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EXTENDED WAVELENGTH OPERATION OF AN Er^{3+}-DOPED FIBRE LASER PUMPED AT 808nm.

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ABSTRACT

An Er^{3+}-doped single-mode fibre laser with an extended output wavelength range around 1.55um is reported. The laser was pumped by either a diode or dye laser and wavelength selection was by adjusting the fibre length.

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SUMMARY.

Rare-earth doped single-mode optical fibres have led to the development of a range of active fibre devices with numerous applications for telecommunications. Low threshold and efficient operation [1] of semiconductor laser pumped Nd^{3+}-doped fibre lasers together with single frequency operation [2] has been reported. In addition, high-powered [3], narrow linewidth Er^{3+}-doped fibre lasers and high gain fibre amplifiers [4] operating within the telecommunications 1.55μm window have been demonstrated. As previously noted [3], Er^{3+}-ions in glass have an absorption band at 808nm and can therefore be diode laser pumped.

In this paper we describe the operation of an Er^{3+}-doped fibre laser pumped at 808nm [5] and the extended wavelength range of operation obtained by employing various fibre lengths.

Er^{3+} lasers operate as three-level systems and thus Er^{3+}-doped fibres possess an inherent loss at the lasing wavelength which must be bleached before lasing can occur. This leads to rather higher threshold pump powers. However, in crystals, the $^4I_{15/2}$ ground state exhibits 8-fold crystal field splitting which in a pseudo-random host such as glass merge into a broad band, broadening the fluorescence spectrum (Figure 1) and enabling widely tunable lasers to be constructed [3]. At wavelengths slightly longer than 1536nm (the pure three level transition wavelength) lasing terminates at a partially thermally populated level significantly above the ground state and the system therefore

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behaves quasi 4-level. Consequently, the inherent loss of the fibre at the lasing wavelength is reduced as the wavelength is increased. By employing a range of fibre lengths the relative significance of this effect compared to other losses can be adjusted, thus enabling an extended range of operation to be obtained.

The experimental arrangement for the Er^{3+}-doped fibre laser is shown in Figure 2. The fibre was cleaved using a commercial cleaver and carefully butted to two dielectric mirrors to form a Fabry-Perot cavity. The input mirror had a 99.8% reflectivity over the lasing range (1.5-1.6μm) and a transmission of 75% at the pump wavelength. The output mirror had a reflectivity of 95% over the lasing range and a reflectivity of 30% at the pump wavelength. The fibre was characterised by a dopant concentration of 300ppm, an NA of 0.27 and a core diameter of 3.4μm, corresponding to a cutoff wavelength of 1200nm. A CW Styryl 9 dye laser, operating at 808nm to coincide with the $^4I_{15/2}$-$^4I_{9/2}$ absorption band of Er^{3+}, was initially employed as the pump source.

Figure 3 shows the lasing wavelength obtained for pump powers just above laser threshold for various lengths of doped fibre. For long cavity lengths, the pure 3-level transition remains unsaturated and so the lasing wavelength shifts towards the quasi 4-level transition around 1.6μm. As the fibre length is shortened the transition becomes bleached and the laser operates at 1.55μm on one of the peaks of the gain curve.

The lasing wavelength was observed to be independent of the pump power, for powers up to four times above threshold. At the important telecommunications window wavelength of 1.55μm the threshold was 1.6mW absorbed and the slope efficiency was 0.6%, although no attempt was made to optimise the output mirror reflectivity to improve this figure.

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Low threshold operation of a similar Er^{3+}-doped fibre laser employing an CW 808nm GaAlAs laser diode as the pump source has also been achieved. A threshold absorbed pump power of 3mW was observed and an output power of 130μW obtained. Based on these early results, the diode-pumped Er^{3+}-doped fibre laser appears extremely attractive as a telecommunications source.

In conclusion we have investigated the importance of cavity fibre length in determining the wavelength of operation of an Er^{3+}-doped fibre laser. The device was pumped at 808nm, both by dye and laser diode sources, and an extended range of operation of over 40nm around the 1.55μm telecommunications window was obtained.

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LIST OF FIGURE CAPTIONS.

Figure 1. Fluorescence from Er^{3+}-doped fibre pumped at 808nm.

Figure 2. Experimental configuration of Er^{3+}-doped fibre laser pumped at 808nm.

Figure 3. Lasing wavelength just above threshold against fibre length for Er^{3+}-doped fibre laser.

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Fig1

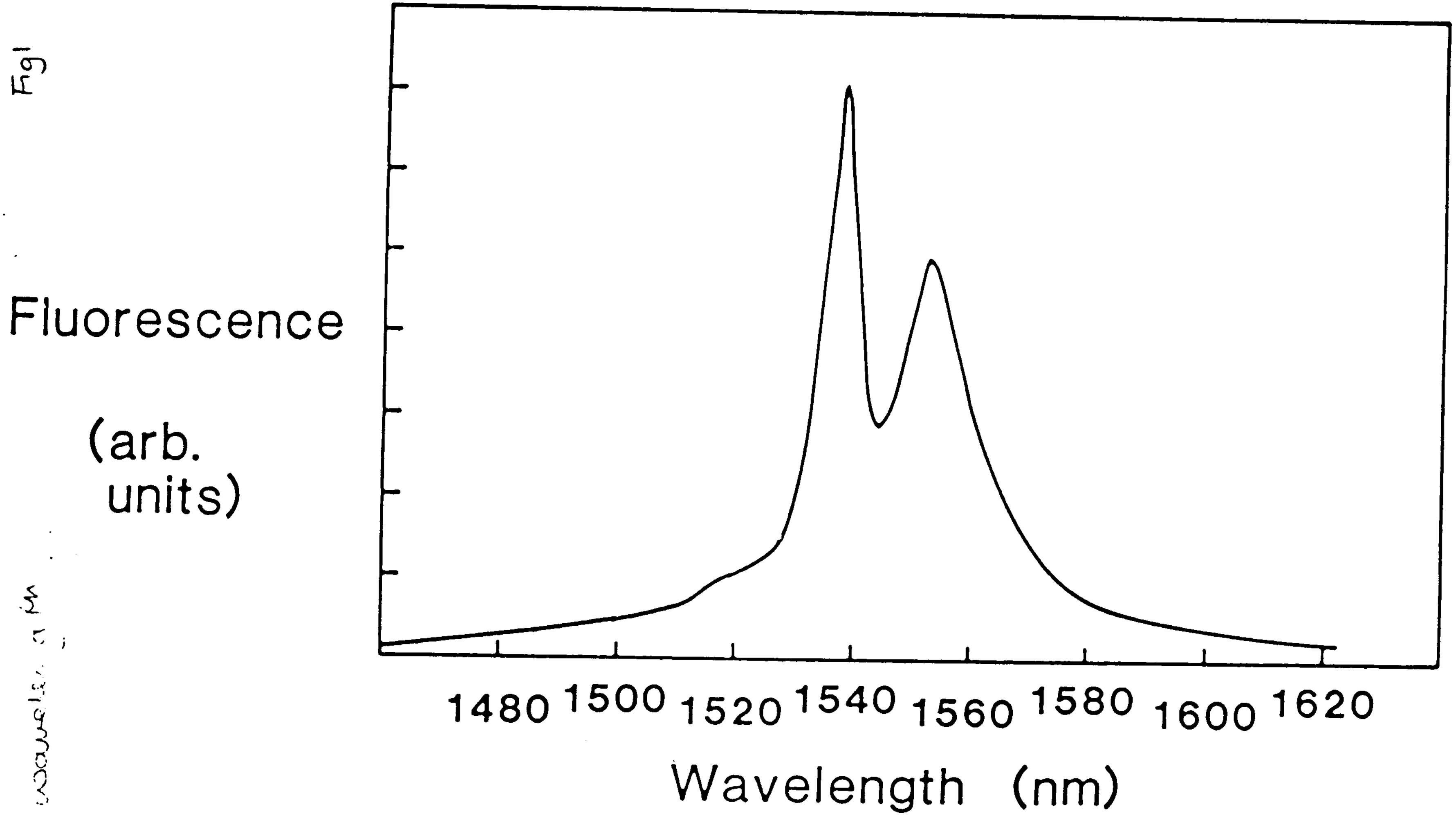

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Fig2

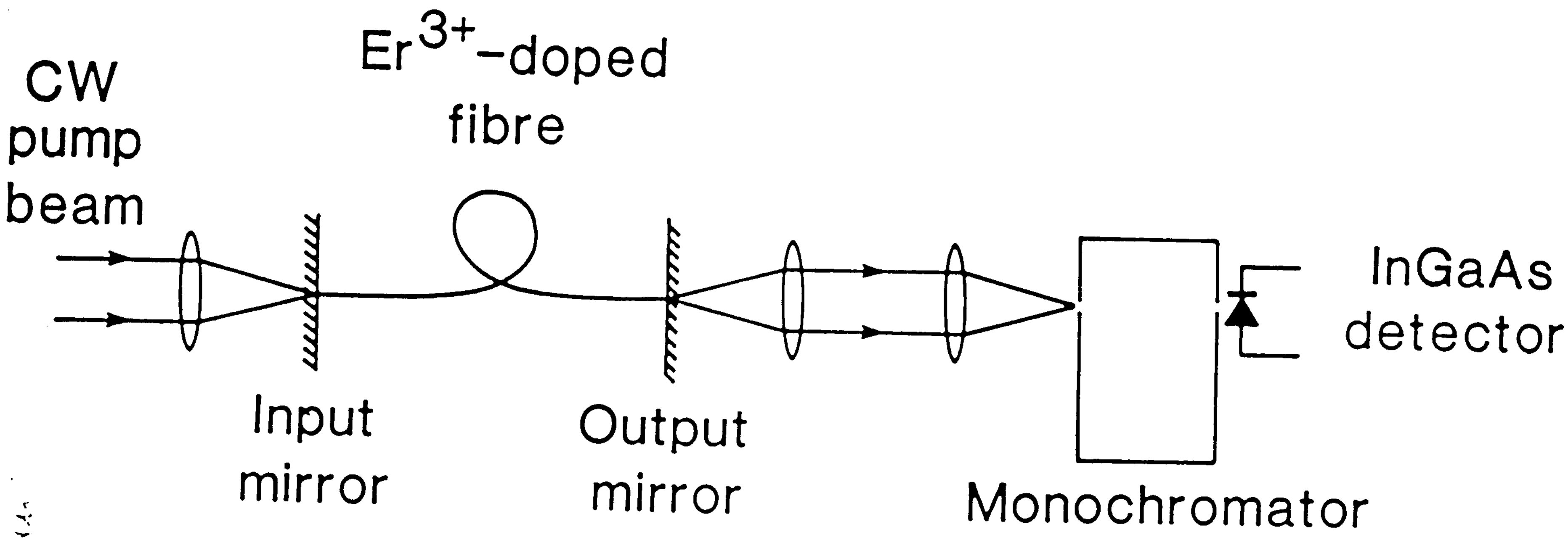

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Fig3