TUNABLE SINGLE-MODE FIBRE LASERS

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ABSTRACT

Tunable laser action has been observed in a Nd-doped single-mode optical fibre using wavelength selective feedback. A tuning range of 80 nm has been obtained from 1065nm to 1145nm.

Introduction

Rare-earth doped single-mode fibre lasers and amplifiers may find many important uses as optical sensors and in long haul optical communication systems. The broad fluorescence linewidth of rare-earth ions in glass allows the construction of broadband amplifiers for use in wavelength-division multiplexing. It should also be possible to use distributed amplification as a means of overcoming losses in soliton propagation.

We have previously reported a technique whereby low levels of rare-earth ions may be incorporated into the core of single mode fibres[1]. The fibres are distinguished from previously-reported Nd^{3+} doped fibres[2] by exhibiting high absorption in the visible and near infra-red regions (>3000 dB/km) while having remarkably-low losses (<2dB/km) in the regions of interest for optical communications (Fig 1). This characteristic allows construction of long fibre amplifier and laser devices. For example, we have recently constructed a 300 m-long fibre laser with a pump threshold of a few mW. In lengths of a few metres we have recently reported the first semiconductor diode laser-pumped single-mode fibre laser with a sub-milliwatt threshold.

In this paper we report a widely-tunable Nd^{3+}-doped single mode fibre laser. The laser employs wavelength-selective feedback and is tunable over an 80nm region from 1065 nm to 1145nm, corresponding to most of the fluorescence linewidth of Nd^{3+} ions in silica. We believe this is the widest tuning range ever observed in a Nd^{3+} laser.

EXPERIMENT

The pump source was a Spectra-Physics 2020 argon-ion laser (514.5nm), coupled into the fibre using an intracavity microscope objective (x 10, 0.25 NA). A 5m length of Nd^{3+}-doped fibre with 15 dB/m unsaturated absorption at 514.5 nm was used as the gain medium. Optical feedback was provided with a plane input mirror (R>99% @ 1.09μm, T = 80% @ 514.5 nm) and a diffraction grating (600 lines/mm, blazed at 1μm). An intracavity pellicle was used as the output coupler. The lasing wavelength could be selected by changing the angle of the diffraction grating, which was mounted on a sine-bar-driven turntable.

As an indication of the gain available, laser action at a pump power of 122mW was observed to occur without the diffraction grating, feedback taking place from the fibre end-face reflection. With the grating in place, threshold occurred (on the peak of the gain curve) at 25 mW input, corresponding to only 10 mW absorbed in the fibre.

The laser characteristic is shown in fig.3. Lasing threshold and output power could be varied by altering the pellicle angle, but optimum output coupling could not be achieved using this configuration. Direct butt-coupling of the laser mirrors to the fibre ends eliminates the intra-cavity losses associated with the microscope objectives and >10mW output power has been observed with this configuration.

The laser tuning curve is shown in fig. 4. The pump power was 125 mW, corresponding to an absorbed pump power in the fibre of only 51mW. By comparison with the fluorescence curve also shown, it can be seen that the laser is tunable over virtually the full gain curve, an extensive tuning range of 80nm.

By incorporating other rare-earth dopants into the fibre, it is possible to cover most of the infra-red portion of the spectrum relevant to optical communications. For example, erbium has strong fluorescent peaks in silica at 1.536μm and 1.55μm, very close to the attenuation minimum in single-mode silica fibres. Using similar techniques to those described above, we have also observed laser action at 1.536μm in an Er^{3+}-doped fibre laser.

References

1. S.B. Poole, D.N. Payne. This conference

2. J. Stone and C.A. Burrus, Appl. Opt., 13, 1256, 1974.

3. R.J. Mears, L. Reekie, S.B. Poole and D.N. Payne, Electron. Letts 21, 738, 1985.

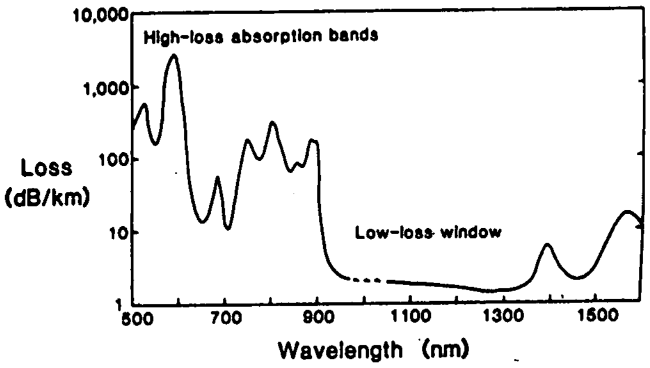

Fig. 1. Loss spectrum of single-mode optical fibre doped with 30ppm Nd^{3+}, showing low loss regions.

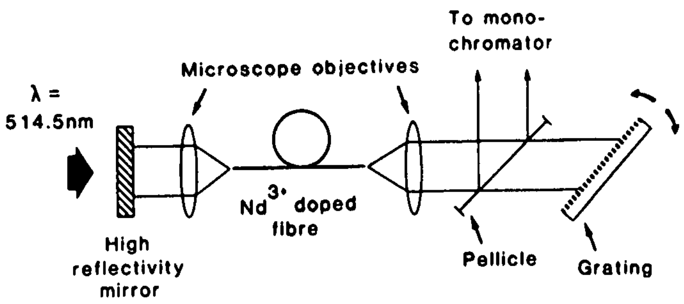

Fig. 2. Experimental configuration incorporating wavelength-selective feedback.

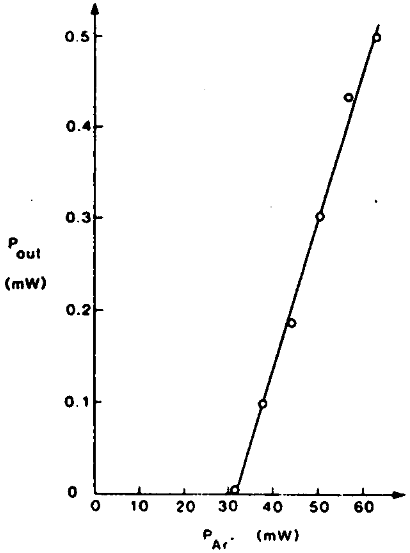

Fig. 3. Lasing characteristic for Nd-doped fibre laser operating at 1.09μm.

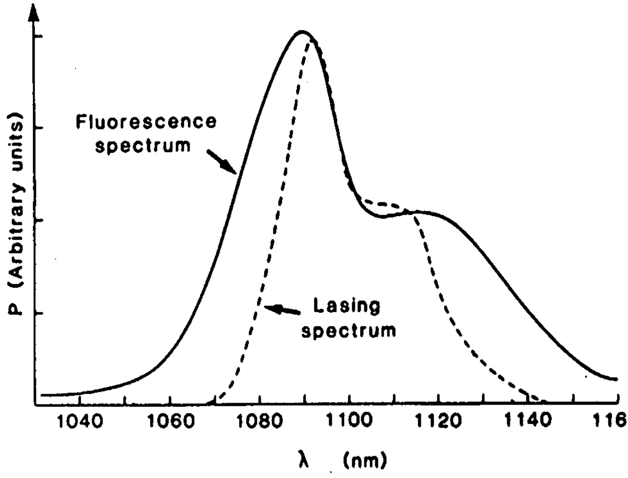

Fig. 4. Tuning range and fluorescence spectrum of Nd-doped fibre laser.