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HIGH-GAIN FIBRE POWER AMPLIFIER TANDEM-PUMPED BY A 3W MULTI-STRIPE DIODE

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An Nd^{3+}-doped compound-glass fibre laser pumped by a 3W AlGaAs laser diode array is employed as pump source for an Er^{3+}/Yb^{3+} optical fibre power amplifier. An amplifier gain of 45dB and output signal powers in excess of +20dBm are demonstrated.

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Erbium-doped fibre amplifiers (EDFAs) capable of a high output saturation power (> +20dBm) are needed to compensate splitting losses in large-scale subscriber networks. To obtain the requisite high pump power, the only practical means reported to date involves the use of multiple 1480nm diodes[1] or a miniature diode-pumped Nd^{3+}:YAG laser[2]. We report here a new all-fibre tandem-pumping approach which permits the use of readily-available, high-power (up to 30W), multi-stripe AlGaAs diode-lasers operating at 808nm. The light from the high-power diode is efficiently (~45%) converted into single-mode radiation at 1.053μm using a new cladding-pumped Nd^{3+}-doped fibre laser fabricated from compound glass. The 1.053μm radiation is then used to pump an EDFA co-doped[3] with Yb^{3+} to give a small-signal gain of 45dB and an output power in excess of +20dBm.

The design of the cladding-pumped Nd^{3+}-doped fibre laser is shown in Fig. 1 (inset). The fibre was fabricated from compound glass so as to obtain the high NA necessary to match the pump-diode diffraction angle and to obtain a higher Nd^{3+} radiative cross-section. A heavily Nd^{3+}-doped (3 wt%) core made from Schott F7 and having an NA of 0.13 and diameter 5.9μm is located centrally within a rectangular, highly-multimode, undoped, inner waveguide (Schott F2). This in turn is clad with Schott LF8 to give a circular fibre cross-section. The pump light is injected into the multimode rectangular core (NA 0.42) which is designed to match the diode characteristics and minimise the core/inner cladding area-ratio, thus optimising the pump absorption in the core[4]. The fibre core and inner cladding losses were respectively 0.86dB/m at the lasing wavelength of 1.053μm, and 0.3dB/m at the pump wavelength of 808nm. Owing to the high Nd^{3+} concentration, the optimum fibre length was only 1.2m.

A 3W diode array (Spectra-Diode Labs) was launched into the rectangular inner cladding of the laser fibre through an 808/1053nm highly-reflective dichroic mirror butted to the endface, the other mirror being simply a 4% cleaved endface reflection. For 1.5W of launched power, the laser gave an output power of 680mW (Fig. 1), at a wavelength of 1.053μm, with a slope efficiency (45%) which is close to the maximum attainable.

The output from the high-power Nd^{3+}-doped fibre laser was used to pump an Yb^{3+}-sensitised, Er^{3+}-doped amplifier fibre described elsewhere[3]. The fibre is based on a phosphosilicate composition and exhibits remarkably-high energy transfer efficiency (90%) from the Yb^{3+} absorbing ions to the Er^{3+} ions.

The 1.053μm pump light was launched in the counterpropagating direction into the 2.4m amplifier fibre through a 1053nm/1535nm WDM fibre coupler by butting the Nd^{3+} fibre laser directly to the coupler input arm. Losses incurred in the coupler and through various spot-size mismatches were ~2.5dB. The output characteristics of the amplifier are shown in Fig. 2 as a function of input pump power for an input signal power of 1mW from a 1535nm DFB laser. A maximum output power of 106mW was achieved for a launched power of 380mW, representing the highest output power yet achieved from an Er^{3+} amplifier when pumped unidirectionally by a single diode. The amplifier threshold was 50mW and the slope efficiency was ~33%, which is similar to that obtained in the Nd:YAG pumped case[2].

The Er^{3+}/Yb^{3+}-doped fibre amplifier (EYDFA) characteristics are shown in Fig. 3 as a function of input signal power at a constant pump power of 360mW. The small signal gain is ~45dB and an output signal of ~100mW is attainable for ~100μW of signal power.

In conclusion, we have demonstrated an all-fibre approach to obtaining high output saturation powers from an erbium-doped fibre amplifier. The technique allows the use of readily-available, high power AlGaAs pump-diodes and, unlike direct diode excitation, is therefore scalable with pump array size. To date, output powers in excess of +20dBm and gains of 45dB have been obtained using only a counterpropagating configuration, which compares favourably with previously reported schemes. By improving the butt, splice and coupler losses, as well as diode launch efficiency, amplifier output powers in excess of 300mW can be anticipated, with still further increases obtainable using bidirectional pumping.

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Figure Captions

Figure 1 Characteristics of the diode-array-pumped Nd^{3+}-doped fibre laser. Output wavelength is $1.053\mu m$. Inset shows the cladding-pumped fibre cross-section.

Figure 2 Er^{3+}/Yb^{3+} co-doped fibre amplifier output power vs. input pump power from the Nd^{3+}-doped fibre laser.

Figure 3 EYDFA gain and output power vs. input signal power.

J.P. Minelly et al , FIG 1

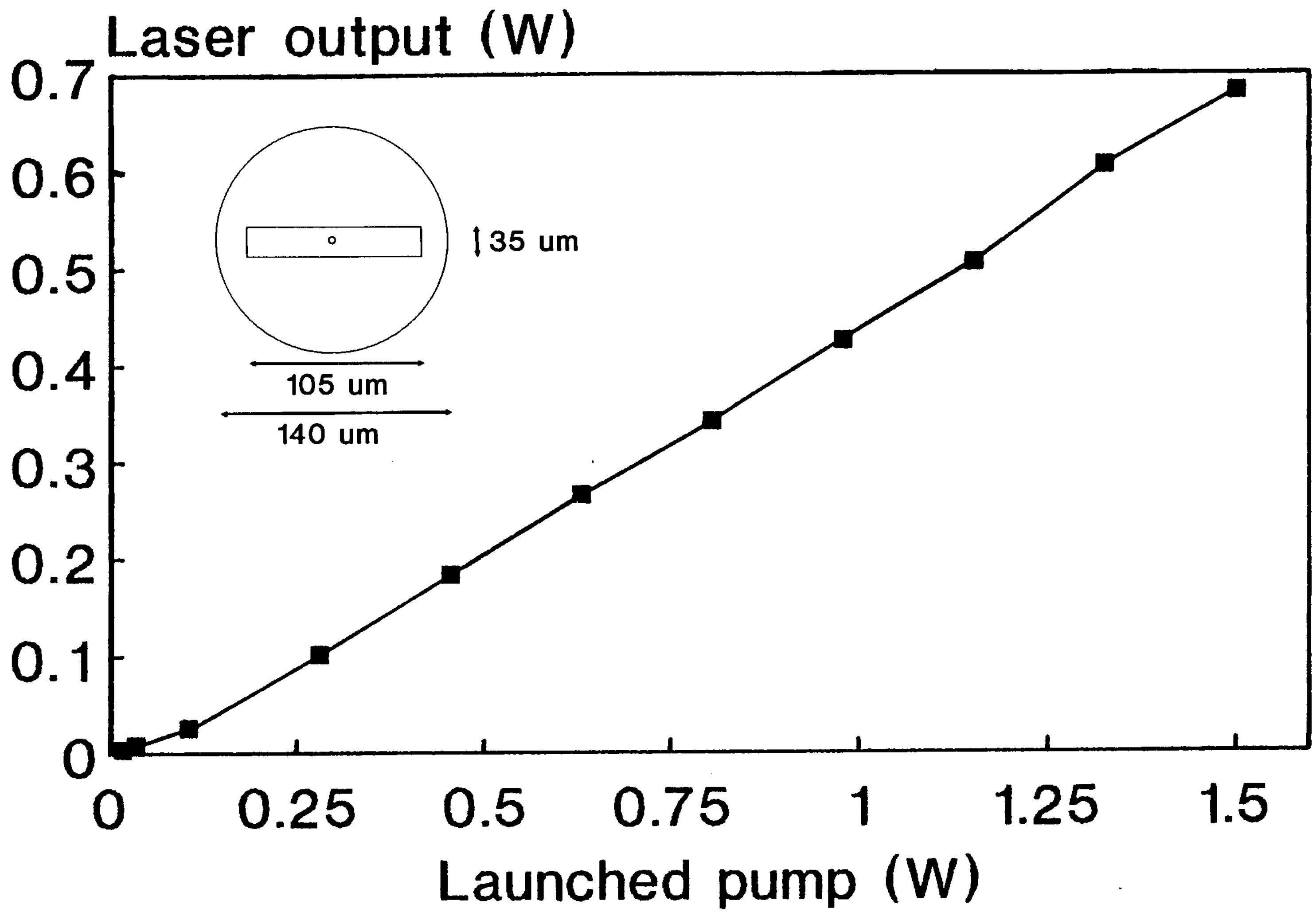

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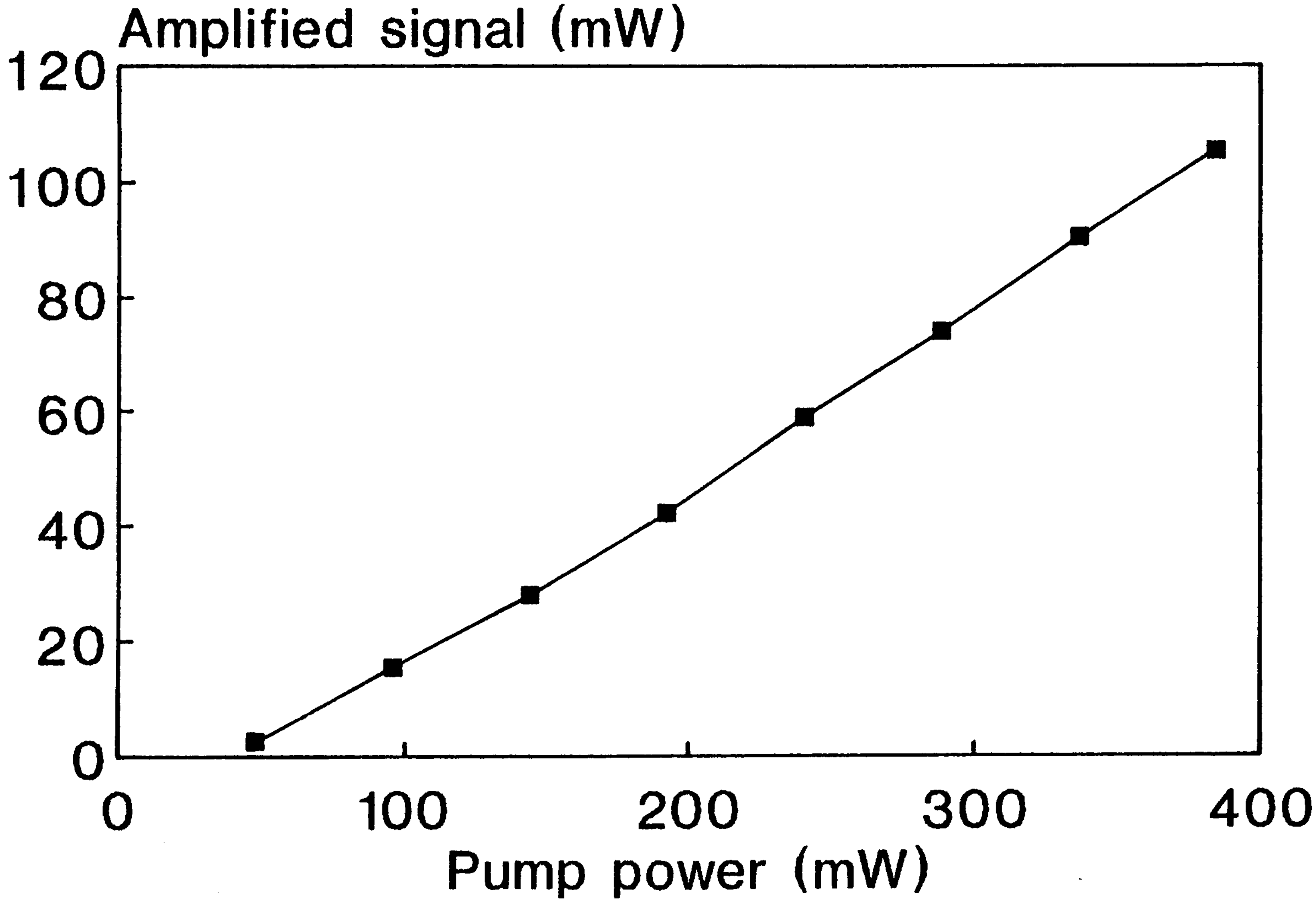
FIG 2



J. D. Minelly et al, FIG. 3