High Peak Power Polarization Preserving EYDFA

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1 Introduction:

Lidar applications involving human presence require eye safe laser emission. Good beam quality, for efficient power delivery to the target, and relatively short pulses of 1ns or less, for good spatial resolution, are also common modern Lidar requirements. These applications are therefore ideally suited for an efficient fiber source operating at repetition rates of 10-100Kpps. The operation of these fiber laser systems is however not limited by average power but by nonlinear optical phenomena such as Stimulated Raman Scattering, Self-Focusing and primarily optically induced damage.

We will present peak power results in excess of 30kW from an all fiber laser system operating at 1563nm. This system is based on an all PM fiber architecture operating at 100Kpps and emitting pulses as short as 1ns. To date, we have achieved over 10W of average power at 100Kpps with 3ns pulses with the last stage of amplification based on a Nufern 18/250 EYDFA. To the best of our knowledge this represents the largest peak power reported in the 1550nm eye safe region with a single transverse mode operation resulting in an $M^2<1.15$. Remarkably also, this fiber allows for operation over many hours at peak irradiances of $20GW/cm^2$ and fluences of $65J/cm^2$. The latter results are comparable to single pulse optical damage threshold of fused silica.

2 Experimental Setup:

Our experimental setup involves a master oscillator amplified in a chain of three fiber amplifiers. A commercial DFB laser diode is current modulated to produce pulses as short as 1ns. The output of the DFB laser is inserted into a polarization maintaining Erbium-Doped-Fiber-Amplifier pumped by a commercial 980nm laser diode. A second stage amplifier uses fiber pigtailed 3W laser diodes to achieve over 1W of output power. Up to this point the optical pulses propagate in single mode fiber. The last stage of amplification consists of a Nufern double cladding fiber co-doped with Erbium and Ytterbium. The fiber is pumped by a single fiber pigtailed diode laser bar emitting 60W at the output of the multimode fiber. The double cladding fiber has a core NA of 0.17 and a core diameter of 18μm. This fiber sustains four modes. The highest order modes are stripped by coiling. The fundamental mode is carefully seeded allowing for good gain extraction, resulting in limited growth of the second order transverse mode. An improved fiber design is needed to eliminate the second order mode via simple coiling losses. The following figure shows our experimental setup.

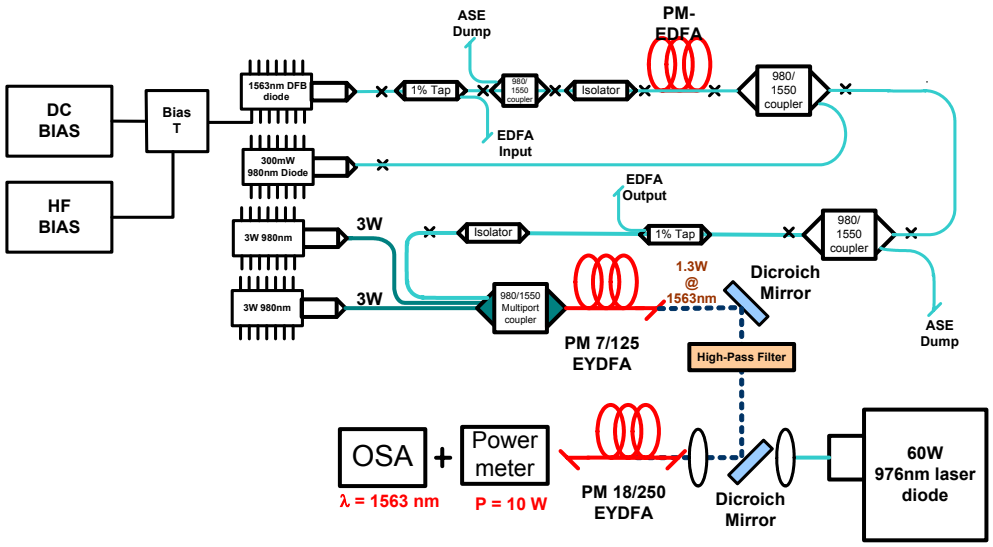

Figure 1: Experimental setup of our 10W fiber laser source emitting over 10W at 1563nm.

3 Experimental results:

To date our best results have been achieved with the DFB laser diode producing 3ns pulses resulting in an average power in excess of 10W. The optical to optical efficiency we have been able to measure is approximately 30% in the PM 18/250 EYDFA power amplifier. The pump power coupling efficiency into the first cladding is typically 80%. The following figure shows the output power versus pump power into the EYDFA.

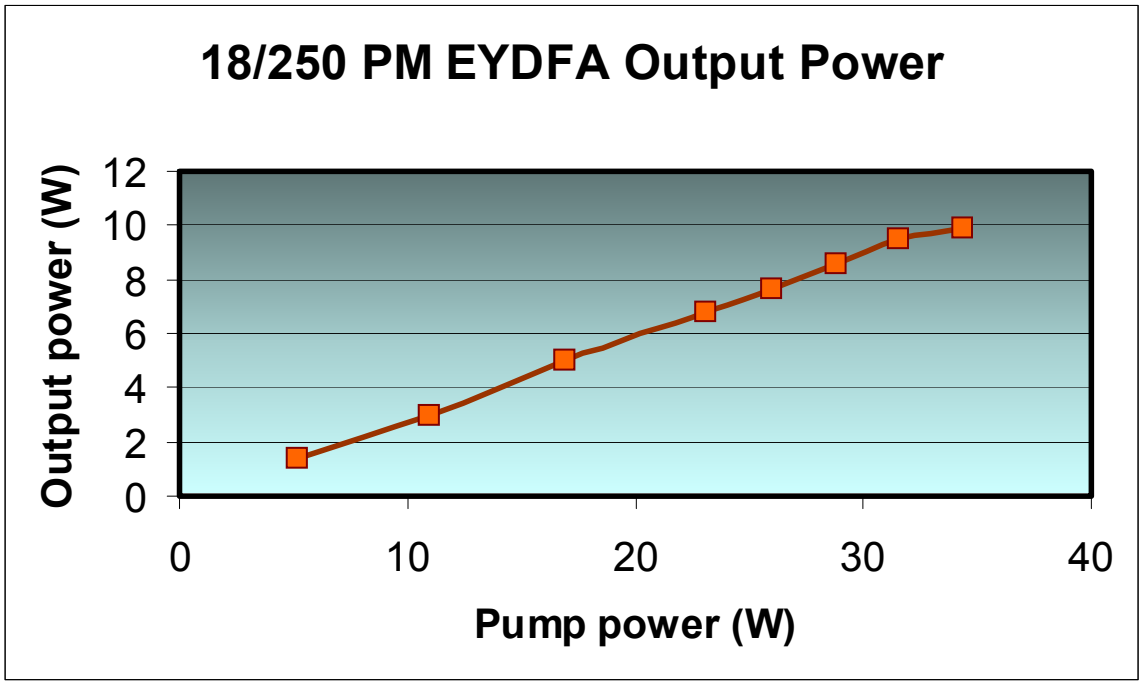

Figure 2: Output power versus pump power for the EYDFA.

We have measured an M^2 of less than 1.15 at the output of the 18/250 PM-EYDFA as shown in the following figure. The fiber was coiled to a diameter of three inches.

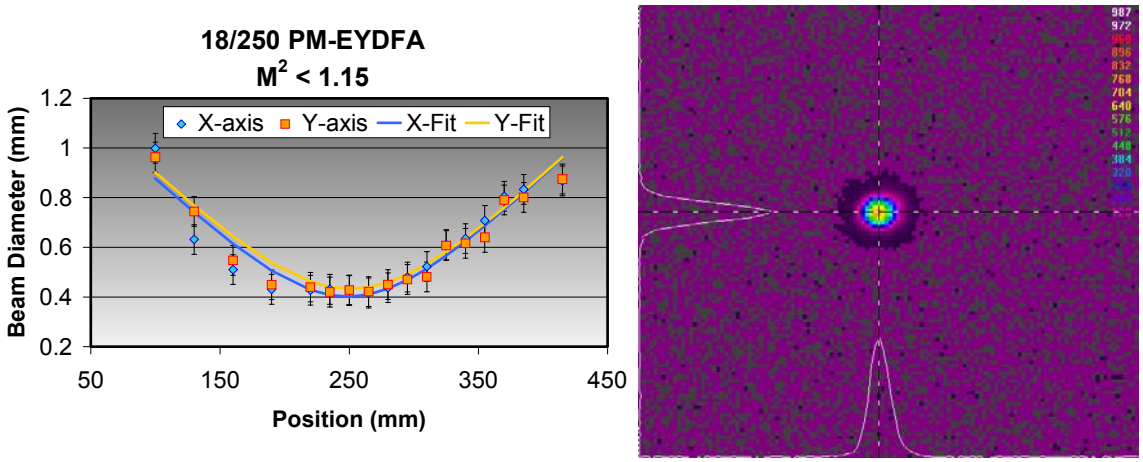

Figure 2: Output power versus pump power for the EYDFA.

4 Conclusion

We have investigated a large core polarization maintaining double cladding fiber co-doped with Erbium and Ytterbium. This fiber effectively amplifies a train of 3ns pulses at 100Kpps resulting in peak power of 30kW. To the best of our knowledge these are the highest peak powers from a PM-EYDFA emitting near diffraction limited beams.

5 Acknowledgements

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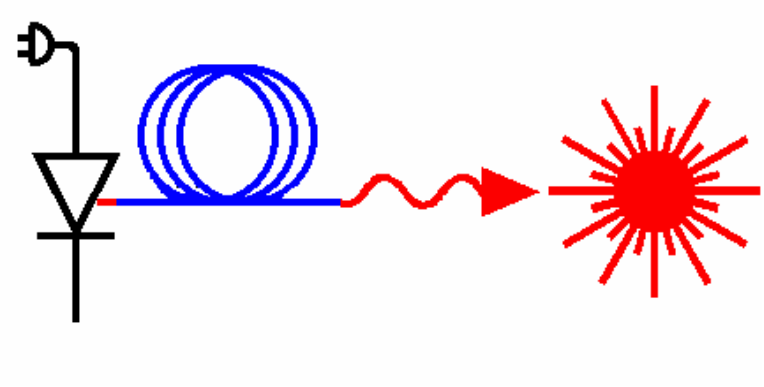

Thermal Effects on the Emission Properties of Yb-doped Fibers

Poster Presentation Only