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CWE2 High efficiency amplification and low threshold lasing at 0.8 μm in a thulium-doped fluorozirconate fiber

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Monomode Tm-doped fluorozirconate fiber can exhibit high gain amplification with pump and signal wavelengths both in the AlGaAs diode range. This is of great potential interest for local area networks operating near 0.8 μm, where transmitters and receivers are significantly less expensive than those at 1.3 or 1.5 μm. In this paper we describe a Tm^{3+}-doped fluorozirconate fiber acting when pumped at 785 nm both as an amplifier giving 20-dB gain at 806 nm and as a fiber laser.

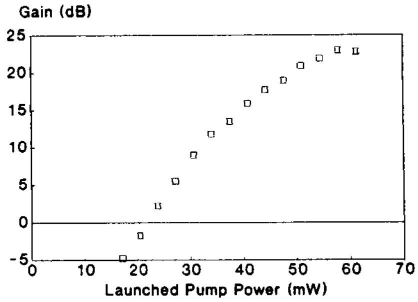
The Tm^{3+} ion in fluorozirconate (ZBLAN) glass has a strong absorption band at 790 nm corresponding to the $^3H_6$–$^3F_4$ transition. Approximately 88% of ions excited to the $^3F_4$ level relax radiatively back to the ground state. The peak of this emission is at 805 nm. By contrast, in Tm^{3+}-doped silica fibers, essentially all ions excited to the $^3F_4$ level decay nonradiatively via multiphonon emission to the $^3H_4$ level as a result of the higher phonon energies in this host, which means that a high gain 0.8-μm amplifier based on a Tm^{3+}-doped silica fiber is not achievable.

A 3-m length of 1000-ppmw Tm^{3+}-doped ZBLAN fiber of core diameter 3.5 μm was used for the amplifier. The pump source was a Ti:sapphire laser providing power at 785 nm. The signal was provided by a second tunable Ti:sapphire laser, the output power of which was attenuated to ~10 μW to allow the measurement of small-signal gain. Pump and signal beams were combined using a polarization rotator and polarizing beam splitter and launched copropagating into the fiber. The ratio of the transmission of the signal when the pump beam was blocked and unblocked was measured, and the host absorption (determined by a cutback) subtracted from this value to give the small-signal gain. Amplification was observed between 800 and 830 nm (Fig. 1 and 2), with a gain of 23 dB at 806 nm for 50 mW of launched pump power.

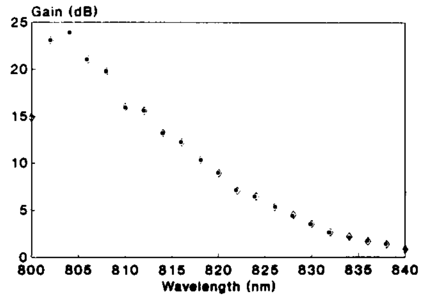
Modeling of the performance of this amplifier using a numerical method has been undertaken and is in excellent agreement with the experimental results obtained.

Lasing was observed in a resonator formed by butting a >99% reflecting mirror against the input end of the fiber and using the 4% Fresnel reflection at the output end to complete the cavity. The lowest threshold observed was 15-mW launched pump power achieved using a 2-m fiber length. Shorter fibers absorbed the pump less efficiently, and in longer fibers the three-level transition was not saturated over the full length, leading to higher thresholds in either case. For fiber lengths in the 2–3-m range slope efficiencies between 60 and 70% with respect to launched pump power were measured.

This laser has the potential to be operated as a diode-pumped short pulse source. The long metastable level lifetime (1.1 ms) should enable high peak powers (several watts) to be achieved using a single stripe AlGaAs diode-pump laser.



CWE2 Fig. 1. Gain (dB) vs launched pump power (mW).



CWE2 Fig. 2. Gain (dB) vs wavelength (nm).

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