Single longitudinal mode multi-wavelength fiber ring laser

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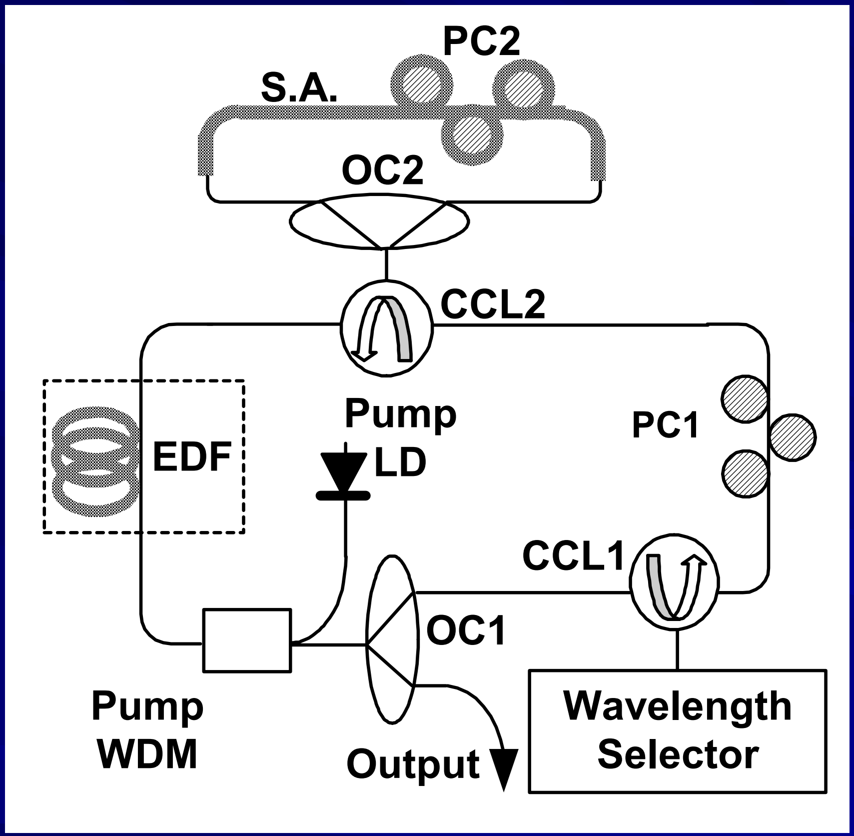
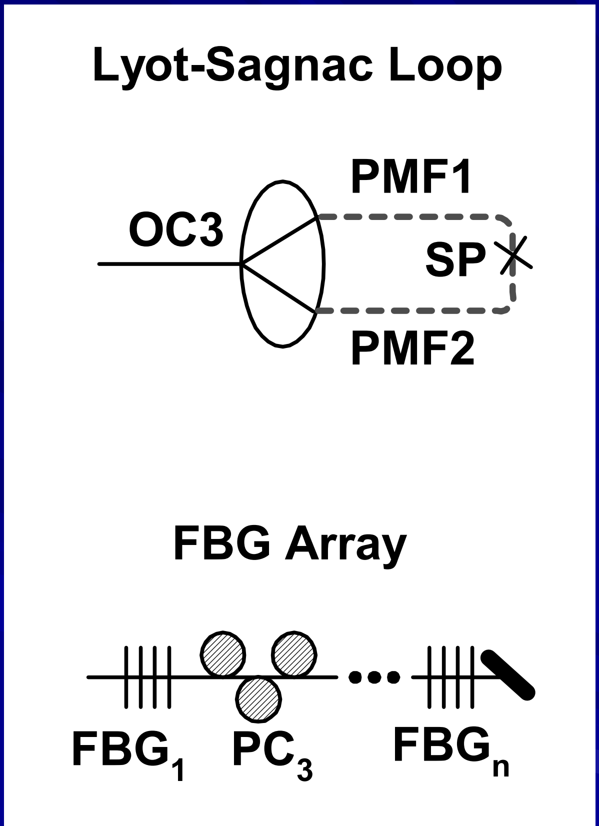
Outline

- Laser configuration
- Principle of single longitudinal mode operation
- Experimental results
- Conclusion

Single longitudinal mode multi-wavelength fiber ring laser



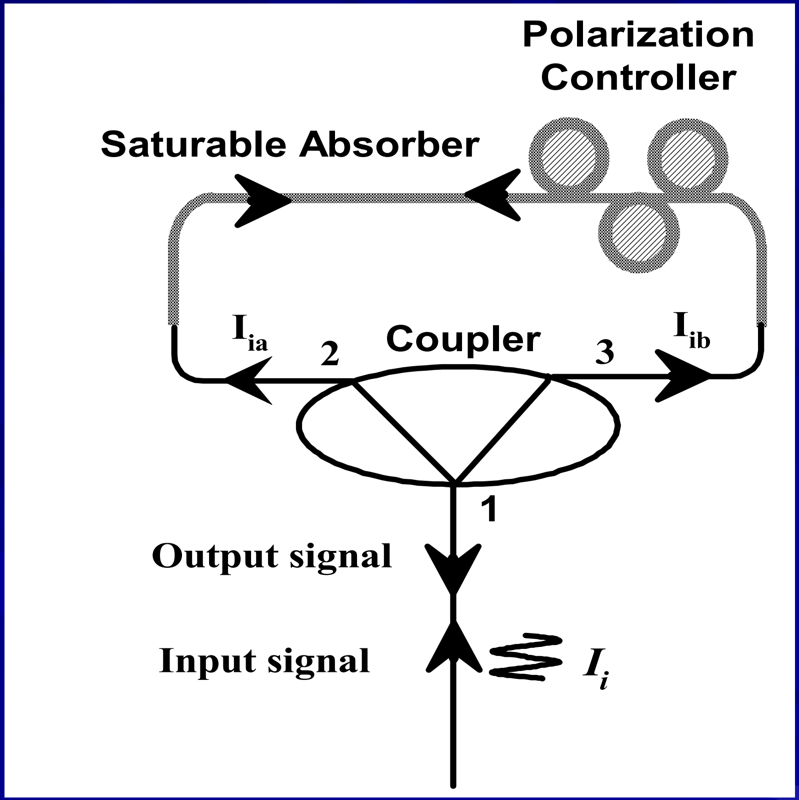


Single longitudinal mode operation

1. The loop mirror creates counter propagation optical waves, which generate standing waves.

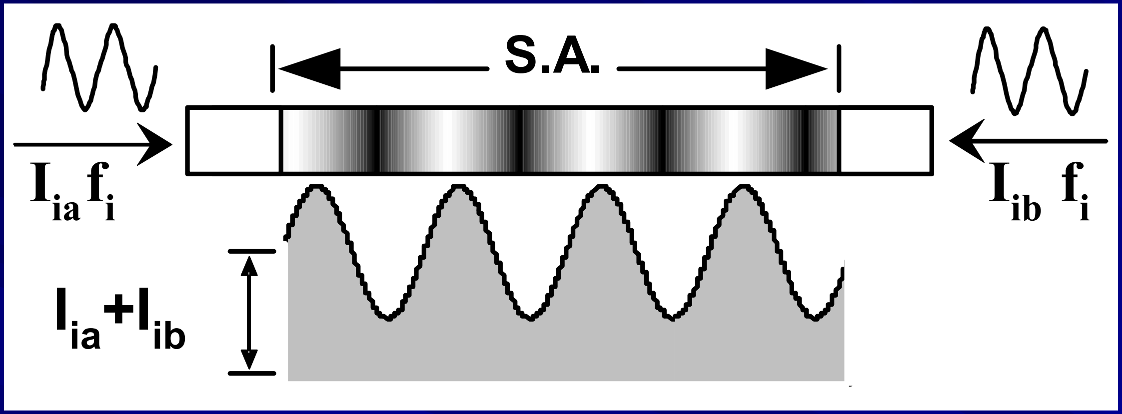
The optical power distribution of the *i*th wavelength in the absorber:

$$I_i = I_{ia} + I_{ib} + 2(I_{ia} I_{ib})^{1/2} * \cos(2\beta z)$$



Single longitudinal mode operation

2. Spatial hole burning is generated in the absorber.



3. Spatial hole burning leads to periodically changed refractive index, which creates narrow bandpass filter.

4. Multiple interference patterns can be generated if multi-wavelengths are lunched into the absorber, which leads to a multi-band filter.

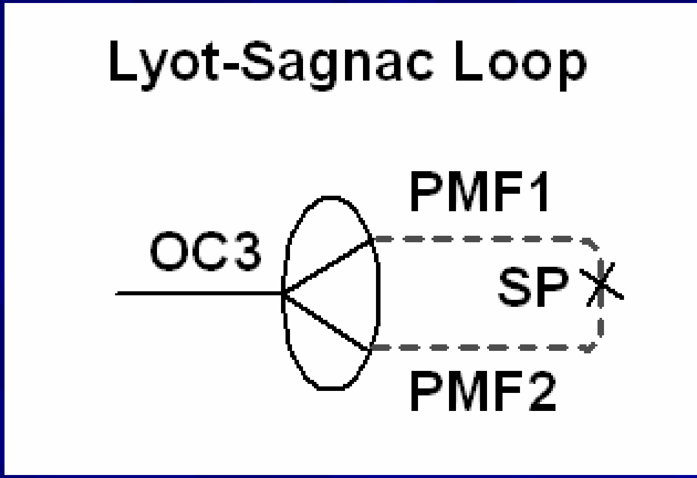
Wavelength selection scheme

- Sagnac-Lyot filter:

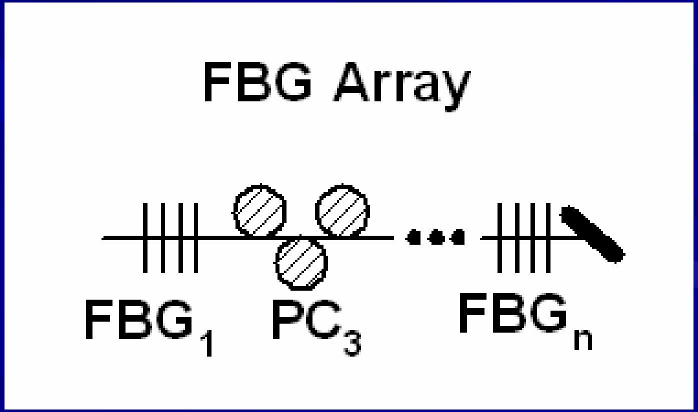
Frequency spacing:

$$\Delta \nu = c/_{B\Delta l}$$

c: the light speed in vacuum
B: the birefringence of the PMF
Δl: the length difference



- Fiber Bragg grating array:



Experimental results and discussions

Reflection spectrum of Sagnac-Lyot loop:

$$R_{ref} = 1 - \sin^2\theta \times \sin^2\left(\frac{2\pi}{\lambda} B \times \Delta l / 2\right)$$

Wavelength spacing:

$$\Delta\lambda = \frac{\lambda^2}{B \cdot \Delta l}$$

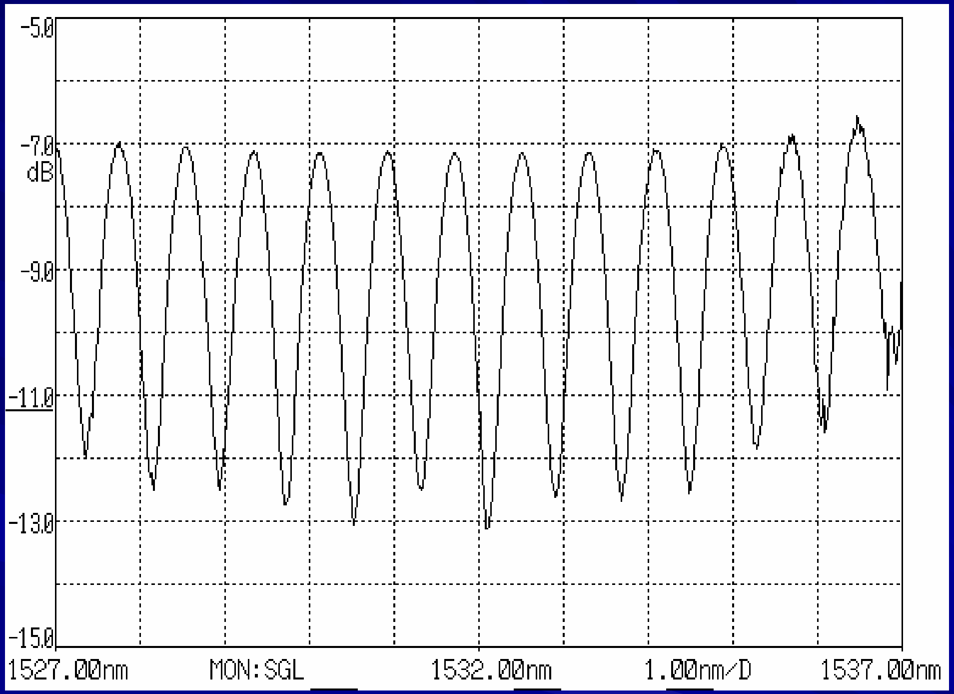


Fig. 1 The reflection spectrum of the Sagnac-Lyot filt

Experimental results and discussions

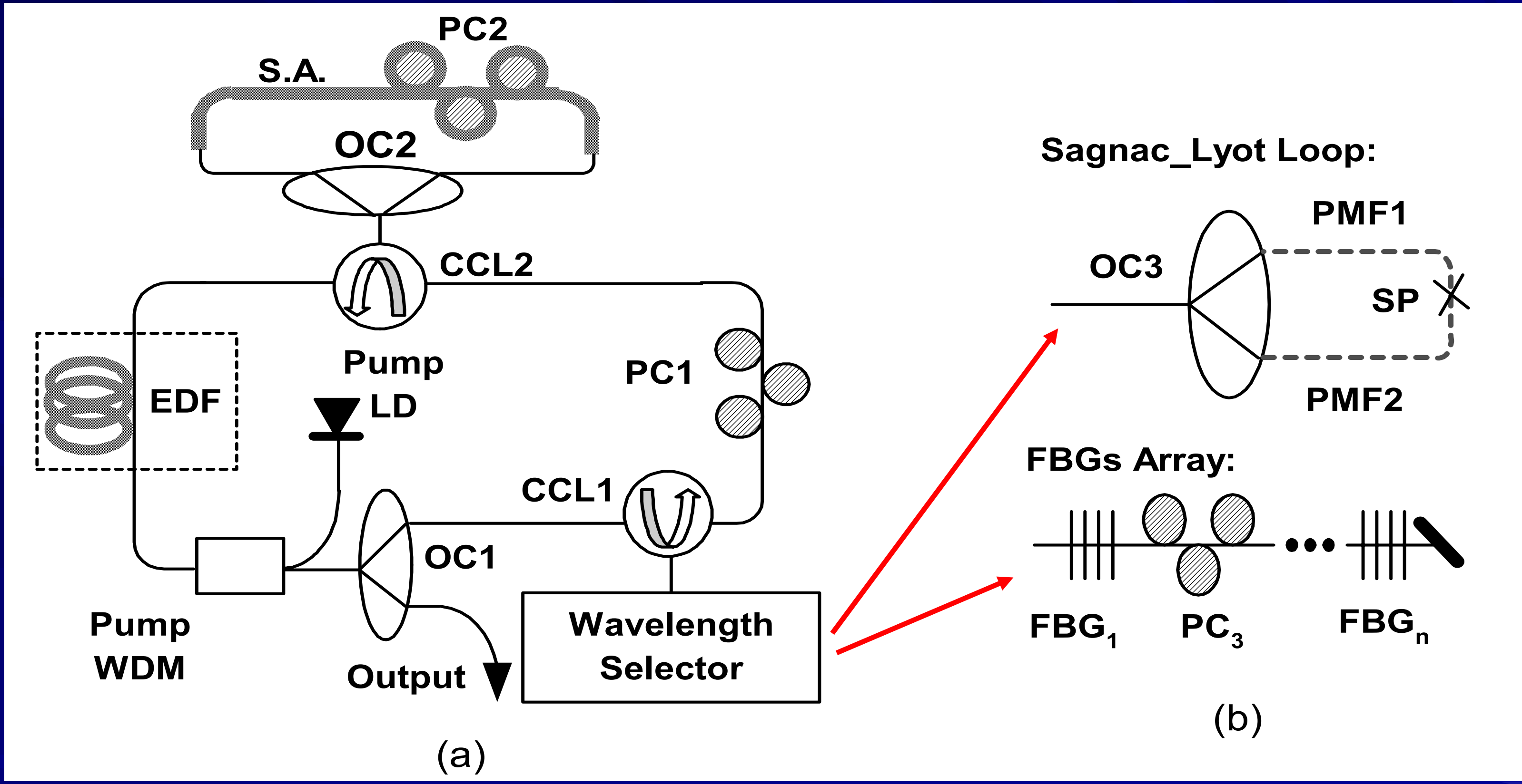


Fig. 2 Configuration of the single longitudinal mode multi-wavelength fiber ring laser.

Experimental results and discussions

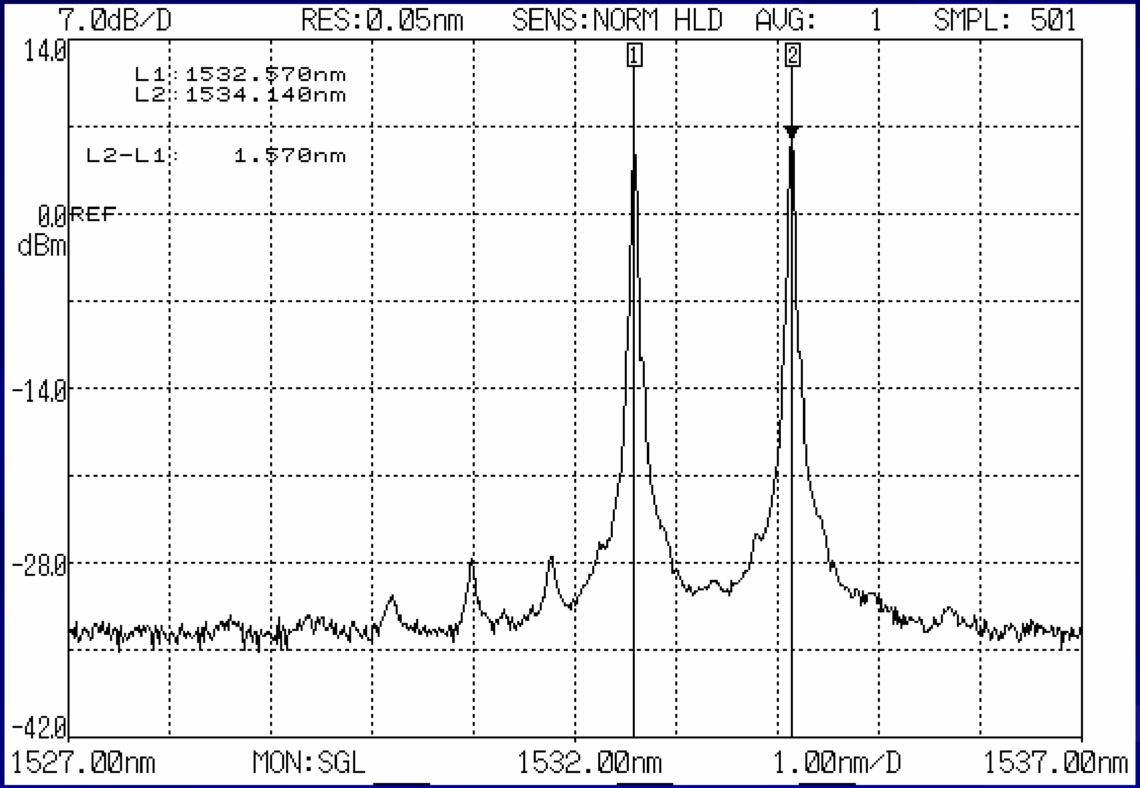
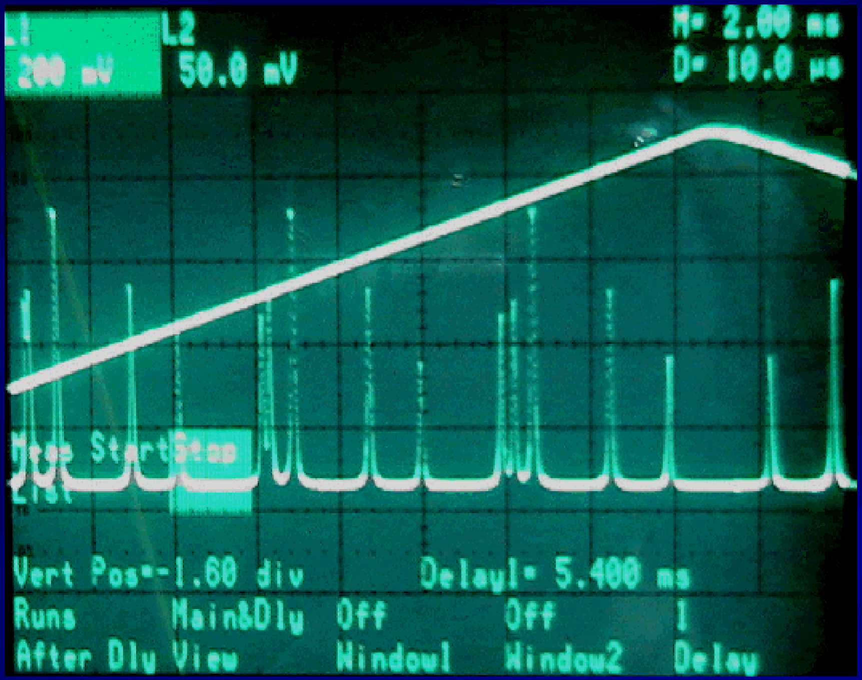


Fig. 3 Optical spectrum of the dual wavelength single longitude mode fiber ring laser.

Experimental results and discussions



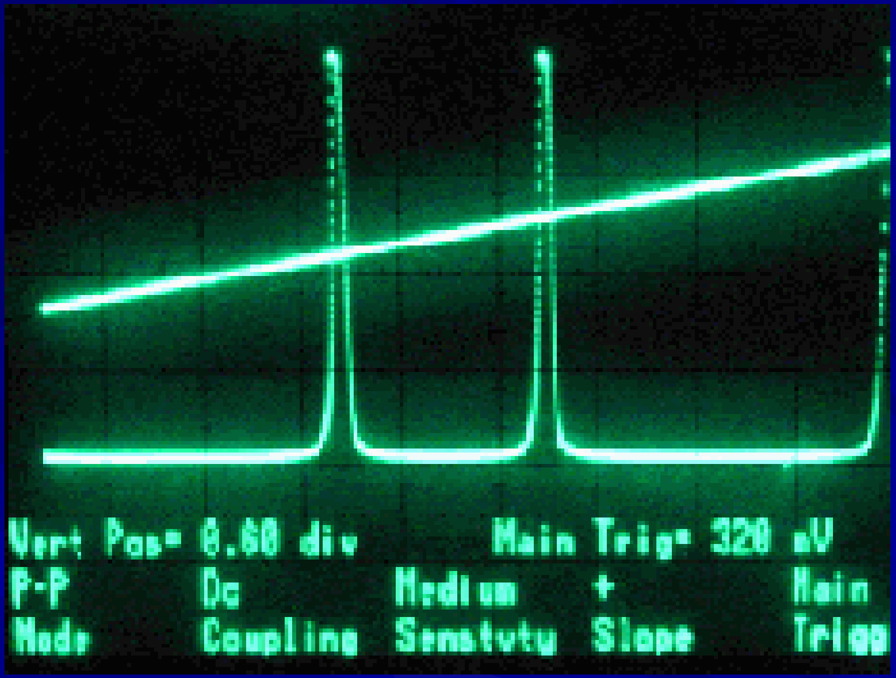
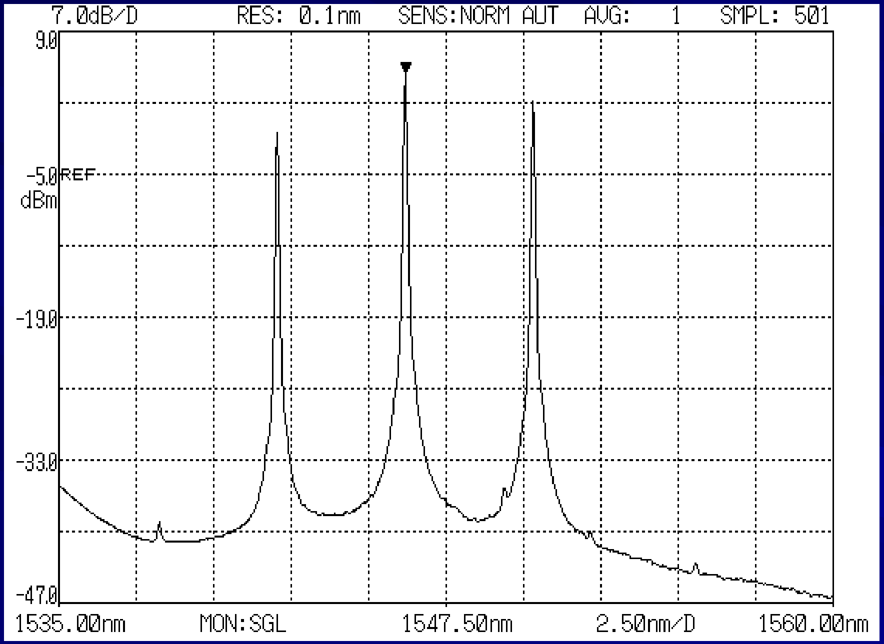


Fig. 5 Mode structure of dual-wavelength SLM fiber ring laser without and with the absorber loop mirror using a laser spectrum analyzer.

Experimental results and discussions



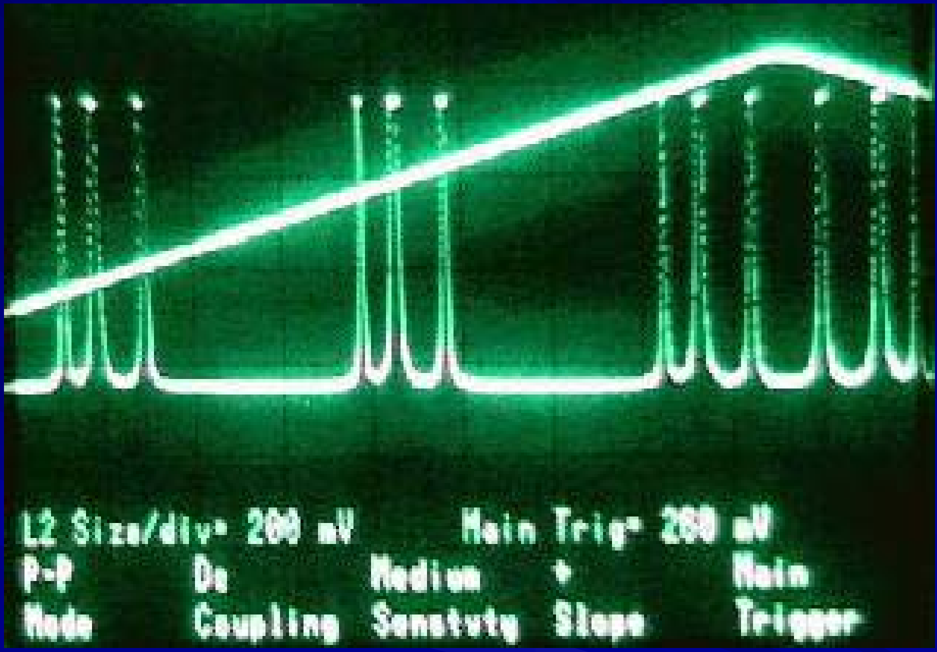


Fig. 6 (a) Optical spectrum and (b) Mode structure of 3-wavelength SLM fiber ring laser with the absorber loop mirror.

Experimental results and discussions

The single longitudinal operation was also demonstrated by beating the two wavelengths generated by the dual-wavelength fiber ring laser.

$$P = |E(t)|^2 = |E_1(t) + E_2(t)|^2$$

$$= P_1 + P_2 + 2\sqrt{P_1 P_2}\cos[2\pi(f_1 - f_2)t + (\varphi_1 - \varphi_2)]$$

An RF signal at 32.4 GHz was generated, which corresponds a wavelength spacing of about 0.25 nm.

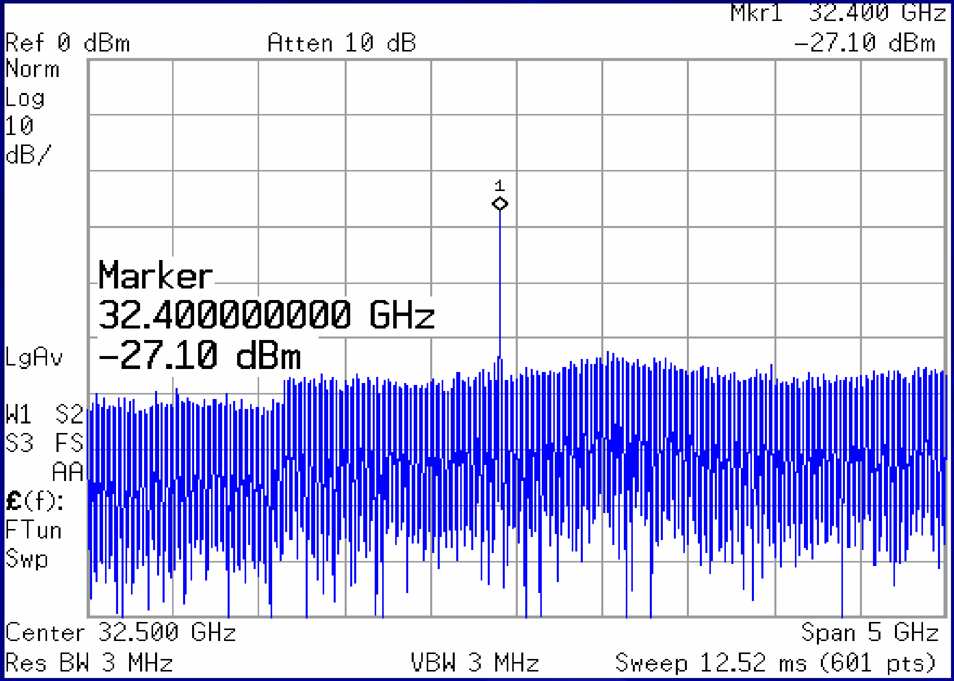


Fig. 7 RF signal generated by beating the two wavelengths at a photodetector.

Conclusion

1. A single-longitudinal-mode multi-wavelength fiber ring laser has been successfully demonstrated.
2. The single-longitudinal-mode operation was realized by using a saturable absorber loop mirror.
3. Multi-wavelength operation was implemented using a Sagnac-Lyot loop or an array a fiber Bragg gratings.
4. Multi-wavelength single-longitudinal-mode lasing was also realized.
5. RF signal by beating two wavelengths were obtained, which further demonstrated that the dual wavelength lasing was single longitudinal.