of 15dB level.