Low Noise High Power Solid State Laser for 1550 nm Wavelength Band

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Introduction

Low noise high power lasers are needed for a number of analog and digital communications systems as well as for other analog signal processing applications. In the 1550 nm wavelength band erbium doped glass is widely used for fiber amplifiers. At Princeton Optronics we have developed a high power diode pumped Er:Yb co-doped phosphate glass laser. Erbium doped phosphate glass permits high co-doping with ytterbium ions that strongly absorb at 976 nm and efficiently transfer their energy to the active erbium material. Therefore co-doping the erbium doped phosphate glass with ytterbium drastically decreases the absorption length at the 976 nm pump wavelength so that small solid-state lasers can be built. Aside from the obvious advantage for packaging a short cavity length results in a large longitudinal mode-spacing (>40 GHz). A single longitudinal mode can be obtained by inserting a low-finesse etalon. By using either an air-spaced etalon with a piezo controlled air gap or a temperature controlled solid etalon consisting of a material with high dn/dT different modes in the 1550 nm telecom wavelength band can be selected. Fine tuning of the lasing wavelength is achieved by controlling the cavity length using a piezoelectric moveable output coupler. We have developed a patented noise reduction technology based on intra-cavity non-linear absorption, which reduces the relative intensity noise (RIN) at the relaxation oscillation frequency by more than 50dB to -130 dB/Hz. In addition we have designed and built high stability lockers for stabilizing the frequency of the laser. With our current laser design we have achieved 150 mW out of PM fiber. We are currently developing a new laser design that allows us to pump the erbium glass from both ends. Preliminary bench-top results show power in excess of 500 mW.

Noise Reduction

Due to the energy transfer between the co-dopant and the active material the laser shows a strongly reduced sensitivity to fluctuations in pump power. Hence the RIN spectrum is mainly determined by cavity loss perturbations [1]. The RIN spectrum of Er:Yb lasers is close to shot-noise limited at higher frequencies (>10 MHz) but shows a strong peak at the relaxation oscillating frequency, which is in the 100 kHz to 1 MHz range, depending on the cavity layout and laser power. Without active stabilization of the laser cavity the typical observed RIN peak is approximately -70dB/Hz. We have developed a patented noise reduction technology that is based on intra-cavity non-linear absorption. Figure 1 shows measured RIN spectra for Er:Yb laser with and without noise reduction. With noise reduction the RIN at the relaxation oscillation frequency is reduced by more than 50dB to -130 dB/Hz.

Frequency Stability and Linewidth

Our standard wavelength locker has a low finesse ULE glass air spaced etalons and is used for standard laser operation, it uses two low finesse etalons and can be used to lock any wavelength. For ultra-stable frequency locking new fiber coupled lockers were designed that use one high finesse etalon and have a separate temperature control from the laser. The lockers have a laser power monitor for normalization. Our laser was connected to the ultra-stable locker using low noise control electronics to stabilize the frequency. The short-term stability of the average laser frequency was measured to be ~5 kHz for time periods of 10 minutes. The laser linewidth was measured to be ~35kHz.

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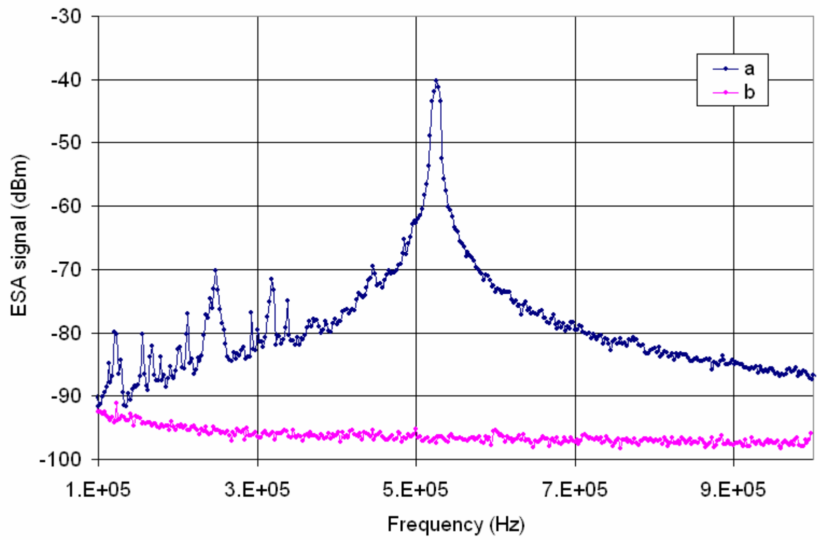

Figure 1. RIN spectrum of laser with noise reduction (a) and without noise reduction (b).

Laser Power

A new cavity layout with a double side pump configuration is currently being developed to achieve significantly higher power and improved inherent stability. Figure 2 shows some initial results of the laser power as a function of total pump power on a bench-top set-up. The optical slope efficiency is 25%. The linewidth for this laser was measured to be ~7 kHz and the side mode suppression ration (SMSR) is better than 70dB.

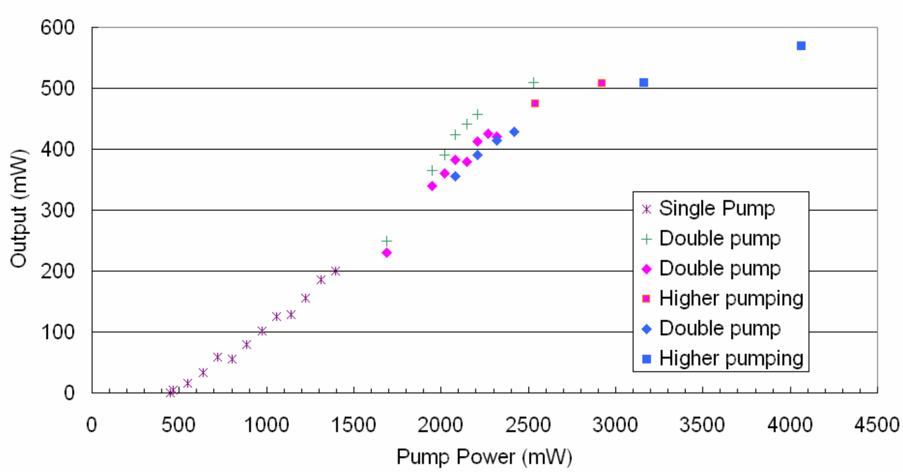

Figure 2. Laser power as a function of total pump power for double side pump configuration.

References

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