LL01

Highly Efficient Er^{3+}-doped Fibre Lasers Pumped at 980nm

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Introduction

The Er^{3+} fibre laser operates at a wavelength between 1.5 and 1.6 microns and is thus of interest for both telecommunication purposes and, since it can be Q-switched to give high pulse powers, in eye-safe range-finding systems. To date, ~810nm has been the preferred pump wavelength owing to the ready availability of laser diodes. However, the 810nm pump band of Er^{3+} suffers from the serious disadvantage of pump excited-state absorption (ESA). As a result much of the pump light is wasted in exciting ions from the metastable level to a still higher energy level, rather than producing stimulated emission. This is reflected in the best reported slope efficiency of 17%[1], obtained for Er^{3+} sensitized with Yb^{3+}.

A recent report[2] has demonstrated that the most efficient wavelength to pump Er^{3+} doped fibre amplifiers is 980nm, since this pump band is entirely free from ESA. Further, laser diodes operating at 980nm are a realistic proposition[3] and their development will, as is shown here, enable the production of a particularly useful class of fibre lasers with very high pump conversion efficiencies operating in the third telecommunications window.

Figure 1: The effect of output coupling.

Experiment

An Er^{3+} doped fibre (0.08 wt%, NA = 0.15, cutoff = 950nm) was fabricated using the solution doping technique. In addition, Al_20_3 and P_20_5 were added to the core to ensure an even distribution of Er^{3+} ions. Pump light at 980nm was obtained from a CW Styryl 13 dye laser. By monitoring the residual pump power emerging from the fibre end as the fibre was cut back, the launched and absorbed power could be determined. Lasers were formed by butting fibre ends against dielectric mirrors.

Both the output power and the operating wavelength of the laser depend on the output coupling, as shown in Figure 1, for a fixed launched power of 13mW and a fibre length of 0.89m. The three discrete operating wavelengths are a feature of Er^{3+} doped silica fibres that have been co-doped with Al_20_3, and result from selection of the various Stark levels for different cavity losses. The optimum output coupling is seen to be R ~40% at which the operating wavelength is 1.56μm.

Figure 2: Output power vs fibre length.

Since Er^{3+} is a three level system, the fibre must be optically bleached before lasing may occur. As a result, the optimum length of fibre to use depends on the pump power available. Data demonstrating this is shown in Figure 2, which was obtained using the optimum output coupling of R = 40%. For the maximum pump power available (15mW) the optimum length was found to be ~1.3m. A laser characteristic obtained using these optimized parameters (length = 1.37m) is shown in Figure 3. A slope efficiency (in terms of launched power) of 51±7% was obtained corresponding to a quantum efficiency of 0.94±0.14. This is a remarkably high figure and demonstrates almost total conversion of the pump power into a useful laser output at 1.56μm.

Figure 3: Laser characteristic.

Conclusion

Er^{3+} fibre lasers pumped at 980nm are much more efficient than those pumped at 810nm. The data of Figure 3 shows an excellent slope efficiency of 51% which can be compared with only ~17% for Er^{3+} pumped with a diode array operating at 806nm. It is not unrealistic to expect at least 10mW of power between 1.53 and 1.57μm from an Er^{3+} fibre laser pumped with a single stripe 980nm diode once these become available. Moreover, the addition of line narrowing elements to the cavity will allow single longitudinal mode operation and make laser an attractive source for coherent communications.

Perhaps the most attractive feature of the Er^{3+} doped fibre laser is its potential to produce Q-switched pulses in excess of 1kW peak power for applications in non-linear switching, OTDR measurements and range-finding.

Acknowledgement

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References

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2. Laming, R. I. et al: "Optimal pumping of Erbium Doped Fibre Optical Amplifiers", Proc. ECOC '88, Brighton, Vol. II, 1988, pp. 25–28.
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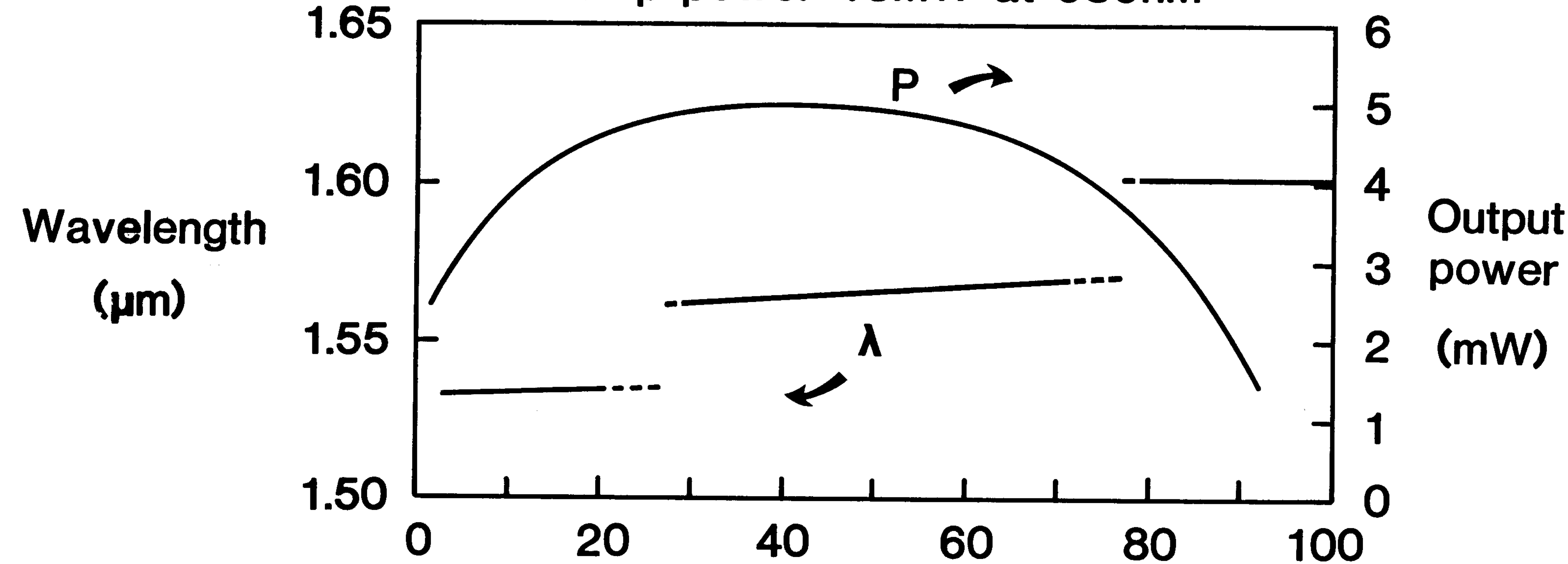
401.1

26.6 TO 80

ERBIUM FIBRE LASER

Selection of wavelength with mirror reflectivity

Pump power 13mW at 980nm



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24·5 TO 8.0

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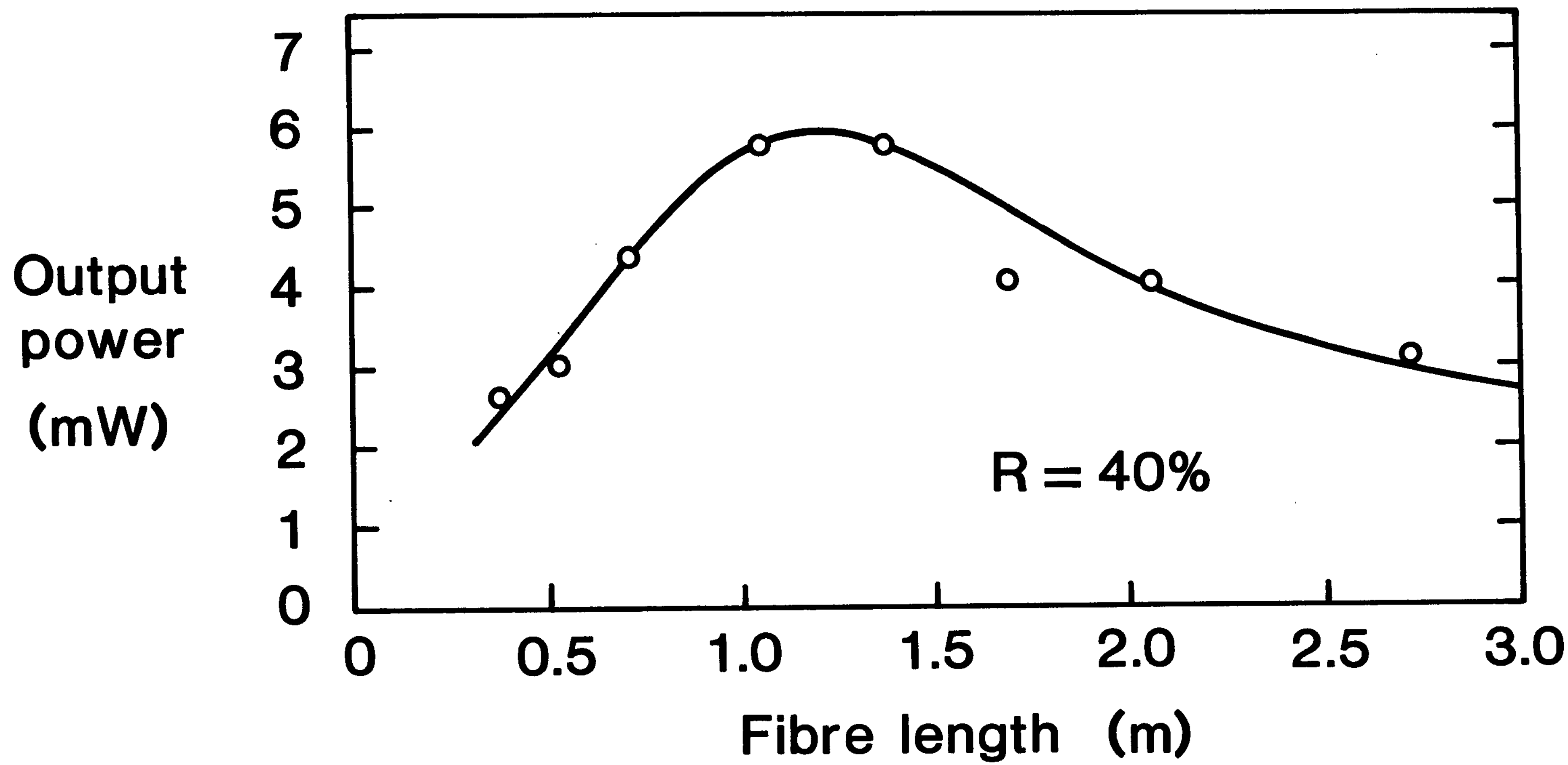

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23.7
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