

Yb³⁺添加媒質を用いた超短パルス光源の開発Development of ultrashort pulse lasers based on Yb³⁺-doped materials

Objectives

Yb³⁺添加超短パルスレーザーは他の超短パルスレーザーにおいては困難な、高効率高出力動作に適している。しかし得られるパルス幅は、Yb³⁺添加媒質の利得帯域幅による制限を大きく受けてしまう。我々は共振器の最適化によるカーレンズ効果の拡大利用、異種の Yb³⁺添加媒質を同一共振器内で用いた人工利得帯域幅制御、新規 Yb³⁺添加媒質の開発等を基盤に、高出力特性と短パルス特性を併せ持った光源開発を行っている。

Ultrashort pulse lasers based on Yb³⁺-doped materials are suitable for highly efficient high-power laser operation, which is difficult to achieve using other lasing materials. However, the pulse duration which can be achieved is strongly restricted by the gain bandwidth available in Yb³⁺-doped materials. We are developing ultrashort-pulse lasers with high average power by fully optimizing the Kerr-lens effect, artificially controlling the gain bandwidth based on a combined active gain medium, and through development of new Yb-doped gain materials.

Fig. 1

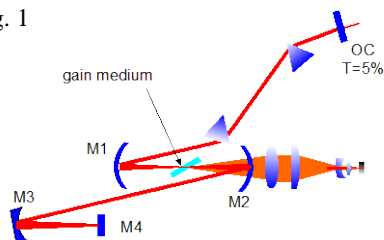
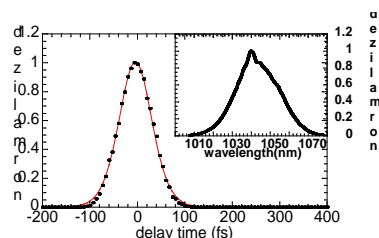


Fig. 2



Achievements

- カーレンズ効果を拡大利用することにより、利得媒質の一般的な帯域幅制限を越えたモード同期発振を可能とし、Yb³⁺:Sc₂O₃ 媒質を用いてパルス幅 92 fs、出力 850 mW を達成した。
- 異種の Yb³⁺添加利得媒質を同一共振器内で用いた複合利得媒質超短パルス光源を開発し、パルス幅 53 fs、平均出力 1W 以上を実現した。
- 新材料 Yb³⁺: (YGd₂)Sc₂(Al₂Ga)O₁₂ ceramic を用いたカーレンズモード同期レーザーを開発し、パルス幅 69 fs、出力 820 mW を達成した。

- By making the best use of the Kerr-lens effect, we have succeeded in overcoming the gain bandwidth restriction. Pulses as short as 92 fs with 850 mW average power were obtained from Yb³⁺:Sc₂O₃ ceramic.
- Pulses as short as 53 fs with an average power above 1W have been obtained from a Kerr-lens mode locked multi-gain media oscillator.
- We have developed a Kerr-lens mode-locked oscillator based on Yb³⁺:(YGd₂)Sc₂(Al₂Ga)O₁₂ ceramic. Pulses as short as 69 fs with an average power of 820 mW were obtained.

Fig. 3

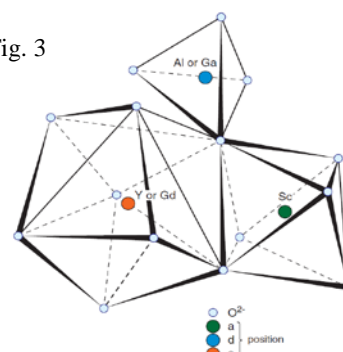


Fig. 1: Experimental set-up of a Kerr-lens mode-locked laser.

Fig. 2: Autocorrelation trace and spectrum (inset) of 53 fs pulses.

Fig. 3: Structure of Yb³⁺: (YGd₂)Sc₂(Al₂Ga)O₁₂ disordered ceramic.

References

- 1) M. Tokurakawa, A. Shirakawa, K. Ueda, H. Yagi, T. Yanagitani and A. A. Kaminskii, *Opt. Lett.* **32**, 3382-3384 (2007)
- 2) M. Tokurakawa, A. Shirakawa, K. Ueda, H. Yagi, S. Hosokawa, T. Yanagitani and A. A. Kaminskii, *Opt. Lett.* **33**, 1380-1382 (2008)
- 3) M. Tokurakawa, A. Shirakawa, K. Ueda, H. Yagi, M. Noriyuki, T. Yanagitani, and A. A. Kaminskii *Opt. Express* **17**, 3353-3361 (2009)
- 4) M. Tokurakawa, H. Kurokawa, A. Shirakawa, K. Ueda, H. Yagi, T. Yanagitani and A. A. Kaminskii, Submitted to *Opt. Express*.