Diode-pumped Tm:YAP/YVO_4 intracavity Raman laser

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Abstract. The laser performance based on YVO_4 Raman conversion in a diode-pumped actively Q-switched Tm:YAP laser is demonstrated for the first time. With an incident diode power of 10.9 W and a pulse repetition rate of 1 kHz, the average output powers for the first Stokes laser at 2.4 μm is about 270 mW.

1. Introduction

Stimulated Raman scattering (SRS) process in crystals is one of the most important nonlinear frequency conversion methods for extending the spectral coverage of the present lasers. The commonly known Raman crystals include $Ba(NO_3)_2$, YVO_4, $GdVO_4$, diamond, and variety of tungstate crystals[1-6].

In this study, we present a diode-pumped actively Q-switched intracavity Raman laser at 2.4 μm. YVO_4 crystal as Raman gain medium and Tm:YAP crystal as laser gain medium are utilized in the intracavity Raman laser. To the best of our knowledge, this is the first time YVO_4 Raman conversion in an actively Q-switched Tm:YAP laser has been demonstrated.

2. Experimental setup and results

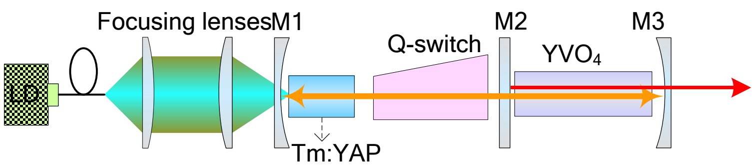

Figure 1. Configuration of the actively Q-switched Tm:YAP/YVO_4 intracavity Raman laser

Figure 1 shows the experimental configuration of the intracavity Tm:YAP/YVO_4 Raman laser. The pump source is a 20 W fiber-coupled continuous-wave 794 nm laser diode with a 400 μm fiber core diameter and a numerical aperture of 0.22. A focus lens system with a pair of plane-convex lenses is used to focus the pump beam into the Tm:YAP crystal. The a-cut Tm:YAP crystal is doped with 3.0 at.% Tm^{3+}, and the laser crystal has dimensions of 3 mm×3 mm×10 mm. Both end faces of the crystal are antireflection coated for the fundamental laser wavelength at 1.99 μm and the pump wavelength at 794 nm. The crystal is wrapped in indium foil and held in a copper heat sink whose temperature is maintained at 16 ℃. The YVO_4 crystal with dimensions of 4 mm×4 mm×30 mm is antireflection coated in the range of 1800-2550 nm (R<3%). It is wrapped with indium foil and mounted on a water-cooled copper heat sink maintained at a temperature of 18 ℃. A water-cooled acousto-optic

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modulator is used for Q-switched operation.

The actively Q-switched Tm:YAP/YVO_4 intracavity Raman laser comprises a fundamental laser cavity and a Raman cavity. The fundamental laser cavity is consisted of a flat mirror M1 and a concave output coupler M3 with a curvature radius of 300 mm. One surface of M1 is antireflection coated at 794 nm (R<0.2%), the other surface is coated for high reflectivity at 2 μm (R>99.8%). The other mirror M3, shared with the Raman cavity as output coupler of the Raman laser, is coated for high reflectivity at 2 μm (R>99.5%), and partial transmission at 2.4 μm (T=10%). One surface of the flat intracavity mirror M2 is antireflection coated at 2 μm (R<1%), the other surface is antireflection coated at 2 μm (R<1%) and high reflectivity at 2.4 μm (R>99.8%). Mirrors M2 and M3 compose the Raman Cavity. The physical length of fundamental laser cavity is about 145 mm, and the Raman laser cavity length is about 40 mm.

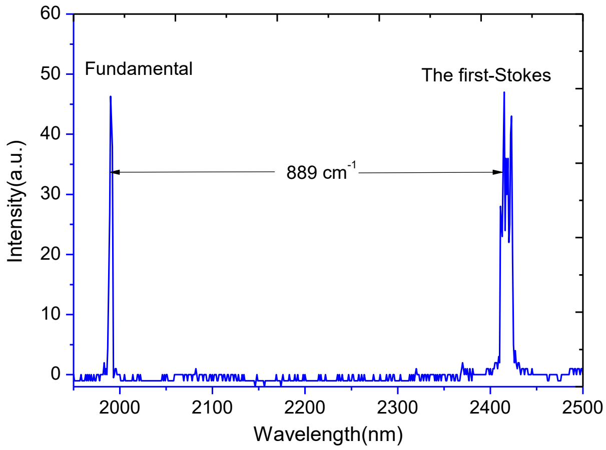

Figure 2. Optical spectrum of the actively Q-switched Tm:YAP/YVO_4 intracavity Raman laser.

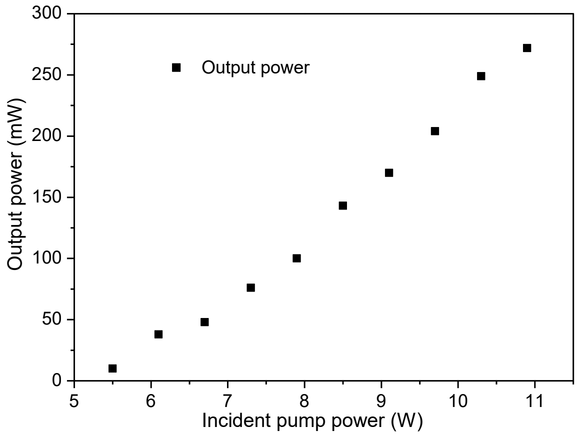

Figure 3. Raman output power versus incident diode pump power

The spectral information of the intracavity Raman laser in Q-switched operation is monitored by a Zolix spectrograph. The Raman laser output powers are measured by a power meter (Coherent, PM10). The operation of the intracavity Raman laser is investigated at a pulse repletion rate of 1 kHz. Figure 2 shows the spectral information of the intracavity Raman laser. The central wavelengths of the fundamental laser and first-Stokes laser are 1990 nm and 2418 nm. We can see that the frequency shift of the fundamental laser and the first Stokes component is 889 cm^{-1}.

Figure 3 shows the average output powers of the first Stokes laser as function of the incident pump power at 794 nm. It can be seen that the threshold powers of the Raman laser at a pulse repetition rate of 1 kHz are approximately 5.0 W. The fundamental and Raman output powers increase almost linearly with the incident pump power from 5.5 to 10.9 W. With an incident diode power of 10.9 W and a pulse repetition rate of 1 kHz, the average output powers for the first Stokes laser at 2.4 μm is about 270 mW.

3. Conclusion

The characteristics of diode-pumped actively Q-switched Tm:YAP/YVO_4 intracavity Raman laser has been demonstrated. With a pump power of 10.9 W, the average output powers of 272 mW for the first Stokes laser of 2.4 μm are obtained at a PRR of 1 kHz.

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