

Diode-pumped Ho³⁺, Pr³⁺-doped fluoride glass double clad fibre laser tuneable from 2.825 μm to 2.90 μm

D. Hudson¹, L. Anderson¹, E. Magi¹, B. J. Eggleton¹, L. Gomes² and S. D. Jackson¹

¹CUDOS and Institute of Photonics and Optical Science, School of Physics, University of Sydney, Camperdown, 2006 Australia

²Center for Lasers and Applications, IPEN/CNEN-SP, P.O. Box 11049, São Paulo, SP 05422-970, Brazil

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 Er³⁺-doped ZBLAN fibre lasers operating on the ⁴I_{11/2} → 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 Ho³⁺-doped ZBLAN fibre laser operating on the ⁵I₆ → ⁵I₇ 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 Ho³⁺ 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; Ho³⁺-doped ZBLAN fibre offers the opportunity to create a high power diode pumped fibre laser with true mid-infrared emission.

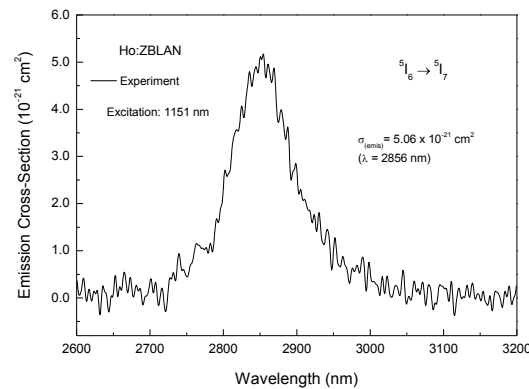


Figure 1: Measured fluorescence spectrum of the ⁵I₆ → ⁵I₇ transition of Ho³⁺

To explore the tuning potential of this transition, a simple Littrow configuration was incorporated into our previously demonstrated diode-pumped Ho³⁺-doped ZBLAN fibre laser arrangement [8]. The diffraction grating was an Au-coated 300 lines/mm ruled grating and was illuminated with collimated light (CaF₂ 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° 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.

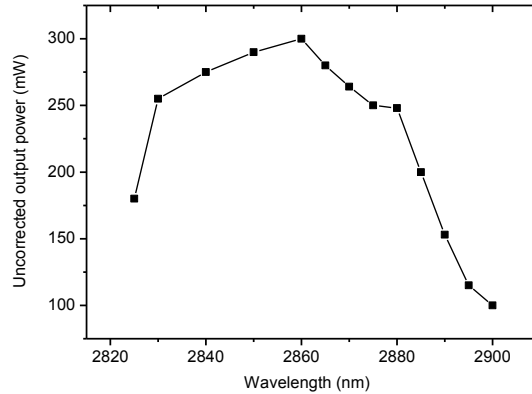


Figure 2: Measured output power vs emission wavelength

The first grating-tuned fibre laser operating at $\sim 3 \mu\text{m}$ was demonstrated with this transition and provided tuning between $2.83 \mu\text{m}$ and $2.95 \mu\text{m}$ [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 $^5\text{I}_7$ level of Ho^{3+} for a YAG host is $\Delta E=226 \text{ cm}^{-1}$ [10] which is smaller than the measured splitting of the $^4\text{I}_{13/2}$ level of Er^{3+} which is $\Delta E=340 \text{ cm}^{-1}$ [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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