Actively Modelocked Laser-diode-pumped Nd:glass Lasers

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Summary

The mode-locked Nd:glass laser is a well-known source of short pulses due to its large fluorescence linewidth (5.3 THz). Traditionally, this laser has been pumped using flashlamp excitation or end pumping using an argon ion laser operating at 514 nm[1]. More recently, the development of diode laser technology has lead to the use of diode lasers as pump sources for actively modelocked neodymium-doped solid state lasers, including the Nd:glass laser[2,3,4]. The Nd:glass laser is particularly suitable for pumping with laser diodes due to its wide absorption linewidth in the region of 800 nm. We have investigated both acousto-optic amplitude modulation (AM) mode-locking and electro-optic frequency modulation (FM) mode-locking of the laser-diode-pumped Nd:glass laser.

The use of electro-optic FM mode-locking techniques has several advantages over the acousto-optic AM techique. These include the fact that there is no need to adjust the orientation of the crystal to optimise the Bragg angle. Also, the operating frequency of a phase modulator can be changed without changing the modulator itself, which cannot be done for acousto-optic amplitude modulators. Due to their broader resonance (typically several hundred kilohertz as opposed to several kilohertz), FM mode-locked lasers show better long term stability. Finally, FM mode-locked lasers show a negligible reduction in output power from the cw situation.

The laser cavity used in our experiments was the same for both mode-locking techniques. The pump source was a ten-stripe 500mW laser diode array (SDL 2432) temperature-tuned using a Peltier cooler to give optimum absorption (>90%) in the active medium. The pump beam was collimated using a 6.5 mm focal length lens and a prism beam expander, and was passed through a x2 telescope in order to achieve single transverse mode operation of the Nd:glass laser. The beam was then focussed on to a 1.2 mm thick disc of highly doped (8% wt.) Schott LG760 Nd:phosphate glass. This disc was placed at Brewster's angle at the focus of a standard astigmatically compensated 3-mirror cavity. With no modulator in the cavity, the laser exhibited a threshold of 60mW absorbed pump power with a slope efficiency of 9.5% for 1.5% output coupling.

The acousto-optic amplitude modulator used was a Brewster angled fused quartz modulator, and was driven at its resonant radio frequency (RF) of 120 MHz (which corresponds to a laser repetition rate of 240 MHz). At an applied RF of 1 watt, the device exhibited a diffraction efficiency of 19%. The modulator had a negligible passive insertion loss, but when mode-locked the maximum average output power fell to 30 mW, a reduction of approximately 17%. The mode-locked pulse duration was measured by standard autocorrelation techniques, and the minimum pulse duration obtained was 9 ps, assuming a Gaussian temporal profile. When mode-locked, the lasing bandwidth was measured to be 80 GHz.

The phase modulator used was a Brewster angled $LiNbO_3$ crystal of dimensions 24 x 6 x 6 mm^3. An RF power of between 1 and 2 watts was coupled into the crystal using a resonant circuit formed by placing a search coil across the crystal. The modulator was operated at 235 MHz, although this could have been altered by changing the search coil in the resonant circuit. The single pass phase retardation of the device was found to be greater than 1 radian per watt of RF power. The modulator was measured to have a passive insertion loss of 3%. When mode-locked, there was a negligible reduction in the average laser output power, which remained at 14 mW, and the shortest pulse duration obtained was 9 ps. The mode-locked laser bandwidth was 71 GHz.

Detailed performance characteristics of the laser will be presented, and possible future development of this system will be discussed.

References

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