Diode-Pumped Tunable Ho^{3+}, Pr^{3+}-Doped Fluoride Glass Double Clad Fibre Laser

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Abstract: We present the tuning characteristics of a Ho^{3+}, Pr^{3+}-doped ZBLAN fibre laser that is diode pumped at 1150 nm.

The burgeoning field of mid-infrared photonics requires a wide range pump and probe sources in order to develop the integrated optical components that are required for applications in medicine, defence and astronomy. Shortwave infrared (SWIR) fibre lasers based on mature fluoride glass optical fibre technology offers high power radiation in the 2.7 μm to 3 μm region; a region that is not covered by the emission from quantum cascade lasers. The Er^{3+}-doped ZBLAN fibre lasers operating on the $^4I_{11/2} \rightarrow {}^4I_{13/2}$ transition offers high power [1,2] and broad tunability [3-5] in a diode pumpable format with multiple Watt output recently produced between 2.71 μm and 2.88 μm [6].

The Ho^{3+}-doped ZBLAN fibre laser operating on the $^5I_6 \rightarrow {}^5I_7$ transition [7] offers a comparatively longer operating wavelength and a higher Stokes efficiency limit when diode pumped at 1150 nm [8]. The fluorescence spectrum of this transition when Ho^{3+} is doped into ZBLAN is shown in Fig. 1. It can be observed that the fluorescence peak is located at 2.856 μm and extends up to and beyond 3 μm; Ho^{3+}-doped ZBLAN fibre offers the opportunity to create a high power diode pumped fibre laser with true mid-infrared emission.

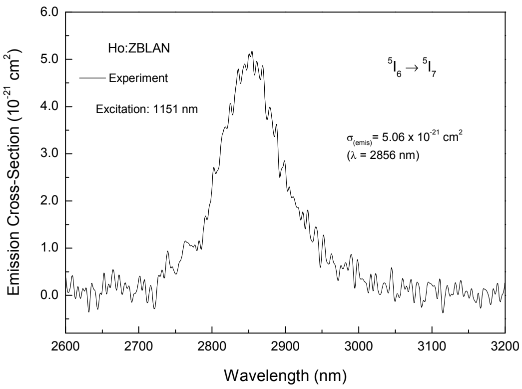

Figure 1: Measured fluorescence spectrum of the $^5I_6 \rightarrow {}^5I_7$ transition of Ho^{3+} when doped into ZBLAN glass

To explore the tuning potential of this transition, a simple Littrow configuration was incorporated into our previously demonstrated diode-pumped Ho^{3+}-doped ZBLAN fibre laser arrangement [8]. The diffraction grating was an Au-coated 300 lines/mm ruled grating and was illuminated with collimated light (CaF_2 lens, f=40 mm) from the non-pumped end of the fibre. Both ends of the fibre were cleaved near-perpendicularly to the axis of the fibre and hence further tuning is expected with an angle cleave placed at the diffraction grating end to the fibre. The fibre laser was pumped with high power diode lasers operating at 1150 nm and the output measured with a power meter and monochromator after reflection from a dichroic mirror placed at 45^0 to the fibre axis at the pumped end of the fibre.

The measured output power as a function of the emission wavelength is shown in Fig. 2. A total tuning range of 70 nm was measured and the maximum output power was 300 mW which was not corrected for mirror and collimating lens losses. The spectrum of the output at the centre of the tuning range is shown in the inset to Fig. 2.

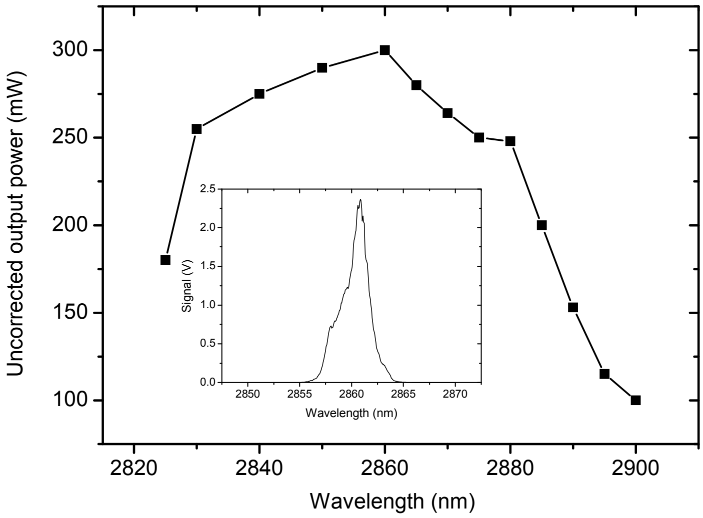

Figure 2: Measured output power vs emission wavelength from the Ho^{3+}, Pr^{3+}-doped ZBLAN fibre laser. The inset shows a typical spectrum of the output near the centre of the tuning range.

The first grating-tuned fibre laser operating at ~3 μm was demonstrated with this transition and provided tuning between 2.83 μm and 2.95 μm [9]. The addition of Pr^{3+} to Er^{3+}-doped ZBLAN has been shown to provide a wider tuning range compared to singly doped lasers over a broad range of pump powers. When this de-sensitiser is added to Ho^{3+} a broad tuning range is expected but the tuning range will be comparatively narrower. The measured splitting of the $^5I_7$ level of Ho^{3+} for a YAG host is ΔE=226 cm^{-1} [10] which is smaller than the measured splitting of the $^4I_{13/2}$ level of Er^{3+} which is ΔE=340 cm^{-1} [11] again for a YAG host. Thus, with higher pump powers and an angle cleave, we anticipate the measurement of a comparatively narrower but significantly red-shifted tuning range compared to Er^{3+}-doped ZBLAN fibre lasers.

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