IEE Colloq. 1982. 157

POLARISATION CHARACTERISTICS OF FIBRES FOR COHERENT DETECTION SYSTEMS

A. J. Barlow, D. N. Payne, M. P. Varnham, R. D. Birch,
Department of Electronics, University of Southampton,
Southampton, Hampshire, United Kingdom, SO9 5NH

INTRODUCTION

Coherent transmission systems utilising the optical heterodyning principle require a stable polarisation state for both the local oscillator and incoming signal waves[1]. For a fixed input state the output polarisation of a single-mode fibre in general varies according to the prevailing environmental conditions. Efficient heterodyning can be obtained only by stabilising the output state . This may be accomplished by either (i) designing the fibre polarisation properties to be intrinsically immune to the environment[3], or (ii) by actively controlling the output to maintain the required state of polarisation at the detector[2]. In this paper the design, manufacture and properties of fibres suited to both these approaches will be considered.

POLARISATION-MAINTAINING FIBRES

Environmental effects caused by bending, twist or side pressure introduce small amounts of birefringence into the fibre. The variations may be swamped by deliberately increasing the fibre birefringence $\Delta\beta$ to a level far greater than that produced by external perturbations. A highly linearly- birefringent fibre can transmit a stable, linear-polarisation state with an extinction ratio of 30dB after 1km[4].

Fibres are normally made birefringent by deliberately inducing a very highly asymmetric radial-stress profile. Thermal stress is introduced by using materials with widely-different expansion coefficients, while the asymmetry is usually in the form of an elliptical cross-section[4]. We report here the results of a new and remarkably simple stress-analysis technique. The analysis indicates the existence of an optimum cross-sectional geometry which is not elliptical but which nevertheless maximises the asymmetric stress component. The use of this geometry allows highly-birefringent fibres to be manufactured with a relatively low expansion-coefficient mismatch. Fibres with very close to optimum geometry have been fabricated and have given a beat length $L_p = 2\pi/\Delta\beta$ as low as 1.3mm at 0.633μm, without problems due to preform shattering during manufacture. Properties of these new fibres will be described, together with an assessment of their suitability for long-distance single-polarisation transmission.

LOW-BIREFRINGENCE FIBRES

For the output polarisation state of a fibre to be actively stabilised by means of a polarisation controller[2] it is important that (i) the polarisation state does not vary too rapidly and (ii) the total excursion of the polarisation state is as small as possible. The latter is important in view of the limited range of the polarisation controller.

A major cause of the variation in output polarisation state in a typical telecommunications-grade fibre is the temperature dependence of birefringence. By spinning the preform during manufacture[3] we have shown that a permanently twisted (spun) fibre can be manufactured which has no birefringence properties of its own and furthermore exhibits no temperature sensitivity. Thus variations in output polarisation are due solely to fibre packaging. The development of properties of spun fibres will be discussed, and the stability of their polarisation properties in various environments reported.

CONCLUSIONS

We have manufactured both high and low birefringence fibres representing the full spectrum of polarisation properties. Their suitability for coherent optical transmission depends on a number of factors such as loss, jointing ability, polarisation mode-dispersion and ease of manufacture. Results relevant to each of these factors will be presented.

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