Neodymium doped chalcogenide glass fibre laser

B.N. Samson, T. Schweizer, R.C. Moore, D.W. Hewak, and D.N. Payne

Optoelectronics Research Centre, University of Southampton

Southampton, SO17 1BJ, United Kingdom

Tel: +44 01703 594523

Fax: +44 01703 593142

Abstract

We report on laser action in a Neodymium doped Gallium Lanthanum Sulphide glass fibre. Laser action at 1080nm was obtained in a 22mm long multimode glass fibre with a neodymium doped core, fabricated by the rod-in-tube technique. The laser was pumped continuous wave with a Ti:sapphire laser at 815nm and showed a self-pulsing behaviour.

Laser action in rare-earth doped chalcogenide glasses has recently been reported in neodymium doped bulk gallium lanthanum sulphide (Ga:La:S) glass [1], a chalcogenide glass which combines high rare earth solubility with good thermal stability. However, there is a greater potential of this family of glass when pulled into fibre form; examples include rare-earth doped chalcogenide glass fibres operating at 1.3μm for telecommunication applications [2,3] and fibre lasers emitting in the mid-infrared wavelength region for trace gas detection [4]. Many of these devices are not feasible in silica or fluoride fibres, either due to the transition of interest being quenched by the high non-radiative (multi phonon) decay rates or to the poor glass transmission in the mid-infrared.

The Ga:La:S glasses and fibres used in these experiments were prepared using melt quenching and the rod-in-tube technique as reported in reference [5]. The optimum neodymium concentration was obtained by measuring the lifetime of the metastable $^4F_{3/2}$ level in a range of glass samples, figure 1, where we observe the onset of concentration quenching to occur at around 0.1mol% Nd_2S_3.

Below this concentration the metastable lifetime is 75μs, a value considerably less than that observed in neodymium doped silica and fluoride glasses due to the high radiative transition rate, a consequence of the high refractive index in Ga:La:S glass.

The 22mm long Ga:La:S fibre used in the laser experiments had a 14μm core doped with 0.05mol% Nd_2S_3, an outer diameter of 230μm and was held in a V-groove with plane mirrors butted to either end using index matching fluid. The input mirror had a high transmission at the pump wavelength and a high reflectivity at the laser wavelength whilst the output coupler had a reflectivity of 93% at 1080nm. The Ti:sapphire laser pump beam operating at 815nm, was focused into the fibre core with a ×20 microscope objective. As with the bulk laser [1], room temperature laser action was achieved on the $^4F_{3/2}$→$^4I_{11/2}$ transition at a wavelength around

1080nm and the dependence of the output power on the incident Ti:sapphire pump power is shown in figure 2. The threshold is about 200mW and a maximum output power of 1.2mW was obtained for this particular output coupler, however, by increasing the output coupler reflectivity to 99.5% the laser thershold could be reduced to around 50mW.

Although pumped continuous wave (cw) the fibre laser did not lase cw but showed a self-pulsing behaviour, an effect not observed in the bulk laser which showed stable cw laser action [1]. The fibre laser emitted pulses with about 0.2μs width and regular pulse spacings with repetition rates between 2μs and 3.5μs. A typical train of pulses is shown in figure 3. Self-pulsing has been observed in rare-earth doped fibre lasers before although the explanation for such effects are not fully understood. In this particular case, the fact that the bulk laser operates cw would indicate that the effect is concentration dependent since the neodymium dopant level is much lower in the case of the fibre laser. Finally the laser was operated for a considerable time without a significant change in the threshold or slope efficiency indicating that pumping close to the intrinsic glass absorption edge is practical in these glasses.

In conclusion, the neodymium doped Ga:La:S glass fibre was fabricated using the rod-in-tube technique and showed laser action at room temperature at a wavelength of about 1080nm when pumped with a Ti:sapphire laser at 815nm. This result is a significant step towards the realisation of practical devices in this new class of materials, in particular, efficient 1.3μm amplifiers for telecommunication and new fibre lasers operating at mid-infrared wavelengths.

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References

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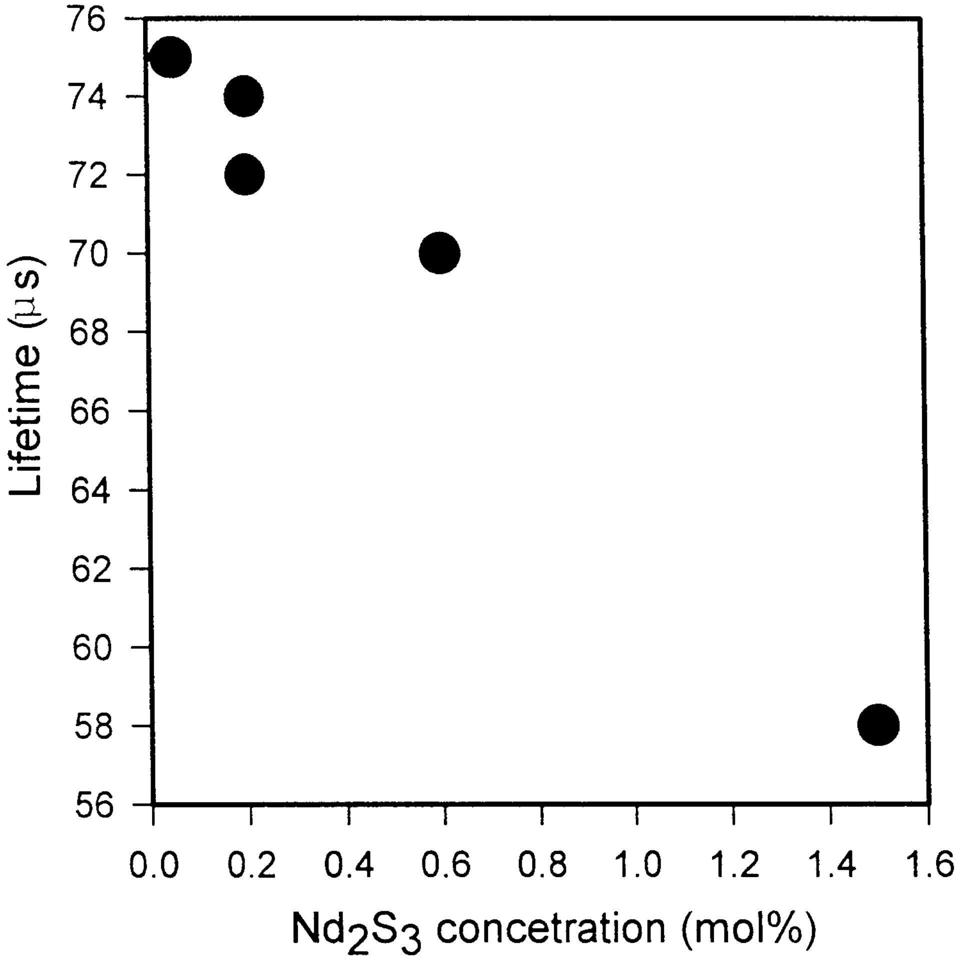
Figure captions

Fig. 1 Lifetime versus concentration for neodymium doped Ga:La:S glass.

Fig. 2 Output power versus incident pump power for a neodymium doped Ga:La:S glass fibre laser operating at 1080nm.

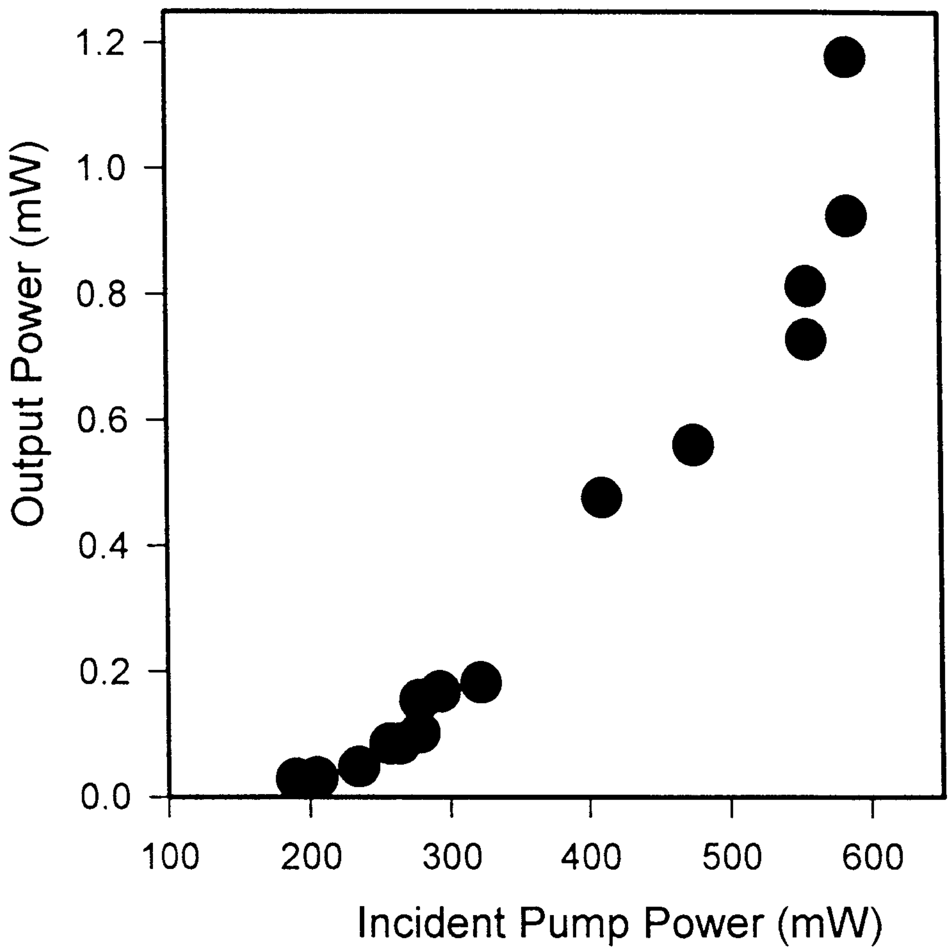
Fig. 3 Temporal behaviour of the output power of a neodymium doped Ga:La:S glass fibre laser.

Fig 1



76
74
72
70
68
66
64
62
60
58
56
Lifetime (μs)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Nd2S3 concetration (mol%)

Fig 2



1.2
1.0
0.8
0.6
0.4
0.2
0.0
Output Power (mW)
100
200
300
400
500
600
Incident Pump Power (mW)

Fig. 3