Compact High Power DPSS Laser with Very Low RIN and Phase Noise for 1550nm Wavelength Band

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Summary

The performance of analog photonic systems is strongly affected by laser power and noise. There are two components to the noise, intensity noise and phase noise. The phase noise directly impacts linewidth and can also be converted to intensity noise via wavelength sensitive components.

At Princeton Optronics we are developing a high power low noise laser using diode pumped Yb:Er doped glass technology. 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).

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. We have developed a patented noise reduction technology that is based on intra-cavity non-linear absorption that reduces the relaxation noise peak by >50dB.

The inherent linewidth of the laser is very narrow and the linewidth broadening is primarily due to mechanical vibrations and other cavity length variations such as refractive index fluctuations. We have developed a locker technology to accurately measure laser frequency variations and a feedback control system to the laser to reduce these fluctuations and realize very low phase noise.

The laser design is shown in Figure 1. For the high power version of the laser two pump lasers (LD) are used.

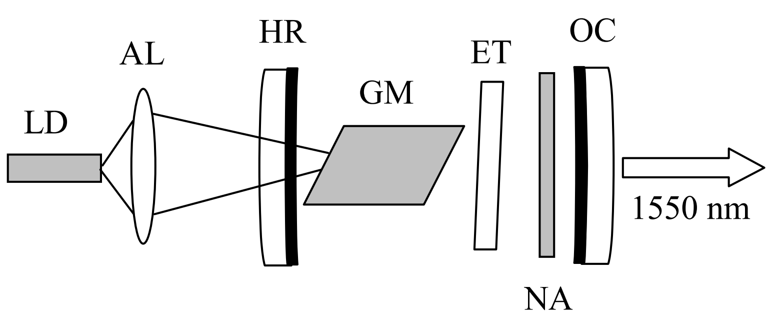

Figure 1: Schematic layout of the Princeton Optronics low noise laser. An aspheric lens (AL) focuses the output of a 976 nm laser diode (LD) through a 1550 nm high reflector (HR) onto the gain medium (GM). A tunable low finesse intra-cavity etalon (ET) selects a single longitudinal mode. An intra-cavity non-linear absorber (NA) reduces RIN. A mirror with a partially reflective dielectric coating (OC) couples 1550 nm light out of the laser cavity.

The output from the laser is fed through an isolator to prevent noise from backreflections and then coupled into a PM fiber.

Measurements of RIN for earlier versions of the laser are shown in Figure 2. The maximum RIN occurs at low frequencies and reduces to –160dBc/Hz at 1MHz. The noise then continues to drop to the shot noise limit (d) before 100MHz frequency. The significant effect of the passive noise reducer is shown by the analytical curve (b) versus (c).

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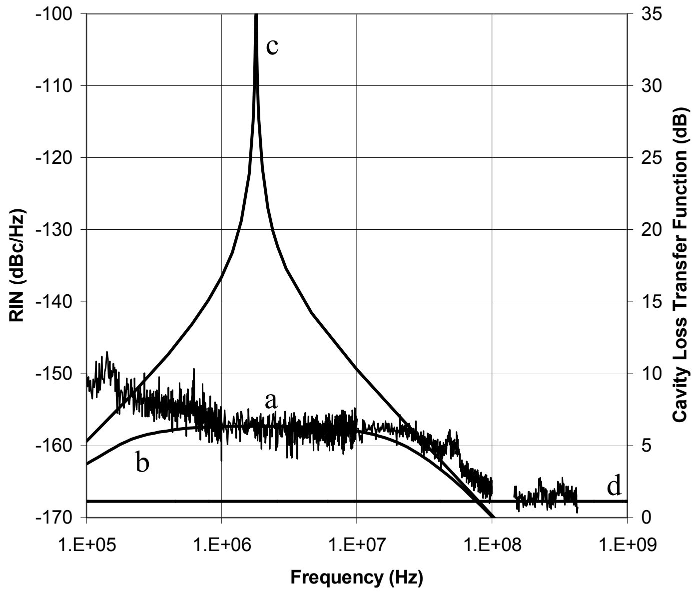

Figure 2: Measured RIN spectrum of the Princeton Optronics low noise laser (a); Calculated cavity loss transfer functions with (b) and without (c) intra-cavity absorber; shot noise limit at 19 mA dc photo current (d)

The RIN is also dependent on the laser intra-cavity power. This is one of the parameters that can be used to further reduce RIN.

The frequency noise measurement of a laser is shown in Figure 3. The average noise is around 10Hz/rt-Hz and results in a linewidth significantly less than 1kHz. The equivalent phase noise is ~0dBc/Hz at 30Hz and drops at a rate of 20dB per decade.

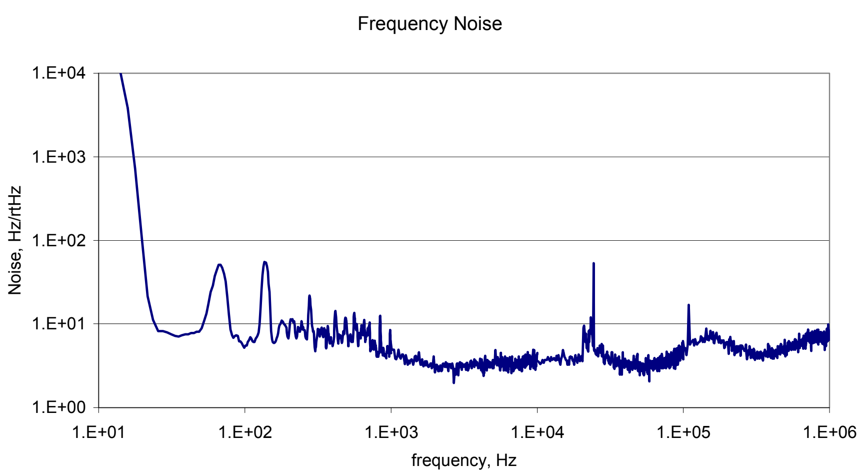

Figure 3. Frequency noise measurement for laser. Indicates a linewidth <1kHz.

The latest lasers we are building have an output power >350mW. We are currently developing the control systems to optimize the noise performance of these lasers. Results for these high power lasers will be presented at the conference.

References

[1] S. Taccheo, P. LaPorta, O. Svelto, and G. De Geronimo, "Theoretical and experimental analysis of intensity noise in a codoped erbium-ytterbium glass laser", Appl. Phys. B, 19-26 (1998)

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