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Neodymium doped gallium lanthanum sulphide glass fibre laser

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Abstract

We report laser action in a neodymium doped gallium lanthanum sulphide glass fibre at 1.08 μm. To our knowledge, this is the first demonstration of laser action in a rare-earth doped chalcogenide glass fibre.

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Summary

Chalcogenide glasses have an extended infrared transparency compared to silica and fluoride glasses and therefore find applications as passive infrared transmitting optical elements and fibres. The low phonon energy of the glass structure which results in infrared transparency also reduces the non-radiative decay rates in rare-earth doped chalcogenide glasses making them interesting for active applications such as lasers and fibre amplifiers.[1-4] Spectroscopic measurements and calculations show that chalcogenide glasses are the only viable alternative to improving the efficiency of existing devices such as the 1.3 μm praseodymium doped fibre amplifier[1] and the 3.9 μm fibre laser[5] in fluorozirconate glasses and to develop new devices such as the proposed 1.3 μm dysprosium doped fibre amplifier[2] and mid-infrared fibre lasers with longer emission wavelength[3]. However, such rare-earth doped devices have not been reported to date, probably due to the difficulty of fabricating doped chalcogenide glass fibres. In this paper we report the first demonstration of laser action in a chalcogenide glass fibre. The first laser action in a bulk chalcogenide glass has been previously demonstrated in a neodymium doped gallium lanthanum sulphide (Ga:La:S) bulk glass. For the laser experiments described here, Ga:La:S glass was pulled into fibres with core/clad structures

using the rod-in-tube technique.[6] The fibre had a 15 μm core doped with 0.05 mol% Nd_2S_3 with an outer diameter of 180 μm.

Room temperature laser action on the $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition could be achieved in a 22 mm long fibre. The laser spectrum at 1080 nm is shown along with the fluorescence spectrum in Fig. 1. The fibre was held in a V-groove with plane mirrors butted to either end. The input mirror had a high transmission for the pump wavelength at 815 nm and a high reflectivity for the laser wavelength at 1080 nm. The dependence of the measured output power on the incident pump power is shown in Fig. 2 for an output coupling mirror of 93% reflectivity at 1080 nm. A minimum threshold power of about 100 mW incident pump power and a maximum slope efficiency of 0.7% were obtained with output mirrors of higher (99.5%) and lower (92%) reflectivity, respectively. The laser output showed a self-pulsing behaviour with pulses of about 0.1 μs in width and about 3 μs repetition rate which might be caused by upconversion of neodymium ion pairs as has been reported in erbium doped fibre lasers.[7] There is strong yellow upconversion, composed of one green and three red emission lines, which corroborates this assumption.

In conclusion, the demonstration of a rare-earth doped chalcogenide glass fibre laser shows the suitability of this class of glasses for active fibre applicatons. Future work will focus on the realization of devices such as the praseodymium doped fibre amplifier and mid-infrared fibre lasers in Ga:La:S glass which will exploit the real advantages of this low phonon energy material.

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Figure Captions

Fig. 1. Laser and fluorescence spectrum of Nd doped Ga:La:S glass fibre

Fig. 2. Output power versus incident pump power of the 22 mm long Nd doped Ga:La:S glass fibre laser

Fig. 1.

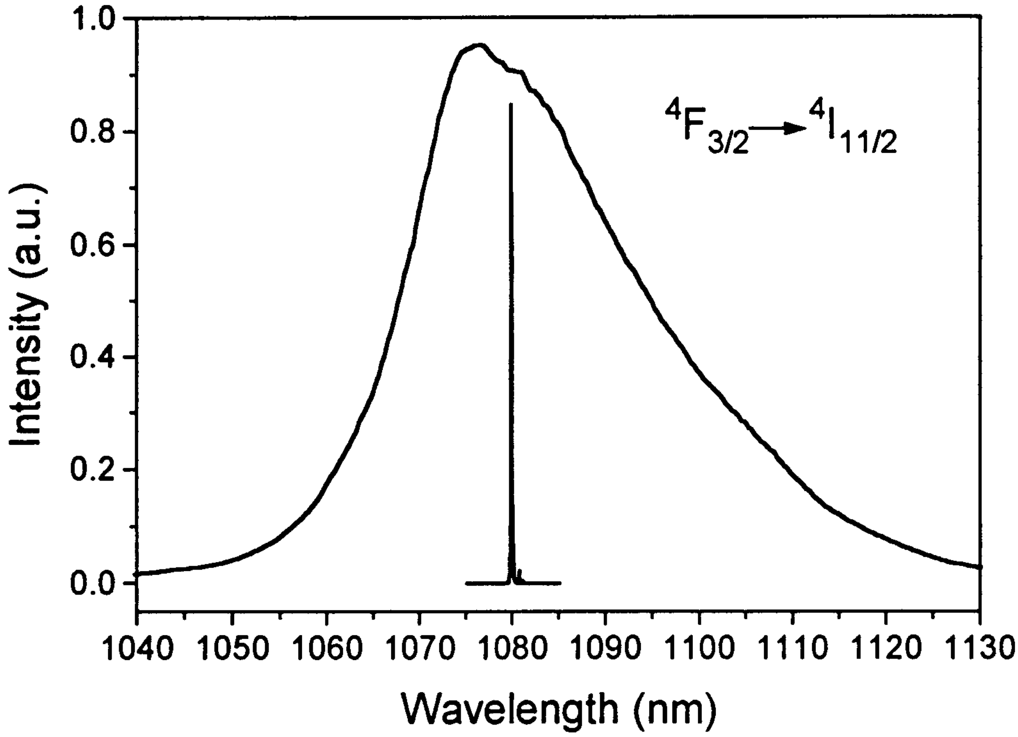

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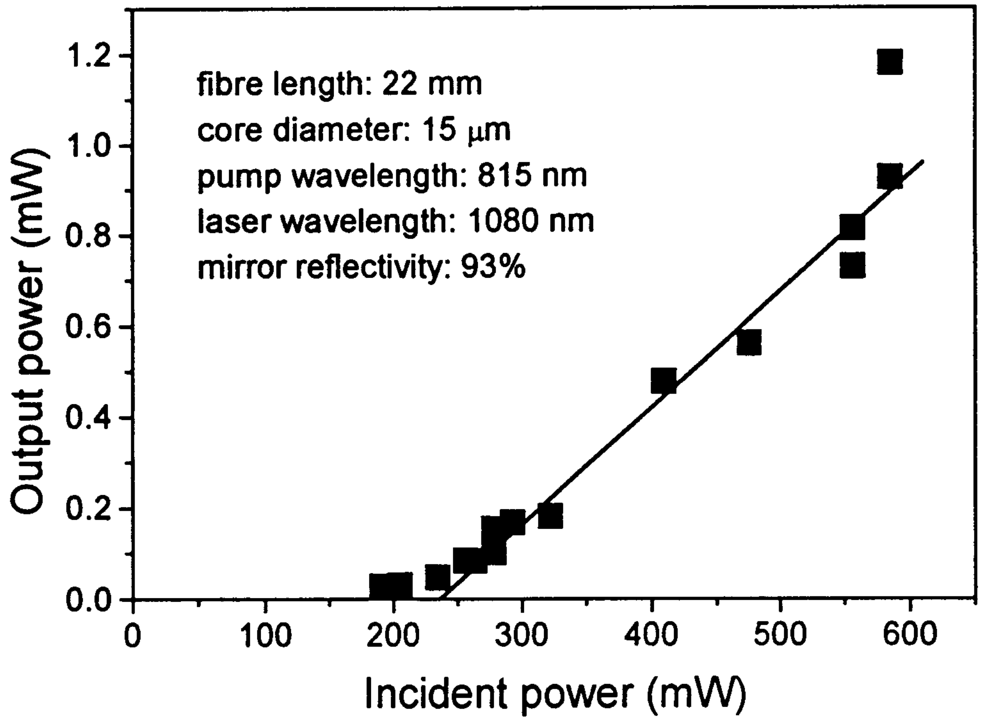
Fig. 2.



fibre length: 22 mm
core diameter: 15 μm
pump wavelength: 815 nm
laser wavelength: 1080 nm
mirror reflectivity: 93%
Output power (mW)
Incident power (mW)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
100
200
300
400
500
600