$\chi^{(2)}$-Lens Mode-Locking of Diode-Pumped Nd-doped Vanadate Lasers

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Multi-Watt operation of picosecond diode-pumped Nd oscillators has been demonstrated mainly by two passive mode-locking methods, one based on semiconductor saturable absorber mirrors (SESAMs) and the other on intracavity frequency doubling. Although SESAMs are well established devices for lasers emitting around 1 µm, their residual absorption, leading to heating, is the major intrinsic drawback and limits their power scaling capabilities. On the other site intracavity frequency doubling is a promising mode-locking approach for up-scaling the power of such picosecond solid-state lasers [1,2], because the damage threshold of nonlinear crystals is an order of magnitude higher and the low residual absorption at the fundamental wave enables operation at high average power. Furthermore, this approach is generally free of spectral limitation and easily extendable to any laser spectral region [3].

The intracavity type-I SHG provides two different types of passive mode-locking mechanisms: The first one is amplitude shaping based on the intensity dependent reflectivity of the FDNLM and the second one is phase shaping based on cascaded $\chi^{(2)}$ nonlinear phase shift of the fundamental wave, i.e. cascaded $\chi^{(2)}$-lens mode-locking (fig.1). Although this is a natural combination of two effects taking place in the same mode-locking device, $\chi^{(2)}$-lens mode-locking assisted by FDNLM has a potential which has not been exploited effectively, yet.

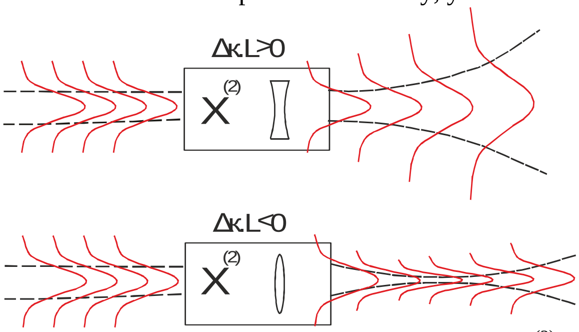

Figure 1. A schematic illustration of the $\chi^{(2)}$-lens formation

In this work we present our experimental results on passive mode-locking of different Nd: **T**VO_4 (**T**=Y, Gd, Lu) laser crystals operating on the $^4F_{3/2}\rightarrow\, ^4I_{11/2}$ and $^4F_{3/2}\rightarrow\, ^4I_{13/2}$ transitions around 1µm and 1.3 µm respectively.

An alternative, passive mode-locking technique based on second-order nonlinearity inside the laser cavity which utilizes $\chi^{(2)}$-lens formation in SHG crystal assisted by the nonlinear reflection of the FDNLM is used in all experiments. FDNLM initiates the passive mode-locking process and ensures self-sustained operation while the defocusing $\chi^{(2)}$ - lens effect leads to the shortest pulse duration (2.9 ps in the case of 1µm laser system and 3.6 ps at $^4F_{3/2}\rightarrow\, ^4I_{13/2}$ transition around 1.3 µm). Thus, although each of the two mode-locking mechanisms in principle can be used alone for passive mode-locking of the laser, the hybrid scheme proves beneficial for the robust laser performance in this study. The output power is ranging from 0.5 to 5 W (in both cases), close to the maximum value for TEM_{00} CW operation of the laser.

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References

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