Development of a 2 micron Ho Fiber Laser

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Abstract

A 2 micron Holmium fiber laser is developed and tested. The Laser is first tested to find most conducive cavity configuration. The laser is then tested for the noise while it is mode locked. Lastly the laser is tested to see the spectrum. It is found that the laser is able to operate between the wavelengths of 2050 nm to 2075 nm. At these mode locks the output power and repetition rates are measure in order to find if the laser is single pulsing or multi-pulsing. It is found that the laser is often multi-pulsing at the lower wavelengths.

Contents

Laser Cavity

The laser was initially placed into a sigma cavity that is displayed in figure 1 below. The sigma cavity was originally chosen because it was necessary to test the laser with a saturable absorber (Se-SAM). The saturable absorber used in the experiment was SAM-2000-20-10ps-4.0-0 #607-11. 6. For the cavity to achieve mode locking the saturable absorber had to be in the cavity. No mode locking was able to be achieved with a mirror in the place of the saturable absorber.

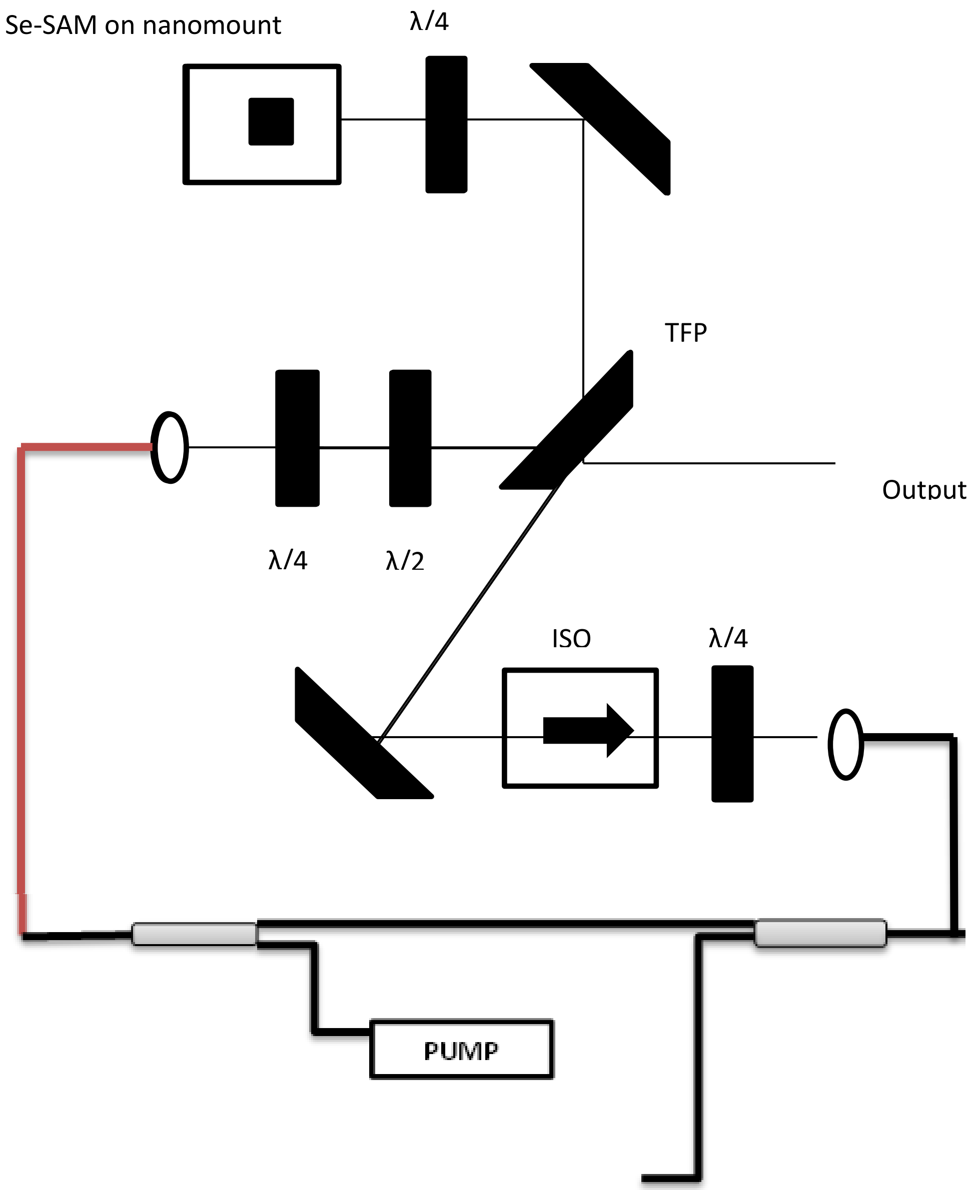

Figure 1: Sigma Cavity Diagram

In the Sigma Cavity shown above in figure 1 the saturable absorber is placed in the sigma branch of the cavity. The saturable absorber acts as a mirror for the branch which allows the laser to remain within the cavity. Unfortunately though, the saturable absorber in this cavity was being destroyed by the laser. The laser also seemed to be extremely unstable in the mode-locking in this configuration.

This configuration was first built with a mirror in the place of the saturable absorber. The laser proved unable to mode lock with the mirror in place of the se-SAM. Unfortunately the beam is destroying the saturable absorber in this configuration. So while mode locking is achieved it is unable to be used for long term because eventually the saturable absorber will no longer work in the laser.

The second set up of the 2 micron Ho laser was in the ring cavity shown below in figure 2.

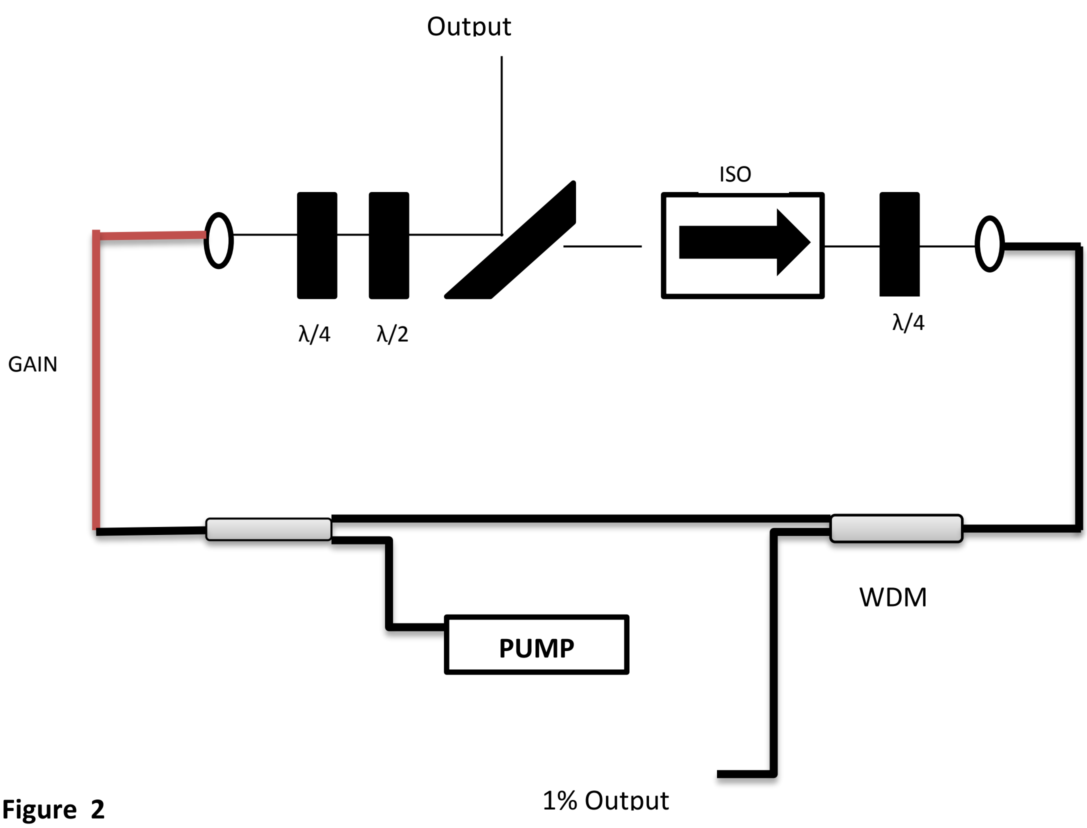

Figure 2

In the ring cavity displayed in figure 1 the sigma branch is removed. The laser was switched into a ring cavity because the mode-locking of the laser in the ring cavity is more stable. The saturable absorber was removed to form the ring cavity. Ultimately the ring cavity proved to be the most effective for a stable mode-lock. This cavity allowed for better spectrum tuning of the laser. Additionally the laser was able to reach the desired wavelength of 2050. This cavity was then examined further and measurements were taken on it.

Noise Measurement

A measurement of the noise for the Laser was taken for the laser in the ring cavity using a vector signal analyzer. This was done after the laser was in a stable mode-lock in the ring cavity without the saturable absorber. Using the Noise measurement it is then possible to find the Relative Intensity Noise (RIN) with respect to the peak noise at which the laser operates. The measured noise and the RIN are shown below in Figure 3.

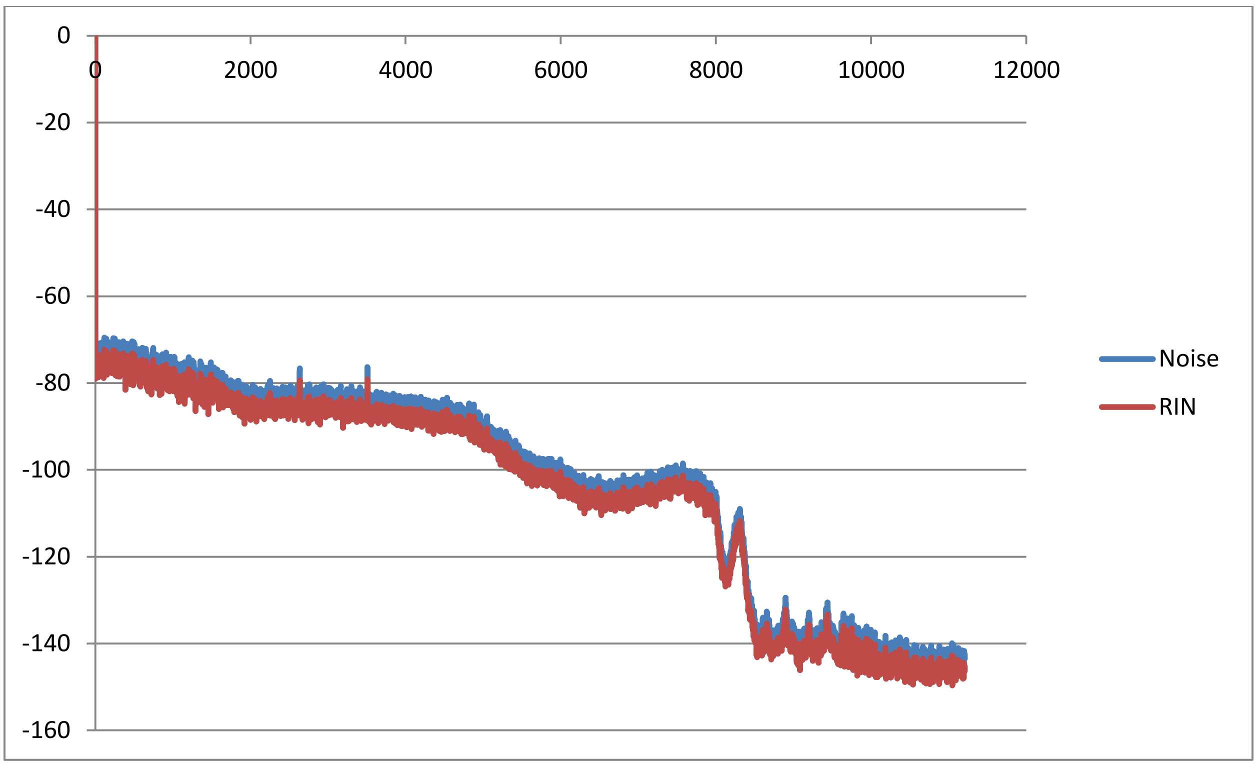

Figure 3: Noise Measurement and Relative Noise intensity for the Ring Cavity

Mode-Lock Spectrum

A2 micron spectrometer was used to take the spectrum data for the Ho laser. The 1% output fiber was coupled into the spectrometer to take the measurement. This was done because the spectrometer is

extremely sensitive and an increased amount of laser output into the spectrometer can destroy the equipment.
The sigma cavity was able to mode lock; however, the mode lock was not the most stable. Tapping the table or laser could cause a loss in mode locking. In addition tuning the spectrum of the laser showed that the laser was unable to reach the desired wavelength of 2050 nm. Figure 4 below displays a mode-lock spectrum for the ring cavity.

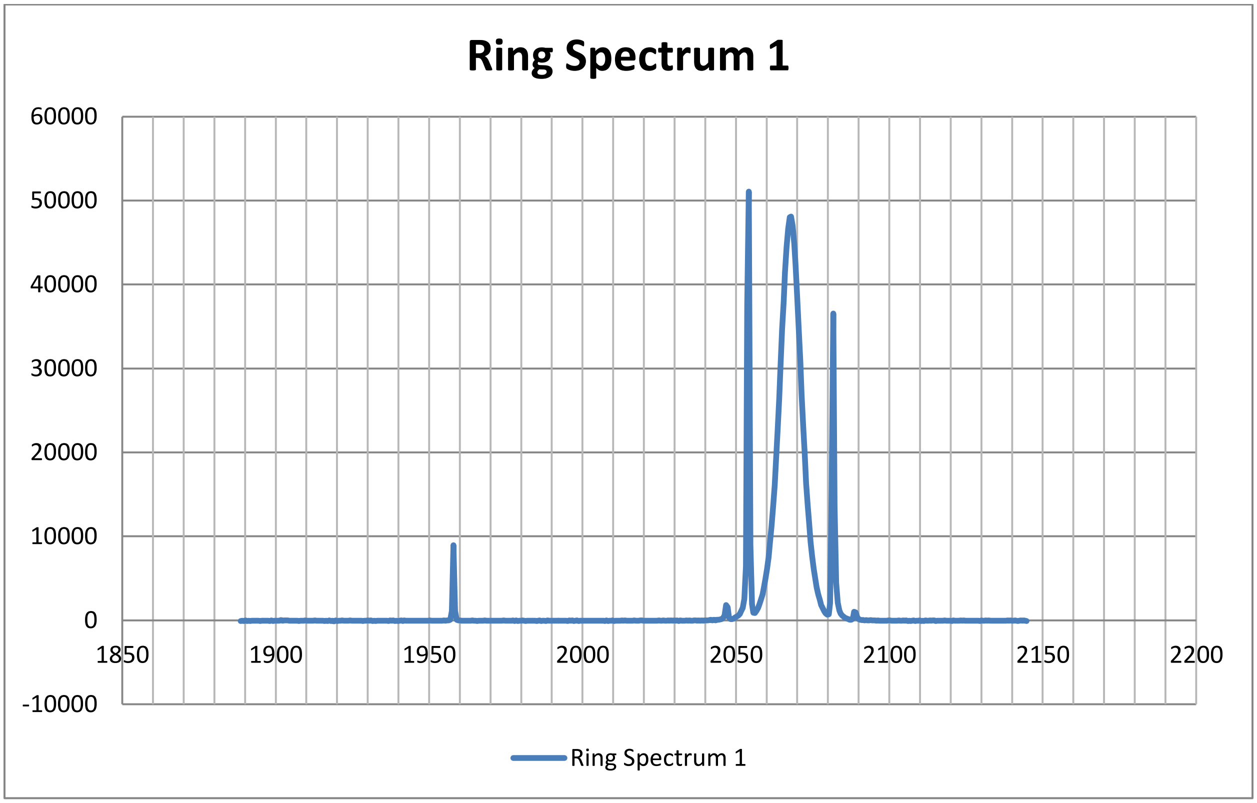

Figure 4: Mode-Lock Spectrum In a Ring Cavity

In Figure Three above the wavelength of the laser in the Ring Cavity is 2068 nm. Because the spectrometer has an error of +7.0 nm the wave length of the laser in the above figure is 2061nm. For most cases when the laser mode locks it will mode lock somewhere around 2060nm. For this laser a wavelength of 2050 nm was required. This was done by tuning the spectrum and adding additional SM 2000 fiber to the cavity. The above modelock was found without additional fiber having been added to the cavity.

Tuning the spectrum involves finding the maximum and minimum wavelengths that the laser can operate at. Adding 1 meter of fiber allowed the spectrum of the laser to be increased. Secondly the addition of the fiber decreases the bandwidth of the mode lock spectrum . The Spectrum below in figure 5 shows the minimum wavelength that was found that the ring Cavity can operate at.

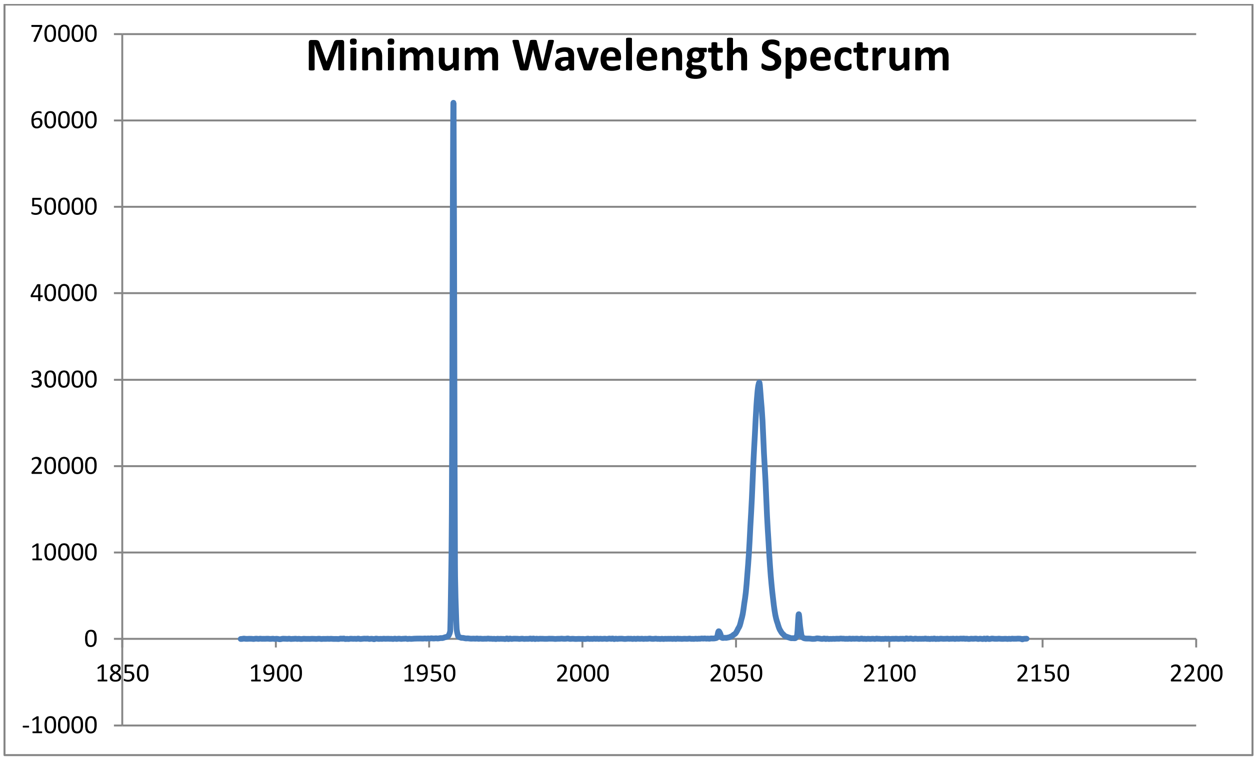

Figure 5: Minimum wavelength Spectrum

The minimum wavelength of 2056 is shown above in figure 5. The repetition rate of the spectrum is 171MHz. Because the repetition rate is so large the laser is multi-pulsing. This occurs when the different wavelengths running through the Laser cavity are not interfering in a way that creates constructive interference for a single pulse. In the case of multi-pulsing the different waves create multiple pluses.

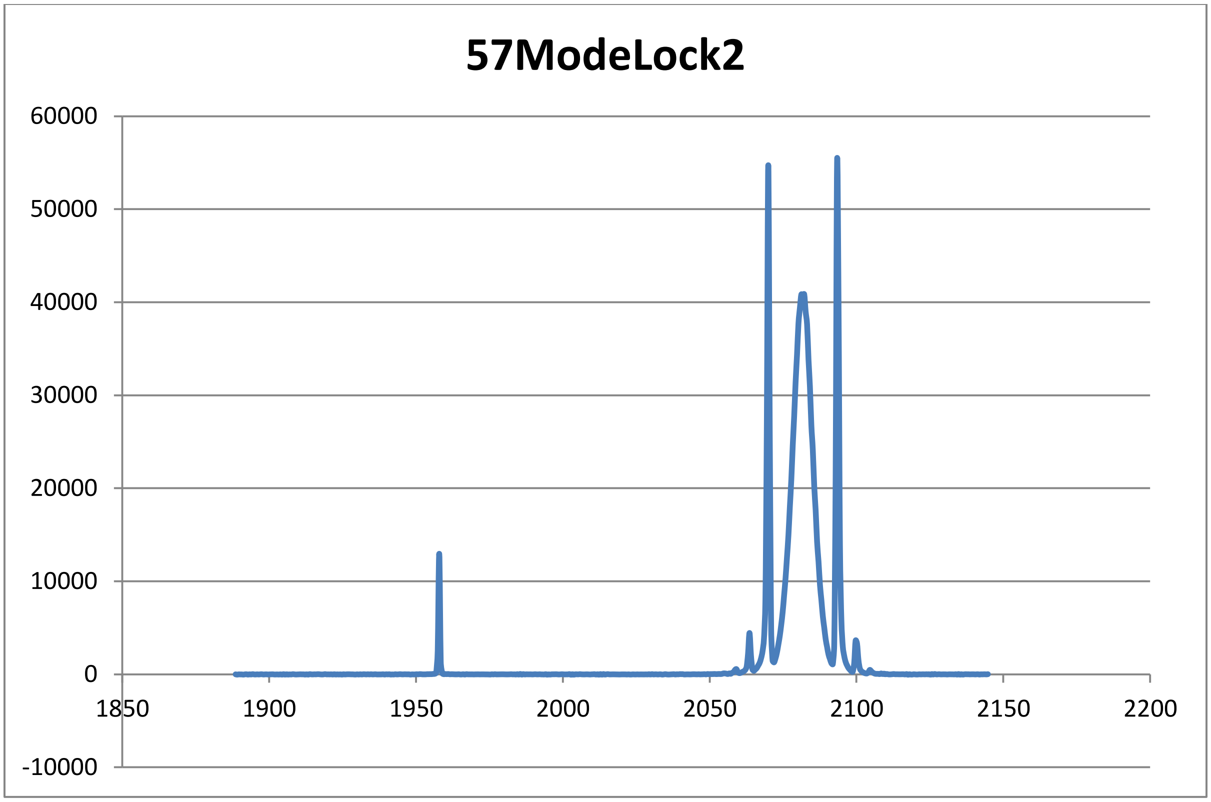

Figure 6: Maximum Spectrum for the ring Cavity

Figure 6 above shows the mode-locking at the max in the spectrum tuning.

Conclusion

In both the ring cavity and the sigma cavity it is possible to achieve mode locking of the laser. The Mode-locked laser seemed to be more stable in the ring cavity. This allowed measurement, testing and spectrum data to be taken on the laser. Ultimately the sigma cavity proved to be the better cavity because it had a more stable mode lock and it was able to reach the desired wavelength of 2050. Unfortunately to reach the desired wavelength of 2050 the power from the pump had to be higher than desired. This higher power