RARE-EARTH-DOPED FIBRES FOR SENSORS

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ABSTRACT

Rare-earth-doped fibre lasers and amplifiers have been demonstrated at several wavelengths in the visible and near infrared regions. As potential sources for optical fibre sensors they have the advantage of wide tunability, high pulse peak-power and complete compatibility with optical fibres.

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The incorporation of rare-earth dopants into the core of single-mode fibres [1,2,3] has led to a new class of both active and passive fibre devices including lasers, in-line optical amplifiers, absorption filters and distributed sensors. Several of these devices have reached a state of development where they are finding uses in telecommunication and fibre sensor applications. There is also considerable interest in the traditional laser area where the fibre laser is seen as a route to compact, tunable sources operating at wavelengths from the visible to the infra-red.

The small core size of the single-mode fibre allows high pump intensities for modest (~mW) pump powers. Moreover, the intensity can be maintained over long lengths and this leads to ultra-low lasing thresholds [4] and even permits CW diode-laser-pumped operation of three-level lasers [5]. In conjunction with the long fluorescent lifetime of rare-earths in glass, the high pump intensity allows high-gain (>30dB) operation of fibre amplifiers with excellent saturation properties[6]. In addition, compatibility with existing fibre components is excellent, allowing all-optical fibre circuitry to be assembled with both active and passive components. This is particularly beneficial for the fibre amplifier, where splicing of the active fibre into the link virtually eliminates troublesome Fresnel-reflection feedback which normally limits the gain in optical amplifiers.

A particular attribute of fibre lasers is that the optical-damage threshold of silica is significantly higher than that of the materials used in semiconductor laser fabrication and it is therefore possible to obtain higher peak-power pulses from fibre lasers using the techniques of Q-switching and mode-locking. Recently [7], pulses at a wavelength of 1.060μm with a peak power in excess of 100W and a duration of 15ns have been obtained from a Q-switched 15cm length of Nd^{3+}-doped fibre for a pump power of only 12mW. Similar performance can be obtained from an Er^{3+}-doped fibre, suggesting exciting prospects as a practical source for distributed sensors based on OTDR's, non-linear optics and photonic switching. The broad tunability should also prove useful in wavelength-multiplexed sensor networks.

Perhaps the first applications of rare-earth-doped fibres in sensors will be as a superfluorescent source for use in the fibre gyroscope[8]. The potential advantage here is that the broad emission spectrum is stable with fibre temperature and this provides a constant gyro scale factor.

Developments in rare-earth-doped fibre temperature sensors, lasers and amplifiers will be reviewed with particular emphasis on their applications in optical sensing.

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