Monomode Neodymium-Doped Fibre Laser: Tunable Continuous-Wave Oscillation at 0.9 μm

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Recent experiments have shown that monomode silica fibre which has rare earth impurity ions incorporated into the core region can exhibit laser action with low threshold and high efficiency when end pumped by an external laser source [1,2]. Initial studies featuring the $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition around 1.08 μm of Nd^{3+} ions in monomode silica fibre investigated this sytem under conditions of Q-switching [3] and active modelocking [4] and demonstrated tuning over the range 1.07 μm - 1.14 μm [2]. A number of different sources have been used to pump fibre lasers including a cw dye laser [1,3,4], and GaAs diode laser [1], and an Ar^+ ion laser [2].

In this paper, we describe the first demonstration of cw operation of the $^4F_{3/2} \rightarrow {}^4I_{9/2}$ transition of Nd^{3+} ions in glass around 0.9 μm using an end pumped monomode fibre laser of this type. The configuration of the fibre laser cavity is shown in Fig. 1. Five hundred and eighty (580) nm wavelength light from a R6G dye laser is launched into the fibre through a high reflector optically contacted to the cleaved end of a Nd^{3+}-doped fibre (core diameter ~6 μm). An intracavity microscope objective (x10) produced a collimated beam at the output coupler. Tuning of the laser output is accomplished by a 2-plate birefringent filter of the type used in cw dye lasers. The insertion loss of such a filter is negligible when used at Brewster's angle with appropriately polarized light. However since the fibre does not preserve polarization, it is necessary to insert two $\lambda/4$ plates into the cavity between the fibre and filter to convert elliptically polarized output of the fibre into the correct linear polarization.

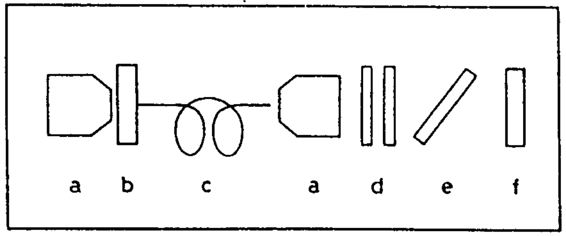

Fig.1. Fibre laser cavity: a) x 10 microscope objective; b) high reflector; c) doped fibre; d) $\lambda/4$ plates; e) birefringent filter; f) output coupler

For the $^4F_{3/2} \rightarrow {}^4I_{11/2}$ Nd^{3+} 4-level laser transition, the fibre length is chosen simply to ensure that the available pump power is absorbed. For the $^4F_{3/2} \rightarrow {}^4I_{9/2}$ Nd^{3+} transition, the situation is complicated by ground state reabsorption of the laser radiation, and, in general, shorter lengths of fibre must be used. The data presented here were obtained using a 1.2 m length of fibre which absorbed ~53 mW out of the available pump power of 130 mW.

Without any tuning elements in the cavity, the laser could be operated either at 906 nm or at 935 nm--wavelengths corresponding to the two peaks in the fluorescence curve (Fig. 2). Either peak could be selected by a small focusing adjustment (~5 μm) of the intracavity microscope objective. The linewidth at 935 nm was 1 nm in this configuration. With the birefringent filter and $\lambda/4$ plates in place, the laser output could be tuned smoothly from 900 nm to 945 nm. The variation of power output with wavelength is shown in Fig. 2.

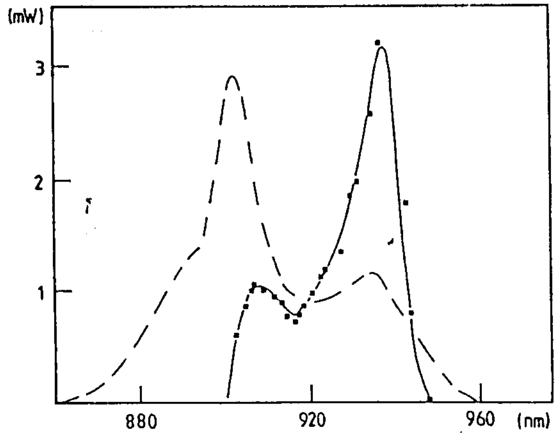

Fig.2. $^4F_{3/2}$ $^4I_{9/2}$ tuning curve (solid line) and fluorescence spectrum (broken line, arbitrary units)

Small rotations of the $\lambda/4$ plates were needed to maintain the correct polarization over the entire tuning range. With the tuning elements in the cavity, the laser linewidth is 0.06 nm. A cw output power of 3.2 mw was measured at the peak of the gain curve.

In conclusion, we have observed cw laser operation on the $^4F_{3/2} \rightarrow {}^4I_{9/2}$ Nd^{3+} transition which has hitherto only been shown to lase in pulsed mode in glass. This illustrates an essential property of glass lasers in fibre form: that confinement of the pump radiation field within a core of small transverse dimensions produces intense pumping without associated thermal problems [5]. Another instance has been provided by the first demonstration of cw laser operation on the 1.54 μm line in an Er^{3+}-doped fibre [2]. We anticipate that it should be possible to achieve lasing on other transitions which have not hitherto exhibited laser action in a glass host. The special technique used to fabricate these doped fibres can be adapted to a very wide range of impurity types [6]. In addition we have applied a simple technique for tuning fibre lasers which has the merit of producing polarized laser output from a polarization non-preserving fibre [7].

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