SPECIAL FIBRES AND THEIR APPLICATIONS

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ABSTRACT

Optical fibre fabrication technology can be extended to produce novel fibres uniquely suited to a wide range of devices and applications. New fibre structures and materials can lead to considerable improvements in device performance.

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A mark of the success of optical fibres is that they are now regarded as 'conventional' technology with widespread application in transmission networks. Recently it has been recognised that fibre fabrication techniques can be extended to produce novel fibres uniquely suited to a wide range of devices and applications. New fibre structures and materials can lead to considerable improvements in device performance, particularly in active and passive fibre components, sensors and other elements of optical fibre circuitry.[1] In this paper existing special fibres will be reviewed and major areas where new fibres will have a strong impact will be identified.

Perhaps the best known special fibre is the highly-birefringent fibre, either in polarisation maintaining or polarising form. These fibres are extensively used for polarisation control in telecommunications, fibregyroscopes and other sensors. In

addition, we have recently reported two circularly-birefringent fibres, one having a helical core and the other made by spinning a highly-birefringent bow-tie fibre.[1,2] These fibres have very unusual propagation properties and are ideal for magnetic field sensing. Work is also underway on metal/glass composite fibres for the production of polarisers[3] and as a means of applying a high electric field close to the core in order to construct a Kerr-effect modulator. Each of these polarisation-control devices will be reviewed and current progress described.

Considerable scope exists for modifying the properties of silica fibres by incorporating dopants to enhance a given effect. Thus, although acousto-optic, magneto-optic, non-linear and electro-optic interactions are low in pure silica, they can be increased by adding various transition and rare-earth ions. Work in this area has begun in several laboratories and will be reviewed. However, it should be noted that, in general, the greatest improvements in sensors, switching devices and non-linear effects can be obtained by abandoning silica altogether as a host material and employing compound glasses, chalcogenide glasses or even polymers. The increased loss intrinsic to this approach is not normally a problem, since several orders of magnitude improvement in device sensitivity is obtainable and only a few metres of fibre are required.

Perhaps the most exciting special fibre recently developed has been the rare-earth and transition-metal-doped single-mode fibre. Whereas it was previously thought that the incorporation of these impurities would destroy the hard-won low-loss characteristics of telecommunications fibres, a simple reproducible fibre fabrication technique[4] has now been developed which does not significantly increase the fibre loss. The process allows the uniform incorporation of rare-earth ions in the core of many types of optical fibre. Applications include switching devices based on controlled absorption and fluorescence, distributed sensors, fibre lasers and amplifiers.

Fibre lasers have been demonstrated[5] at wavelengths of 920nm and 1088nm, 1060 and 1536nm using Nd^{3+}, Pr^{3+} and Er^{3+} respectively. The lasers are widely tunable (typically over 80nm), have low thresholds (sub-mw) and can be diode pumped (Nd^{3+}). Q-switching and mode-locking are possible to give pulses of high peak-power. Amplifiers with gains as high as 26dB have also been demonstrated. The low fibres losses permit very long lasers to be constructed (300m) and this unique property has implications for sensor technology.

Fibre lasers and amplifiers represent a new class of active fibre devices which are fully compatible with existing special fibres and components. Their low threshold, tunability and high peak-power pulsed output provides a new

all-fibre laser technology which will find application in a number of areas.

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