COMPARISON BETWEEN COIL AND TAPER FIBRE-POLARISERS

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Abstract

Experimental results are presented which compare the performance of both coil and taper polarisers made from high-birefringence fibre. Taper polarisers with 35dB extinction have been constructed, while coil polarisers have yielded up to 62dB.

When a highly-birefringent fibre is bent[1,2] and/or tapered, a large differential loss occurs between the two linearly-polarised modes, and this effect can be used to construct high performance polarisers. The present work compares the performance and limitations of polarisers made from coils and tapers.

Coil polarisers were made by winding Bow-Tie fibres[3] into a 15-turn coil of 15mm radius, applying a silicone adhesive and then removing the coil from the former. The excellent reproducibility of the design is shown in Figure 1 by the measured polarisation extinction-ratio and guided mode loss versus wavelength for three unpackaged and one packaged polariser. At 820nm each polariser has a guided mode loss less than 2dB and an extinction ratio >25dB. Figure 2 shows that these characteristics are remarkably stable with temperature.

The 20% reduction in wavelength separation between -63°C and 140°C is attributable to the change in the fibre's birefringence with temperature[4].

Fibre polarisers exhibit both differential attenuation and cross-coupling between polarised modes. Their performance is best described by an intensity transfer matrix I which relates the input and output intensity polarisation states (x_i, y_i), (x_o, y_o) by:

$$(x_o, y_o) = \begin{bmatrix} \alpha_{xx} & \tau_{xy} \\ \tau_{yx} & \alpha_{yy} \end{bmatrix} \begin{bmatrix} x_i \\ y_i \end{bmatrix}$$

where α_{xx}, α_{yy} are the attenuations and τ_{xy}, τ_{yx} represent the cross-coupling between the modes[4]. By using a semiconductor laser at 820nm with a 5nm spatial width. I was found to be:

$$I = \begin{bmatrix} -2 & -42 \\ -42 & -64 \end{bmatrix} \text{dB}$$

Extending the analysis given in reference 5, the effective extinction ratio of this polariser when used in a gyro is $|I|$ = -62dB. The result is thus dominated by the differential attenuation α_{yy} and not by the cross-coupling terms.

Taper polarisers were made by heating and stretching the same Bow-Tie fibre. Figure 3 shows the spectral attenuation of the two polarised modes when the taper was immersed in oils having different indices. The extinction at 810nm is plotted against the oil index with respect to silica in Figure 4. The degradation in extinction ratio and the oscillations in Figure 3 are caused by reflections at the taper/oil interface. The oscillations are bend sensitive and, when using a narrow band source, have resulted in extinction ratios as high as 35dB at

633nm. Perfect index matching removes the oscillations and improves the average extinction ratio. Thus for a broadband source (10nm) an extinction ratio of 26dB has been obtained at 820nm, with an insertion loss of 2dB.

Comparing the two approaches, coil polarisers are easier to make, have reproducible and thermally-stable characteristics and, when used in a fibre gyro, offer high effective extinction-ratios. The value of 62dB represents the highest extinction ratio yet measured for a fibre polariser. Taper polarisers are more compact, have better guidance in the leads, but require close index-matching to silica.

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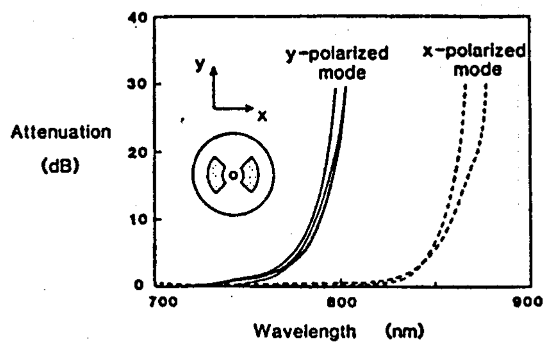

Figure 1: Spectral attenuations of several identical coil polarisers.

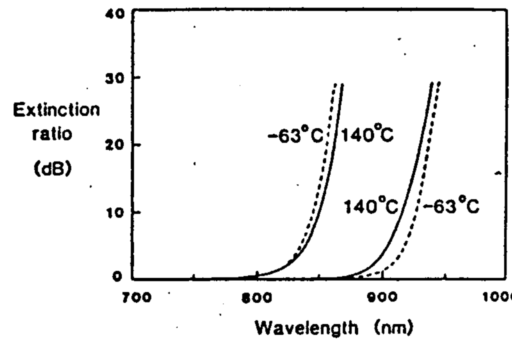

Figure 2: Temperature dependence of extinction ratio and guided mode loss of a coil polariser.

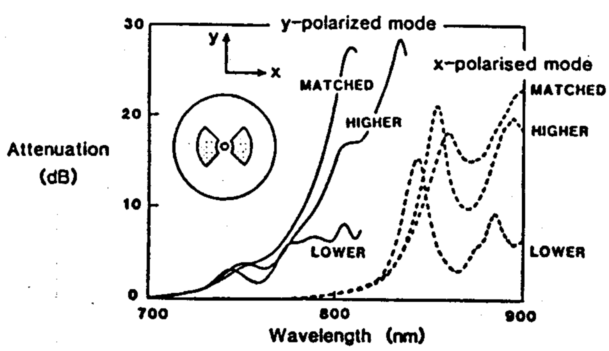

Figure 3: Spectral attenuation of a taper polariser when immersed in oils having indices higher, matched, lower than silica.

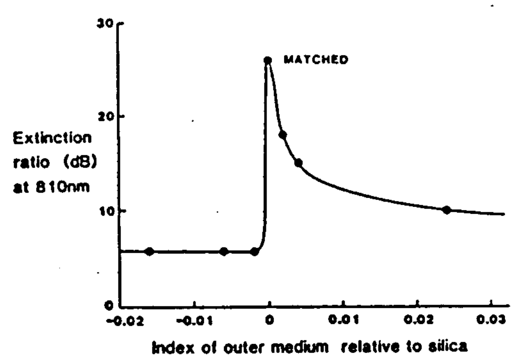

Figure 4: Effect of index matching fluid on extinction ratio.