Three-element modelocked femtosecond Cr^{4+}:YAG laser operating up to 3.6-GHz repetition rate

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Abstract: We report a three-element Kerr-lens modelocked femtosecond Cr^{4+}:YAG laser which uses a fused-silica Littrow prism for intracavity dispersion compensation. This generated transform-limited 145-fs pulses at 1522 nm and a repetition rate of up to 3.68GHz.

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High-repetition-rate Cr^{4+}:YAG femtosecond lasers operating around 1500nm are of growing interest and relevance in the study of optical data-communications systems. Repetition rates in the gigahertz range have already been demonstrated. Collings et al.[1] reported 200 fs pulses at 0.9GHz while Tomaru et al.[2,3] have demonstrated three-element and two-element cavities operating at 1.2GHz and 2.6GHz respectively. Here we present a three-element Kerr lens mode-locked femtosecond Cr^{4+}:YAG laser with a pulse repetition rate up to 3.68 GHz.

Figure 1 shows the three-element L-fold cavity configuration. The crystal rod was 11.6 mm in length with the plane surface for broadband high reflection at 1550 nm and high transmission at the pump wavelength. The other facet was Brewster-angled. The laser crystal was mounted in a copper mount, which was water cooled to 14 °C. The folding mirror had a radius of curvature of -15mm and the Littrow prism completed the cavity configuration. Typically 5 - 6mm of fused silica was inserted to provide the necessary intracavity dispersion compensation. The back face of this element was coated to give a reflectivity of 99.88 % to serve as the output coupler for the laser.

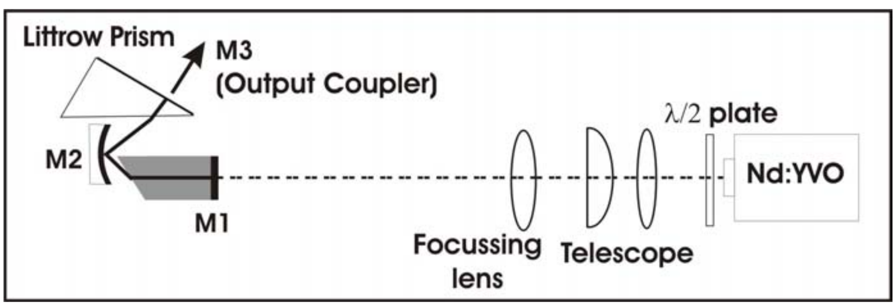

Figure 1. Schematic diagram of KLM Cr^{4+}:YAG laser

The pump source was a 10 W Nd:YVO_4 cw laser operating at 1064 nm, which is at the peak of absorption for Cr^{4+}:YAG. This beam was passed through a simple telescope system and focussing lens onto the plane surface of the crystal rod. Accurate control of the pump beam radius was required so that the effects of the induced Kerr effect could be maximised. The other important parameter for KLM operation was compensation for astigmatism, which was achieved by providing a folding angle between 72° and 80° for the folding mirror.

Figure 2 shows a typical spectrum and intensity autocorrelation for the output pulses from this KLM laser when operating at a centre wavelength of 1522 nm. Assuming a $sech^2$ intensity profile, the FWHM pulse duration was determined to be 145 fs. With the corresponding FWHM spectral width of 19 nm, the deduced time-bandwidth product was 0.35, indicating that the pulses were near-transform limited. The pulse repetition frequency was 3.41 GHz and an output power of 16mW was obtained under these operating conditions. A further reduction in the cavity size also allowed a repetition rate of 3.68 GHz to be achieved.

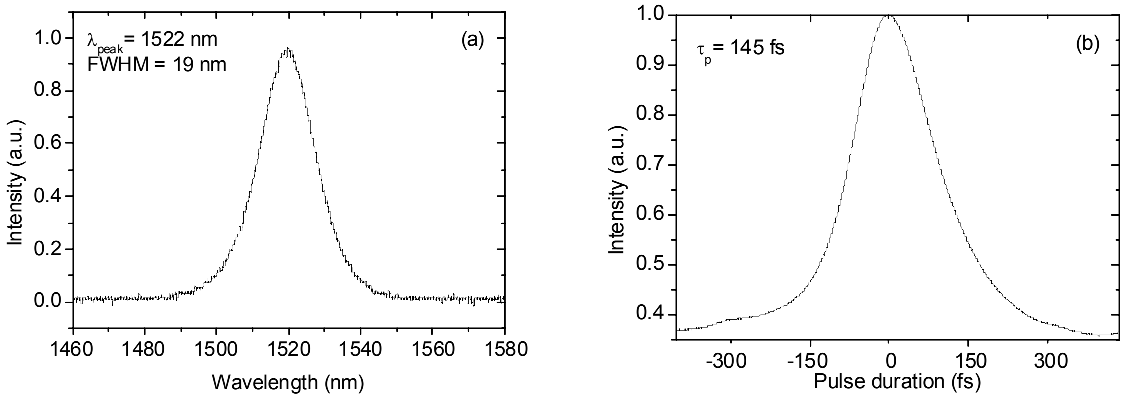

Figure 2. Optical spectrum (a) and intensity autocorrelation (b) of femtosecond pulses from a Cr^{4+}:YAG laser at a prf of 3.4 GHz.

Several aspects of this system have yet to be optimised. We expect the power output will be improved when a suitable output coupler (~0.4 %) is inserted and with further optimisation of the folding angle that pulse durations should reach ~ 100fs. Further investigations are underway to determine whether Kerr lens modelocking can be retained to pulse repetition rates beyond 4GHz.

References

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