A Novel All-Fiber Q-switched Laser Using Fiber Bending Technique

Pramod R. Watekar, Seongmin Ju*, Won-Taek Han

Gwangju Institute of Science and Technology, Gwangju, South Korea
*Optonest Corporation, Gwangju, South Korea

wthan@gist.ac.kr

We report the realization of the all-fiber Q-switched laser operating at 1549.38 nm upon 980 nm pumping. The Q-switch pulse energy was 1.68 mJ at 100 ms pulse width and 168 μJ at 10 ms pulse width upon pumping with 100 mW power. The present all-fiber Q-switched laser has a high potential for several tens of mJ energy pulses upon pumping with a large pump power well beyond a few Watts.

Q-switching of fiber laser has generated tremendous interest in the field of optics due to its potential to generate short and powerful pulses, which are used in many applications such as OTDR, sensing and material processing and medical surgical equipments. Recently, the passive Q-switched laser using the saturable absorber, electro-optic modulators and acousto-optic modulators have been reported [1-3]. However, the use of bulk inactive switching elements causes degradation of the beam quality and cause high cavity losses, which results in a decrease of the overall performance of laser. In such a scenario, all-fiber Q-switch is very attractive device although energy is always limited to a few tens of mJ. A very few reports have been reported for the all-fiber Q-switched laser [4] that can be used for the industrial applications. In this paper, we propose and demonstrate a very simple all-fiber Q-switched laser which has been fine tuned for Q-switched lasing and it showed promising output enhancement of about 1460 times. The Q-switched laser structure that we used is shown in Fig. 1.

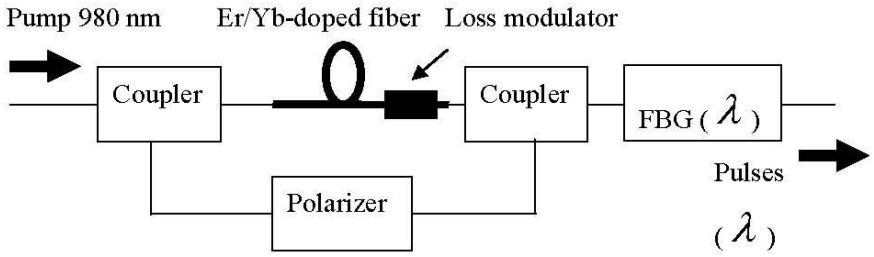


Fig. 1. The configuration of the all-fiber Q-switched laser

The principle of operation can be stated as follows: the ring laser structure with active feedback from fiber Bragg gratings (FBG) generates the lasing output at λ_0, which can be enhanced to store a large energy by using loss modulation technique. The Er/Yb doped fiber needed in the Q-switching experiment was fabricated in-house using MCVD technique with concentrations of 375 ppm (molar) and 750 ppm (molar) for Er and Yb, respectively. The numerical aperture was 0.21 and 0.07 and core diameter of 7 μm and 3 μm, for inner core and outer core, respectively. The fiber diameter of the fiber was 125 μm and low-index polymer was used as the coating. The FBG had 85% reflectivity at λ=1549.38 nm and it was supplied by Optonest Corporation. It was found that the helical bending of the Er/Yb-doped fiber at particular bend radius changed the polarization state to modulate the loss characteristics of the ring laser. The nano-mover was used to detune the ring laser by changing the helical structure. The length of the Er/Yb doped fiber was 1m. The ring laser maximum output was 11.5 μW upon pumping at 980 nm as shown in Fig. 2a. When the loss modulation was introduced by the helical bending, the pulses with intense energy were recorded at oscilloscope. The peak pulse power was 16.8 mW with energy of

1.68 mJ at 100 ms pulse duration which reduced to 168 μJ at 10 ms. The output bandwidth was 0.1 nm centered at 1549.38 nm. The typical outputs are shown in Fig. 2b and Fig. 3 for 50 ms pulses. It is worth mentioning that we used pump power of 100 mW to obtain the output power in mJ, which can be enhanced significantly with application of pump power with over a few units of Watts.

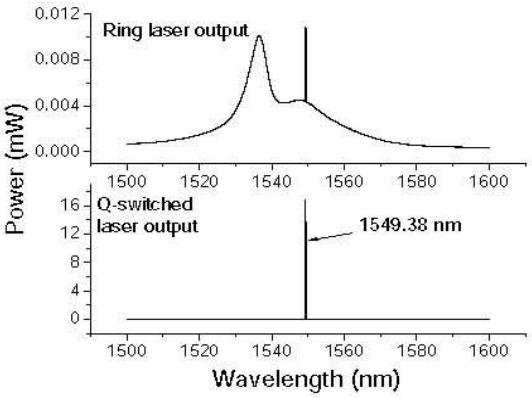
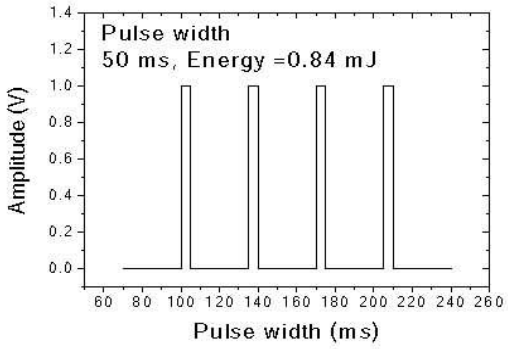
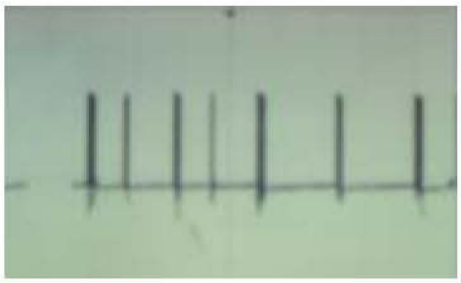


Fig. 2. (a) Top: The ring-laser output at 1549.38 nm. A significant ASE can be noticed.
(b) Bottom: Output in Q-switching mode. ASE is now negligible





Photograph

Fig. 3. (Below-Left): A typical Q-switched output for 50 ms pulses.
(Below-Right) A photograph captured from a digital oscilloscope.

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REFERENCES

[1] V. N. Philippov, A. V. Kiryanov, and S. Unger, "Advanced configuration of erbium fiber passively Q-switched laser with Co:ZnSe crystal as saturable absorber", IEEE Photonics Technology letters, vol. 16, 57 – 59, (2004).

[2] H. G. Kee, G. P. Lees, and T. P. Newson, "Narrow linewidth Q-switched Er-doped fiber loop laser," Electronics Letters, vol. 34, 1318-1319 (1998).

[3] J. A. Alvarez-Chavez, et.al, "High energy high power Yb-doped Q-switched fiber laser," Optics Letters, vol. 25, 37-39 (2000).

[4] P. Perez-Millan, A. Diez, and M. V. Andres, "Q-switched all fiber laser based on magnetostriction modulation of a Bragg grating," Optics express, vol. 13/13, 5046-5051 (2005).