二光子励起顕微鏡に向けた ジャイアントパルス Nd:YVO_4 マイクロチップ MOPA

Giant pulse Nd:YVO_4 microchip MOPA for two-photon excitation microscopy

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Microchip lasers (MCLs) with high peak power over MW as well as very compact and fiber-tailed structure are attractive for various applications based on laser induced plasma breakdown, such as laser ignitor [1], remote laser induced breakdown spectroscopy [2], laser peening [3], and so on. The peak power scale of MCL had been achieved by using a combination of Cr^{4+}:YAG saturable absorber for a high damage threshold and quasi-cw pumping for an effective heat management. On the other hand, some applications such as two-photon excitation (TPE) microscopy for biological imaging require much lower peak power (P_0~kW) below damage threshold and much higher repetition rate for a high average power ($\bar{P}$) as well as the compactness. The two-photon excitation rate is proportional to $P_0 \cdot \bar{P}$ [4]. Therefore, we first targeted a MCL generating pulses with a short pulse width at a high repetition rate from a short cavity length with a semiconductor saturable absorber and then increased the pulse energy using a master oscillator power amplifier (MOPA) for TPE microscopy. The MCL was composed of a 0.2 mm-long a-cut 1.0 at. % Nd:YVO_4 crystal and a semiconductor saturable absorber output coupler (SESOC) [Fig. 1(a)]. The SESOC (Batop GmbH) had a thin saturable absorber and partial reflection layers at the front side, allowing a short cavity length of ~0.21 mm. Its modulation depth, saturation fluence, and relaxation time constant was 9%, 40 μJ/cm^2, and ~15 ps, respectively. The Nd:YVO_4 and SESOC were end-capped by a sapphire or diamond for heat management. A cw LD was used to end-pump at a wavelength of 808 nm. The laser characteristics such as pulse repetition rate, duration, and energy were depended on pump power and diameter. The average power was about 20 mW level. >1 MHz repetition rate for >100 ps pulse width was lowered to ~0.5 MHz with a shorter pulse operation such as 68 and 82 ps [Fig. 1(b)]. A double-pass microchip (μ)-MOPA using a 10 mm-long a-cut 0.3 at. % Nd:YVO_4 crystal and a fiber tailed pump LD (808 nm, 20 W) realized over 50 times amplification ($\bar{P}$~W, P_0~several tens kW), [Fig. 1(c)] where the polarization of seed light was adjusted to match the c-axis of Nd:YVO_4 for a higher gain. TPE fluorescence image using μ-MOPA will be discussed in presentation. This work partially supported by JST-CREST Grant Number JPMJCR1755, Japan. The authors thank Prof. Hiroaki Wake, Prof. Osamu Matoba, Prof. Xiangyu Quan, and Prof. Junichi Nabekura for research advice.

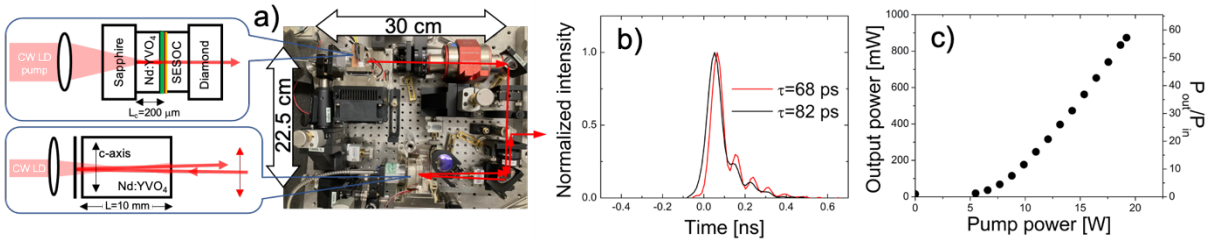

Fig. 1. (a) Schematic experimental setup of μ-MOPA. (b) Measured pulse shapes. (c) Output power and gain versus pump power of μ-MOPA.

References

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