Demonstration of Semiconductor Microring Resonator Coupled Lasers

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Abstract: A microring-resonator-coupled laser is demonstrated using an EDFA and a GaInAsP-InP microring. Integrated SOA can greatly compensate the high optical loss associated with the microring resonator and reduce the threshold of a microring-resonator-coupled laser.

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Passive ring resonator coupled lasers (RCL) were proposed with potential excellent performance, including high side mode suppression ratio, narrow linewidth and large tuning range [1,2]. InP based RCLs were designed and simulated, showing great promises [3]. Recently, a tunable single mode lasers was demonstrated with a polymer double ring resonator and an erbium-doped fiber amplifier [4]. The GaInAsP-InP microrings were successfully fabricated with moderate loss and a free spectral range of 19 nm near 1550 nm [5]. Integrated semiconductor optical amplifier was integrated with InP-based microrings to compensate the propagation loss and improve the quality factor of the filters [6]. In this report, we use the racetrack-shaped and directionally coupled microring filter described in [6] to demonstrate the ring resonator coupled lasers with erbium-doped fiber amplifier gain.

Fig. 1 shows our experiment setup. We launched the output from an INO 50 EDFA to a polarization controller. The TE signal was coupled into the input port of the microring resonator add-drop filter via a tapered fiber. The signal was picked up by a tapered fiber at the drop port. The coupling was optimized by injecting a laser signal and monitoring the photocurrent at the semiconductor optical amplifier section in the microring. The output from the drop port went to a 1x2 coupler with 10/90 splitting ratio. The 10% port was fed into the input port of the EDFA to form a laser cavity. The 90% port was connected to an optical spectrum analyzer to monitor the output spectrum.

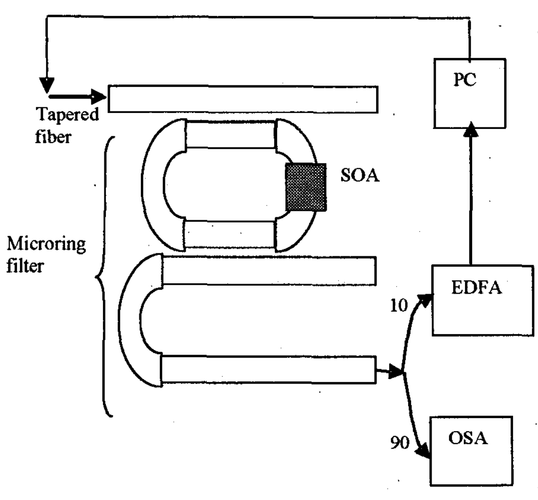

Fig. 1. Schematic of the setup

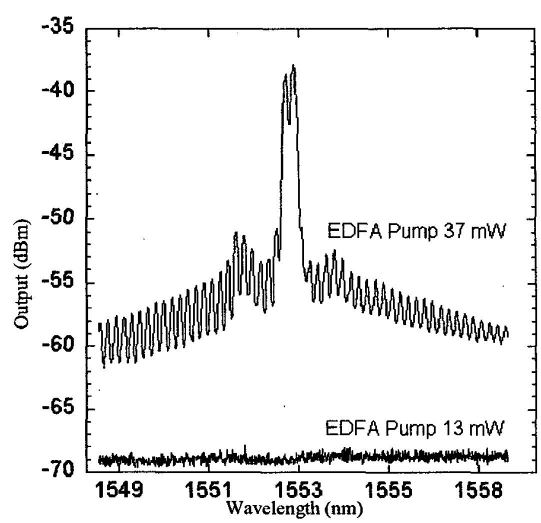

Fig. 2. Output spectrum below and above threshold

Fig. 2 shows the output spectrum when the SOA is biased at 10 mA and the EDFA is pumped at 13 (below threshold) and 37 mW (above threshold) respectively. The bandwidth of the multiple mode lasing is about 0.4 nm due to the mode competition. The single mode operation can be realized in a double ring resonator coupled laser.

Fig. 3 shows the dependence of the output power on EDFA pump and SOA bias current. The SOA is biased under 68 mA, which is the threshold current of the semiconductor microring laser, without the EDFA gain in the setup. The amplified spontaneous emission of the SOA is clear when the bias current is above 40 mA. It can be seen that the threshold pump of EDFA decreases, and external differential efficiency and output power increase with the increasing of the SOA bias current. This is due to the propagation and coupling loss compensation in the ring cavity by the SOA.

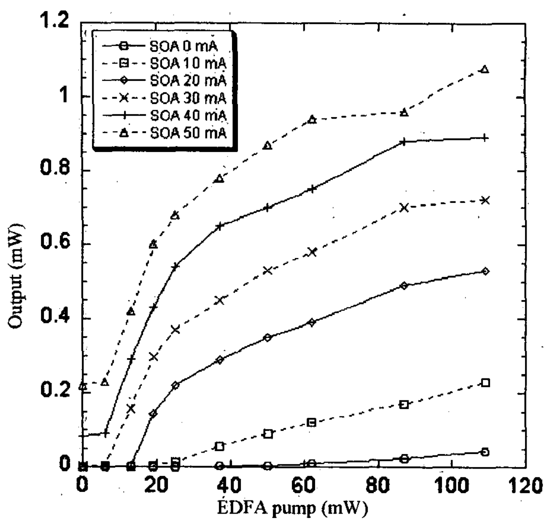

Fig. 3. Dependence of output power on EDFA pump and SOA bias

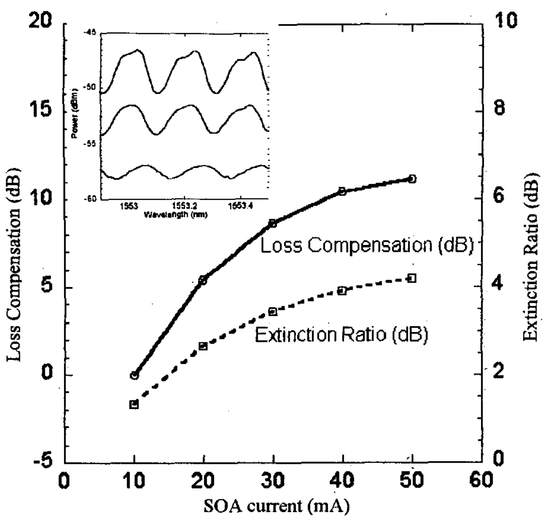

Fig. 4. Transmission and extinction ratio with SOA current

The EDFA source transmission through the ring resonator filter was measured by unplugging the feedback into the EDFA input port. Fig. 4 shows the measured transmission loss compensation (compared to the case of SOA current 10 mA) and the extinction ratio with different SOA bias currents around 1553 nm. It can be seen that both transmission and extinction ratio increase with the bias current, indicating the loss compensation in the ring cavity by SOA. The insert is a zoom-in microring filter transmission around 1553 nm for EDFA source pumped at 87 mW and different SOA bias currents 10, 20, and 50 mA (from the lower to the upper in the figure). The free spectral range of the filter is about 0.2 nm, which is consistent with the lasing mode spacing shown in Fig. 2.

In conclusion, we demonstrated the microring resonator coupled lasers with an EDFA and a GaInAsP-InP microring resonator filter. The integrated SOA can greatly compensate the loss and reduce the threshold of a ring resonator coupled laser.

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