Nanjing University of Posts and Telecommunications

Au triangles array as saturable absorber for a 1.5 μm passively mode-locked erbium-doped fiber laser

Xiaofeng Cai, Ping Gu, Zuxing Zhang

Advanced Photonic Technology Lab, College of Electronic and Optical Engineering & Microelectronics College, Nanjing University of Posts and Telecommunications, Nanjing 210023, China

Corresponding author: zxzhang@njupt.edu.cn

ABSTRACT

Keywords: Au triangles array, localized surface plasmon resonance, mode-locking fiber laser.

The Er-doped mode-locked fiber laser with Au triangles array (Au TA) on the fiber tips as saturable absorber by nanosphere lithography technology has been demonstrated. The obtained LSPR of the Au TA fabricated by the nanosphere with diameter of 1300 nm was 1614 nm (near the C-band), which improved the optical nonlinearity of Au TA to achieved mode-locked operation.

FABRICATION PROCEDURE AND CHARACTERIZATION OF AU-TRIANGLES @ OFT

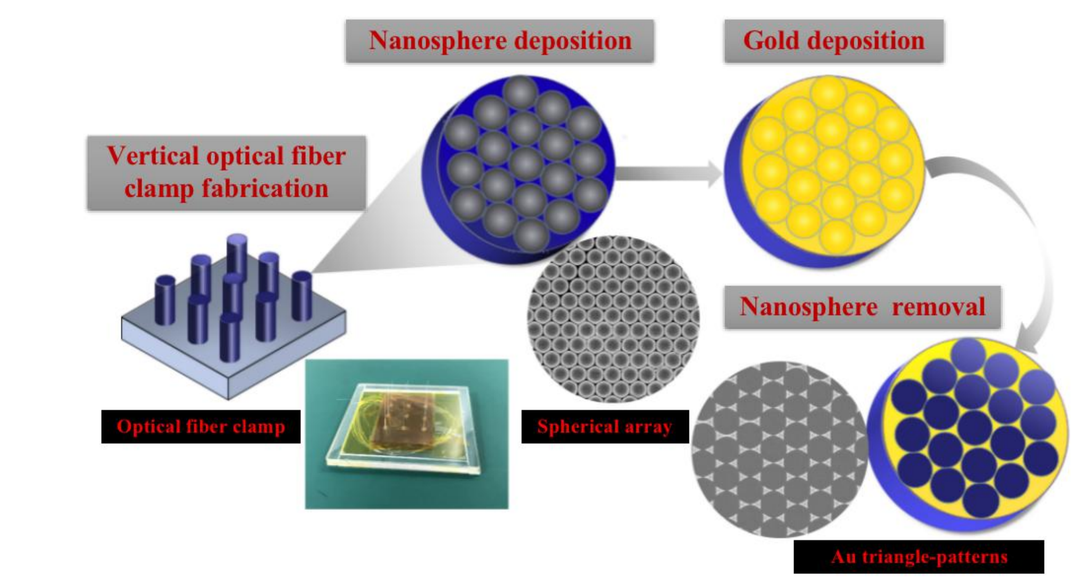


Fig. 1. The fabrication procedure for well-patterned Au triangles on the OFT.

After the polystrene (PS) nanosphere (NS) (diameter: 1300 nm) deposition on the optical fiber tips (OFTs) by Langmuir-blodgett method, gold deposition with thickness of 60 nm by Electron beam thermal evaporation and nanosphere removal by ultrasound treatment, the well-ordered Au TA were fabricated on the OFT. (Fig. 1)

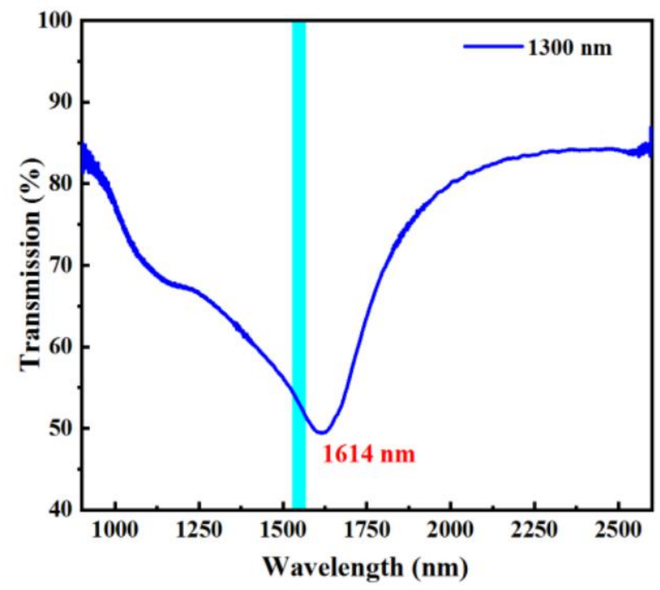


Fig. 2. The linear optical transmission of the Au TA.

To characterize the resonant properties of the fabricated Au TA, the near-infrared transmission spectrum was measured and displayed in Fig. 2. A broad transmission dip, corresponding to the LSPR, was centered at 1614 nm, which was near the C-band (1550 nm) .

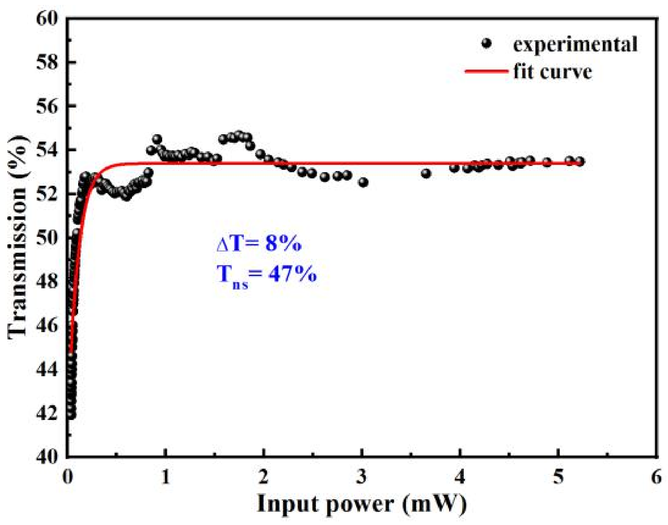


Fig. 3. Nonlinear transmission of the Au TA samples (diameter: 1300 nm).

The nonlinear absorption properties of the sample were measured. The modulation depth of the Au TA was as high as 8%, with a corresponding nonsaturable intensities of 47%, as shown in Fig. 3.

EXPERIMENTAL SETUP

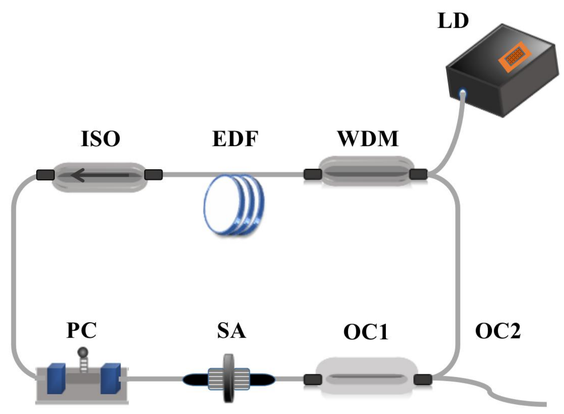
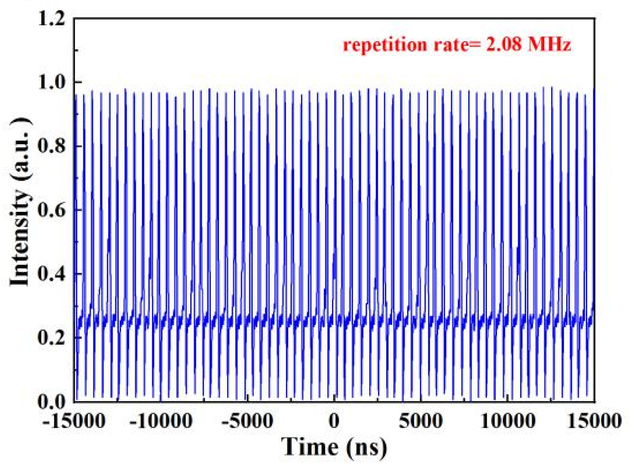


Fig. 4. Schematic of Au TAs-based fiber mode-locked laser.

Fig. 4 shows the ring mode-locked EDFL with the single-mode fiber of about 90 m, and the Er-doped fiber of 5.3 m. Au TAs @ fiber as SA was connected to the cavity through a bare fiber adapter.

RESULTS AND DISCUSSIONS

The phenomenon of passively ML operation has occured as the pump power increased from 127.2 mW to 704 mW.



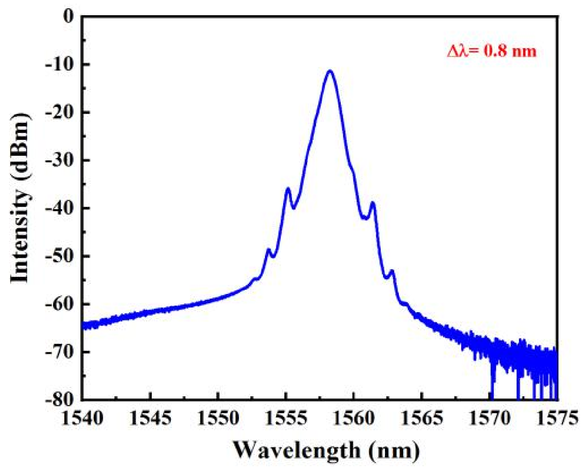


Fig. 5. Output mode-locked pulse train. Fig. 6. Output mode-locked optical spectrum.

In Fig. 5, the fundamental repetition rate is 2.08 MHz with the time period between adjacent pulses of 480 ns at 127.2 mW.

In Fig. 6, the central wavelength is 1558 nm and the 3-dB spectral width is about 0.8 nm.

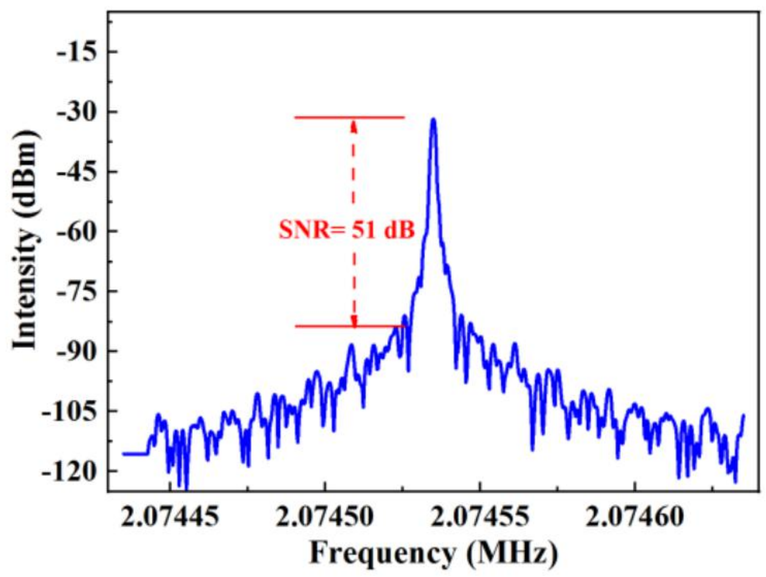


Fig. 7. RF spectrum of the mode-locked pulses.

In order to test the stability of the ML operation, the radio-frequency (RF) spectrum is illustrated in Fig. 7. The fundamental frequency of the EDFL is 2.08 MHz with a signal-to-noise ratio of 51 dB, indicating relatively stable operation of ML.

CONCLUSION

In this paper, we reported an all-fiber passive mode-locking EDFL that use Au TAs @ OFT (the diameters of NS is 1300 nm) as SAs. By NS lithography technology, we achieved LSPR absorption peaks in the C-band. The stable passively mode-locked laser with a repetition rate of 2.08 MHz and a pulse period of 480 ns was obtained for the pump power of 704 mW.

REFERENCES

[1] M. S. Habib, C. Markos, J. E. Antonio-Lopez, R. Amezcua-Correa, "Multioctave supercontinuum from visible to mid-infrared and bend effects on ultrafast nonlinear dynamics in gas-filled hollow-core fiber," Appl. Opt., 58, 13, pp. 7-11, 2019.

[2] Y. C. Wang, R. J. Lan, X. Mateos, J. Li, C. Hu, C. Y. Li, S. Suomalainen, A. Harkonen, M. Guina, V. Petrov, and U. Griebner, "Broadly tunable mode-locked Ho:YAG ceramic laser around 2.1 μm," Opt. Express, 24, 16, pp. 18003–18012, 2016.

[3] L. R. Jing, X. H. Li, Y. M. Wang, et al, "In2Se3 nanosheets for harmonic mode-locked fiber laser," Nanotechnology, 123842, 2, pp. 1-8, 2020.

[4] Y. I. Jhon, J. Koo, B. Anasori, et al, "Metallic MXene Saturable Absorber for Femtosecond Mode-Locked Lasers," Advanced Materials, 1702496, pp. 1-8, 2017.