Study of the wavelength tunable erbium-doped fiber ring laser

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Abstract: A simple configuration to perform wavelength switching in a figure-of-eight fiber laser is demonstrated in this experiment. The main laser cavity is coupled with an all-fiber phase modulator in Sagnac-interferometer structure. In the main cavity, a fiber polarization controller is used to tune the polarization state of the light and ensure the polarization state of the main cavity. The wavelength switching in a range of 23 nm from 1533 nm to 1556 nm can be achieved by tuning the state of the second polarization controller in the external cavity. A biased piezoelectric tube with fiber wounded around is set in the external cavity and the central wavelength switching between two broad bands can also be achieved. The further study of the theoretical modeling and analysis is going on.

1. Experimental Setup

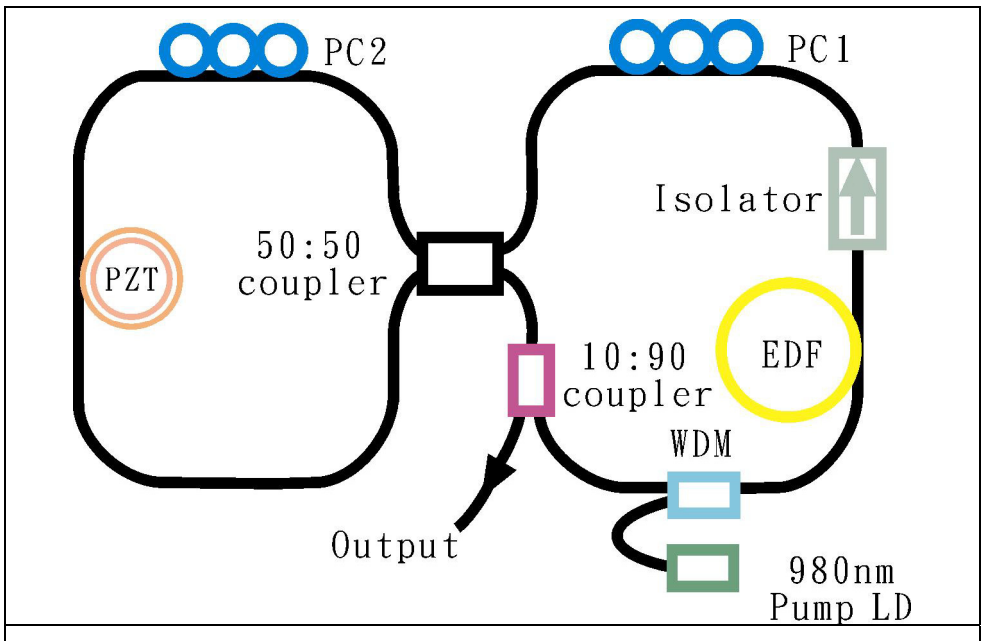

Fig.1. The schematic of a wavelength tunable erbium-doped fiber ring laser: PC, polarization controller; WDM, wavelength division multiplexer; EDF, erbium-doped fiber; PZT, piezoelectric tube.

Figure 1 shows the overview of the experimental setup. In the main cavity, we use a 980 nm laser diode to pump the EDF (erbium-doped fiber). Then a 1550 nm isolator sets to ensure the light direction of the main cavity. After the isolator, the light pass through the fiber polarization controller. We can tune the polarization controller to change the polarization state of the light. A 2x2 coupler is used to connect the main cavity and external cavity. In the external cavity, a fiber polarization controller and a piezoelectric tube with fiber wounded around are set. The output coupler is set in the main cavity.

In the beginning, we turn on the 980 nm laser diode with 300 mA pump current and the laser diode output power is about 200 mW. The light generated by the laser diode first couple in a 980 nm/1550 nm WDM. The WDM can suffer both 980 nm and 1550 nm laser light pass through it. The 980 nm laser pass through the WDM and then pump EDF with 5 m, and the EDF is combined with a 3 m EDF and a 2 m EDF. When the 980 nm laser pass through the EDF, the erbium ion was pumped by the light and generates laser light with its wavelength about 1550 nm. At this time, there are both 980 nm and 1550 nm laser light in the cavity. When 980 nm and 1550 nm laser light pass through the isolator, 980 nm light is reduced to zero. Because the isolator just suffer the wavelength between 1530 nm - 1570 nm. We can choose the polarization state by tune the fiber polarization controller after the isolator and the polarization state affects the PC2 tuning angle of the experiment result. When light couple in the 2x2 coupler in one input, the each outputs get 50% power, and propagate in the different direction. There is no isolator in the external cavity, so the clockwise and counterclockwise propagation both exists. With both propagation, the external cavity just like a Sagnac-interferometer. The PZT with fiber wounded around sets in the light way and is modulated with sine signal generated by function generator.

2. Experimental Results

In this experiment, we mainly tune the PC2 in the external cavity and observe the laser output spectrum by OSA (optical spectrum analyzer). Although the PC1 in the main cavity affects the output spectrum, the wavelength switching mechanism still works depend on the change of the angle tuned by the PC2. The output spectrum is not absolutely depend on the angle but relative to the angle when the PC1 changes its state. There are three parts in each one of the polarization controller, so we can tune the six parts in different angle to observe the output spectrum. After our experiment, we find that wavelength switching occurs only when we tune the part near the 2x2 coupler of the PC2. When we change the other two parts of the PC2, the state of only 1556 nm exist do not occur. The output spectrum only exhibits the state of both 1533 nm and 1556 nm exist and only 1533 nm exist. As we change the state of the three parts of PC1, the wavelength switching do not occur but the relative power to angle figure will change. Fig.2 shows the fiber ring laser output spectrum with changing the part near the 2x2 coupler of PC2 at angles from 0°～180°. When the angle is about 35° , the 1533 nm and 1556 nm laser light simultaneously exist in the cavity. And the state of only 1533 nm exist and only 1556 nm exist both exhibit. Fig.3 (a) shows the relativity of power and angle.

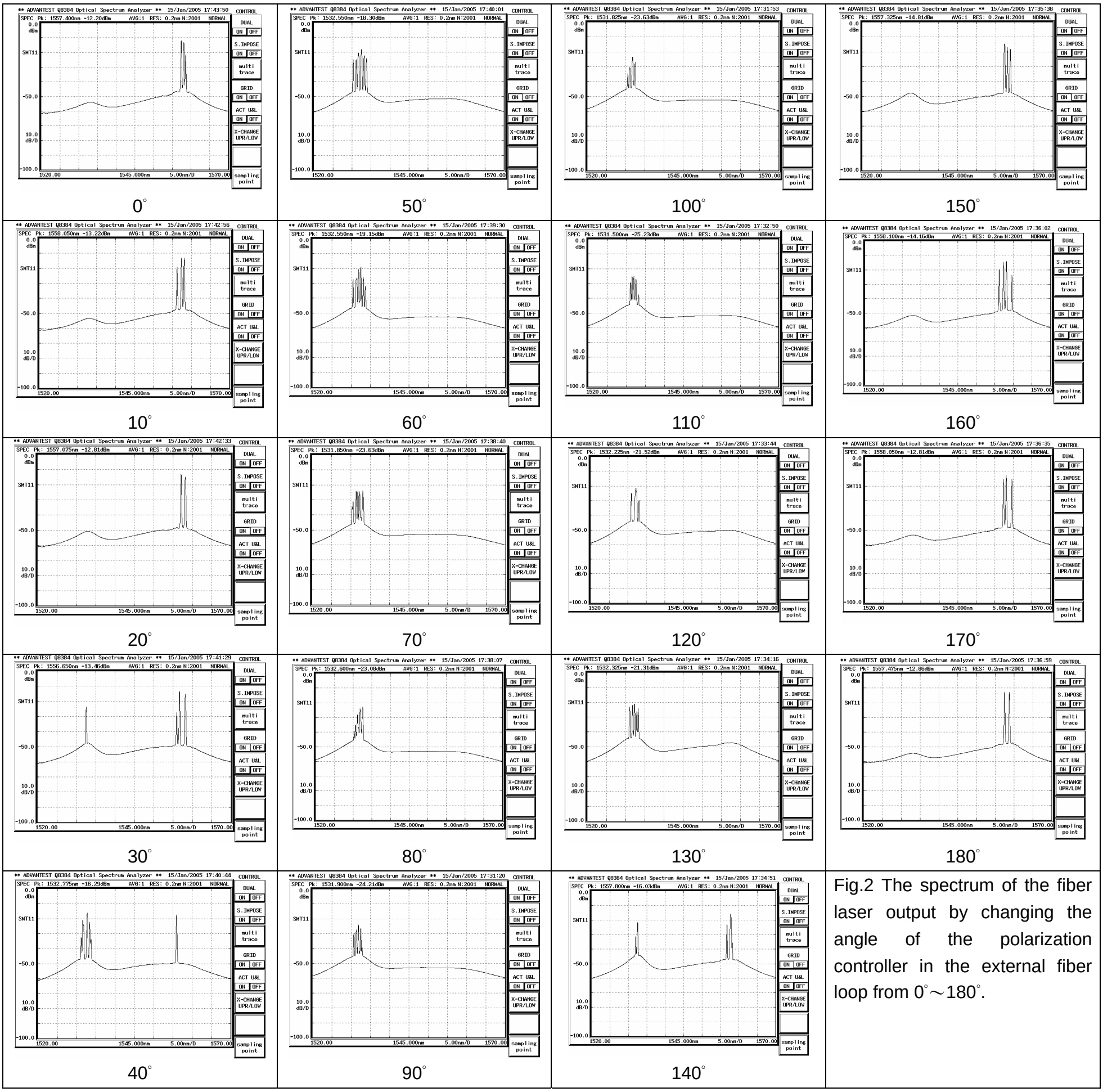

Fig.2 The spectrum of the fiber laser output by changing the angle of the polarization controller in the external fiber loop from 0°～180°.

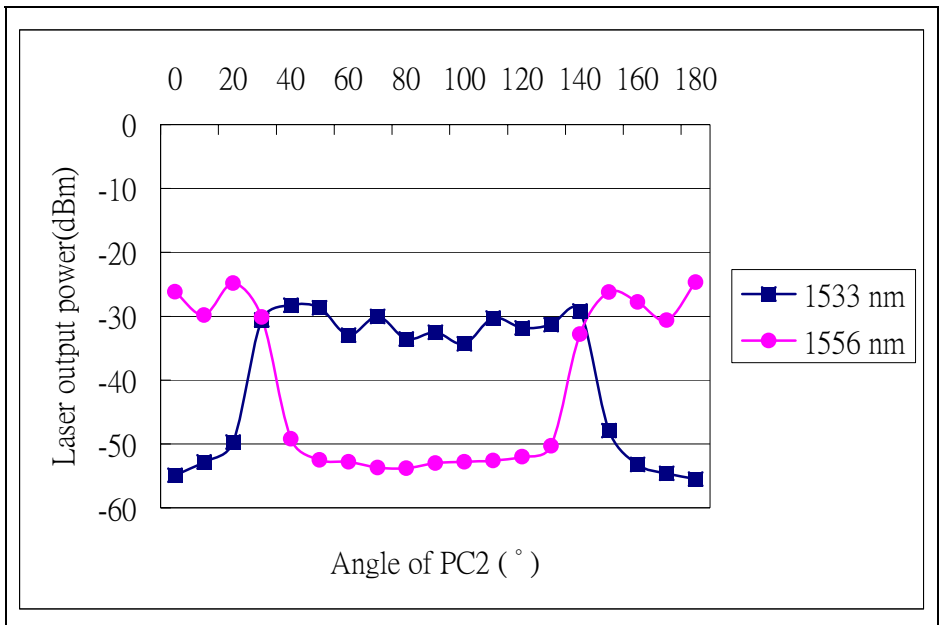

Fig. 3 Dependence of the laser output power on the angle of the polarization controller in the external fiber loop.

A biased piezoelectric tube wounded by the single mode fiber is set in the external cavity which can stretch the fiber so as to achieve phase modulating due to the variation of the fiber birefringence. We use a function generator to provide a sinusoidal signal with the

amplitude of 10 V p-p. We find that the output laser light has many fast sweeping modes and the spectrum becomes broadest at 33 KHz of PZT modulation frequency. Figure 4 shows that the central wavelength switching between two broad bands can also be achieved by setting the angle of the polarization controller in the external cavity when the PZT is vibrating violently as like a phase modulatior.

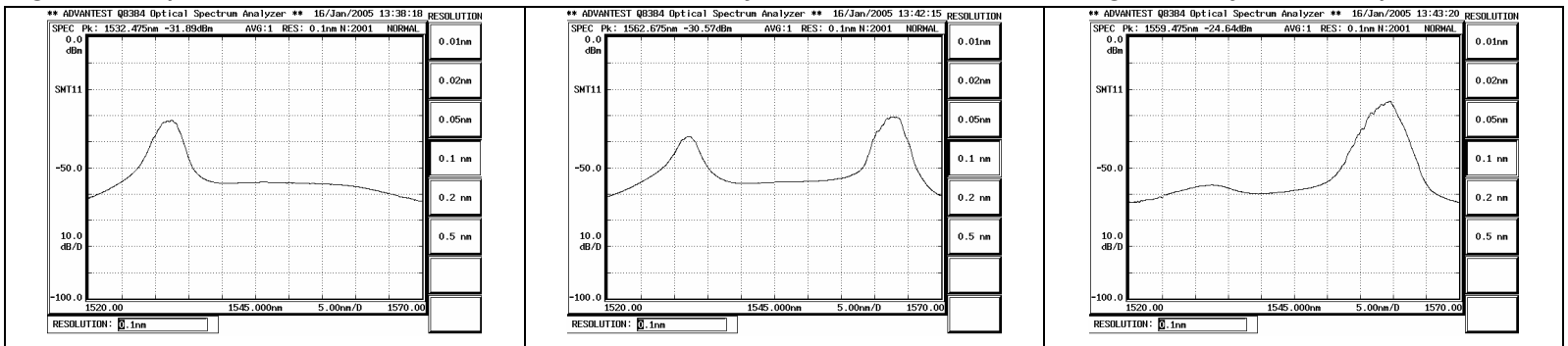

Fig. 4 The spectrum of the laser output with 33KHz sinusoidal signal applied on the PZT. From the left to the right is the measured spectrum when the angle of the polarization controller in the external fiber loop is set at 90°, 130°, and 160°, respectively.

3. Conclusion and future work

We report a wavelength tunable fiber ring laser in a figure-of-eight structure. In this experimental setup, we can easily choose the laser wavelength to be at 1533 nm or 1556 nm by setting the angle of the fiber polarization controller in the external cavity. This structure can be set in room temperature and easily controlled. The further study of the theoretical modeling and analysis is going on. In the future, we wish to combine the wavelength switching technique with the mode-locking mechanism to construct a wavelength tunable mode-locked short pulse fiber ring laser for more applications.

4. Acknowledgment

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5. References

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