BIREFRINGENCE TESTING IN SINGLE-MODE FIBRES MANUFACTURED WITH CONTROLLED POLARISATION CHARACTERISTICS

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Single-mode fibres with well-defined polarisation properties are required to interface to integrated-optical components[1] and in fibre sensors and the Faraday current-monitor[2]. The development of fibres with closely-controlled polarisation characteristics is critically dependent on the ability to accurately measure and interpret complex birefringence properties. A number of test methods for this purpose have been investigated and are described in this paper, together with an indication of the precautions necessary to minimise external effects.

Single-mode fibres may be designed with either high or low birefringence, depending on the intended application. High-birefringence fibres[1] are suitable for communications and interferometric sensor applications (hydrophones, gyroscopes), since they can transmit linearly-polarised light over substantial distances. The intrinsic birefringence arising from core ellipticity[3], asymmetric thermal stress[3] and frozen-in twist[4] is of sufficient magnitude to overwhelm the external effects, such as bending and pressure, which normally modify the polarisation state in the fibre. Low-birefringence[3] fibres, on the other hand, are essential for use in the current-monitor, since the presence of even a small birefringence reduces the device sensitivity[2]. In order to maintain their low birefringence properties, the fibres must be handled with care and this poses some unique measurement problems.

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The development of three techniques for the measurement of birefringence will be described and the results related to a programme of fibre development.

1. The linear birefringence in a fibre has contributions from both core ellipticity and asymmetric stress which arises from an expansion mismatch between core and cladding. The two effects can be separated by observing the variation of retardance with wavelength and with temperature. In the former case, the variation of birefringence with wavelength which is associated with core ellipticity is known theoretically, whereas in the latter the variation is produced solely by a change in thermal stress. Detailed results for both high and low-birefringence will be presented.

2. As a result of extensive measurements of the effect of twist on fibre birefringence, we have shown that ultra-low birefringence fibres can be manufactured by a process of spinning the preform during fibre drawing. The determination of very low retardance values has required specialised measurement techniques and these are described in relation to the development of spun fibres.

3. In addition to its influence on the polarisation state, birefringence can limit the bandwidth of the fibre as a result of a difference in group delay between fast and slow axes. The effect, known as polarisation mode dispersion, has been measured by taking the derivative of the fibre birefringence with respect to wavelength. Typical results for a range of fibres, including twisted fibres, will be presented.

In conclusion, birefringence test methods have been developed which provide essential diagnostic information for quality assessment and for the development of fibres with controlled polarisation properties.

References

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