Appl. Phys. B 65, 245–253 (1997)

Applied Physics B Lasers and Optics

© Springer-Verlag 1997

Sub-20 fs pulse generation from the mirror dispersion controlled Cr:LiSGaF and Cr:LiSAF lasers

I.T. Sorokina[1], E. Sorokin[1], E. Wintner[1], A. Cassanho[2], H.P. Jenssen[3], R. Szipőcs[4]

[1] Technische Universität Wien, Abt. Quantenelektronik und Lasertechnik, Gusshausstr. 27/359, A-1040 Wien, Austria
[2] VLOC, Division of II-VI Incorporated, 431 E. Spruce str., Tarpon Springs, Florida 34689, USA
[3] University of Central Florida, CREOL, 12424 Research Parkway, Suite 400, Orlando, Florida 32826, USA
[4] Research Institute for Solid State Physics, P.O. Box 49, H-1525 Budapest, Hungary

Received: 21 March 1997/Revised Version: 9 May 1997

Abstract. We describe the state of the art of mirror-dispersion-controlled (MDC) Kerr-lens mode-locked (KLM) Cr:LiSGaF and Cr:LiSAF lasers. Such lasers, in comparison to their prism-controlled forerunners, are distinguished by high reproducibility, stability, and quality of the pulses, as well as compactness of the cavity. The shortest pulses of ~ 18 fs duration and nearly bandwidth-limited quality ($\Delta\tau\Delta\nu = 0.33$) have been produced in Cr:LiSGaF lasers, which have an average output power of 100 mW. In both lasers, krypton-laser was used as an ideal pump source. The effect of a red-shift of the operating wavelength (from 850 to 880 nm) when shortening of the pulse width (from ~ 50 fs to ~ 20 fs) has been observed and discussed.

PACS: 42.55.Rz; 42.60.Mi; 42.65.Re

The last decade has been marked by the rapid development of femtosecond solid-state laser technology. The discovery of Kerr-lens mode-locking (KLM) [1], coupled with advances in high-power diode laser arrays, paved the way to compact all-solid-state femtosecond lasers, which have the advantage of low cost, high stability, and robustness. Most of the progress achieved in generation of ultimately short pulses has been made with KLM Ti:sapphire, pumped either by an Ar-laser or a frequency-doubled neodymium laser. However, the only major shortcoming of Ti:sapphire which has absorption in the blue-green spectral region, is the fact that it still cannot be directly diode-pumped due to the absence of sufficiently powerful blue-green semiconductor lasers at the present time. Therefore, Cr^{3+}-doped colquiriite crystals, such as Cr:LiSGaF [2, 3] and Cr:LiSAF [4] which possess absorption bands that overlap the wavelength range of red diode laser arrays (630–690 nm) and emission bandwidths comparable to that of Ti:sapphire (~ 220 nm), are of special interest. At first sight, Cr:LiSGaF and Cr:LiSAF are very similar with respect to basic spectroscopic properties [5] and therefore should exhibit similar lasing and ultrashort-pulse operation characteristics. However, comparing the performance of Cr:LiSAF and Cr:LiSGaF in the same resonator configuration (conventional astigmatically compensated X-cavity), one should note that Cr:LiSGaF demonstrates higher output power in cw (900 mW) and in mode-locked (200 mW) operation than Cr:LiSAF [5]. In the Q-switched regime, Cr:LiSGaF produced four times more energy (12 μJ at 10 kHz repeteition rate) than Cr:LiSAF under the same conditions [6]. Based on these considerations, we anticipate that the application of the concept, recently suggested in [7], to Cr:LiSGaF, allowing for the better diode-pump-resonator beam mode-match and thus higher output power (1.1 W in Cr:LiSAF, the highest value achieved up to now in cw-regime), would also enable even higher cw output powers. In any case, we believe that Cr:LiSGaF, along with the well-established Cr:LiSAF crystal, coupled with advances in 670 nm GaInP/AlGaInP diode lasers and in chirped dielectric mirror technology, offers the potential for the most compact all-solid-state femtosecond laser sources in the future. At this point it is worth stressing that not only the semiconductor pump source but also the prismless dispersion compensation design essentially contributes to the compactness of the laser. In this paper and at this stage of research, we concentrate on the latter aspect, keeping in mind the possibility of a combination of a prismless resonator design with diode-pumping at the very next stage.

Nowadays Kerr-lens mode-locked (KLM) Cr:LiSAF (e.g., [8–10]) and Cr:LiSGaF lasers [5, 11–13] routinely produce pulses below 50 fs [9, 14–19]. However, the shortest pulses obtained in Cr:LiSAF lasers (18 fs [15] and 24 fs [16]) were achieved at the expense of the output power which is negligible in both cases, and at the expense of pulse quality, i.e., which has a relatively large (> 0.4) time-bandwidth product.

Recent achievements in the technology of compact mirror dispersion controlled (MDC) ultrashort pulsed Ti:sapphire lasers generating around- and sub-10 fs pulses ([20–23]) stimulated recent research, which aims towards the development of similar performing chirped mirror dispersion controlled Cr:LiSGaF and Cr:LiSAF lasers. However, this task has remained unsolved at the first stage. This is mainly due to