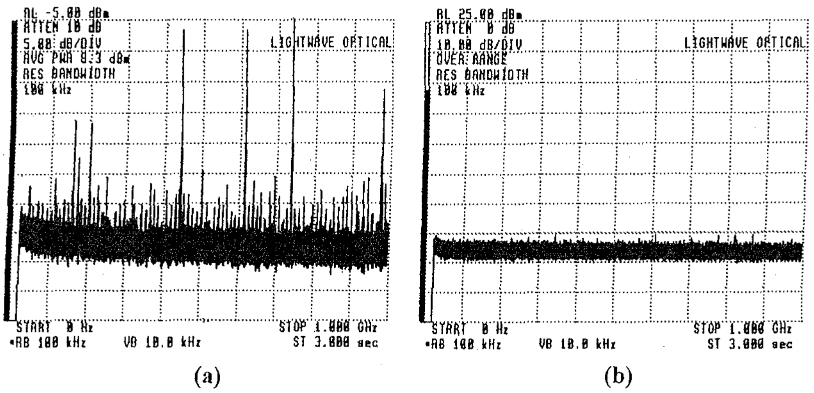
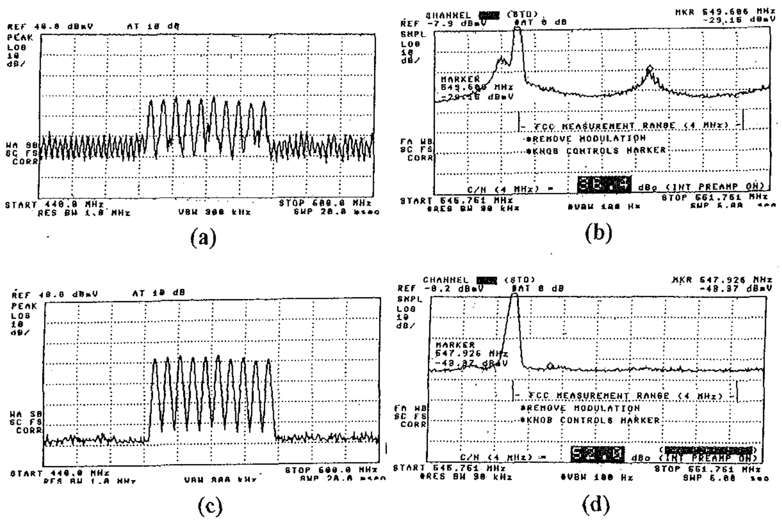


CThO47 Fig. 2. Longitudinal-mode frequencies of the ring resonator measured by a passive homodyne method without (a) and with (b) MRC.



CThO47 Fig. 3. The received rf-output spectra for a 10 NTSC system transmission of full span (a), and the 78th channel at 547.25 MHz (b) with the transmitter without MRC technique and of full span (c), and the 78th channel at 547.25 MHz (d) with the transmitter using MRC operation.

other longitudinal mode frequencies to achieve SLM oscillation.

Figure 1 shows the experimental setup. The fiber laser is mainly composed of a 980-nm-pumped erbium-doped fiber amplifier with 16-dBm power, a fiber Bragg grating with >90% reflectivity at 1533 nm, three monolayer ring cavities, a polarization controller (PC), and a polarization beam splitter (PBS). The fiber grating determines the lasing wavelength. Each subring cavity is composed of a PC and a 50:50 coupler. The lengths of the main and three subring cavities are 72, 5.8, 5.5, and 3.6 m, corresponding to FSRs of 2.8, 35.2, 37.2, and 56.8 MHz, respectively. The MRC effect can be verified by the homodyne method. Figure 2(a) shows the unstable side-mode frequency spectrum of the main cavity without MRC. Figure 2(b) shows that the side-mode frequencies up to 1 GHz can be suppressed while adding MRC. The measured linewidth of this laser is ~2 kHz, measured by using a delayed self-heterodyne method. The output power of this fiber laser is 13.75 dBm at 1533 nm with a side-mode suppression ratio (SMSR) of >51 dB. Finally, this MRC-fiber-laser-based AM video transmitter with 3 dBm output was modulated by 10 NTSC-channel (from 547.25 to 493.25 MHz) signals. Keeping the receiving power at 0 dBm, we measure the carrier-to-noise ratio (CNR) by using an HP8591C spectrum analyzer. Figure 3(a) shows the noisy full-channel spectrum of the transmitter without MRC, and the CNR is ~36.4 dB of channel 78 as shown in Fig. 3(b). Figure 3(c) shows the pure full-channel spectrum of the transmitter after adding MRC, and the CNR is at least 52 dB for all channels in a 2-h operation. The CNR of channel 78 is shown in Fig. 3(d). A VCD player was also used to confirm the transmission quality of this transmitter. The received video picture quality is almost the same as the player output.

In conclusion, we have demonstrated an Er-doped fiber laser, in which the unwanted side-mode frequencies can be removed beyond 1 GHz by the MRC method. The ability of this fiber laser as an AM transmitter source has been verified by the experiment of 10 NTSC-channel transmission with a high CNR of >52 dB and excellent video quality.

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CThO48

Dynamically wavelength-switching, gain-equal, and high-SNR fiber Bragg grating ring lasers

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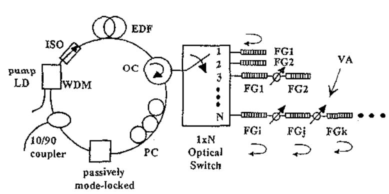
Fiber-ring lasers have some important applications in optical fiber communication. The realization of stable, equal output power and multiple-wavelength lasers in the 1.55-μm band is highly attractive for application in a wavelength-division-multiplexing (WDM) optical communication system.[1,2] Simultaneously dual- or multiwavelength operation has been demonstrated with ~30-dB signal-to-noise ratio (SNR)[3] or with >10 dB output power variation.[4] In this paper, we demonstrate equal-power, dual-wavelength, and dynamically wavelength-switching fiber Bragg grating (FBG) ring lasers. Multiwavelength operation with equal power was also proposed and theoretically discussed in our study.

Figure. 1 shows the proposed multiwavelength, power-equalized ring-laser configuration. It consists of a section of erbium-doped fiber (EDF) with a saturated power of 13 dBm, an optical circulator (OC), and a mechanical optical switch (OSW). A polarization controller was used to optimize the polarization state. All connectors were angled to reduce the backward reflections. The 10/90 coupler served both as output and feedback functions. The isolation and the insertion loss of OC are >50 and 1.2 dB, respectively. The connection loss of OSW is <0.5 dB. Two FBGs provide >90% reflectivity, with 3-dB bandwidth of ~0.25 nm at wavelengths of 1534.0 and 1549.2 nm, were connected to port 1 and port 2 of the OSW,



CThO48 Fig. 1. Experimental setup of the proposed gain-equal multiwavelength ring lasers. EDF: erbium-doped fiber. FG: fiber grating. ISO: optical isolator. OC: optical circulator. PC: polarization controller. VA: microbender as variable attenuator.

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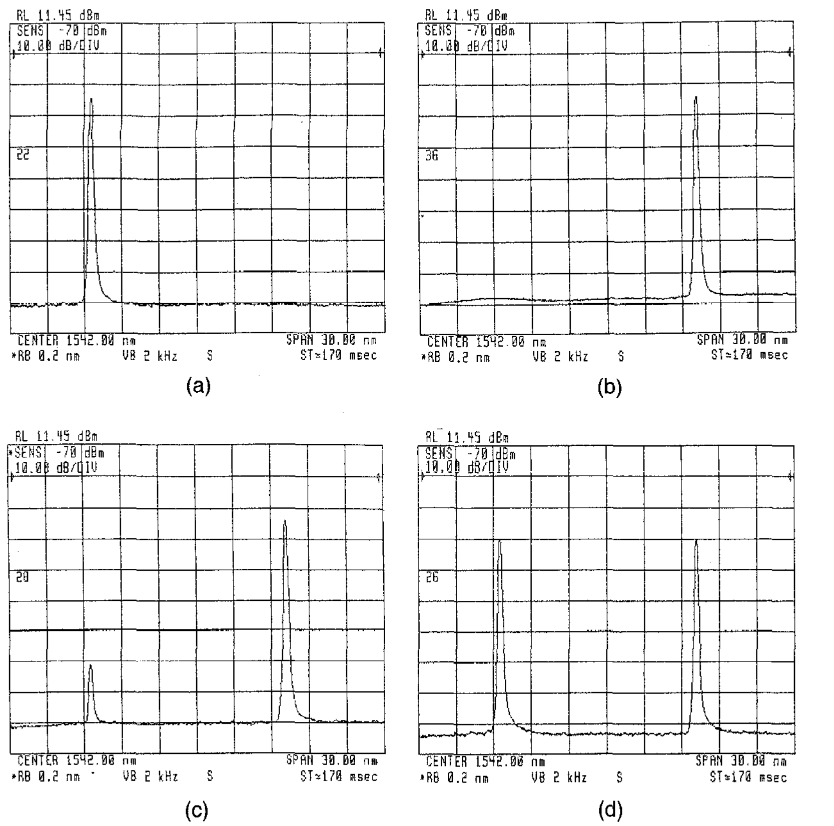
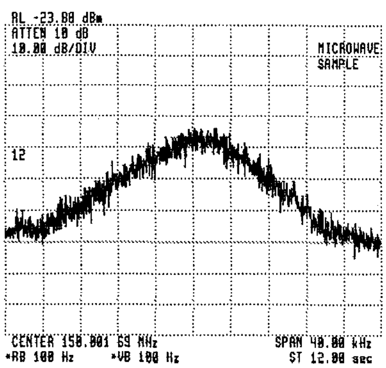


CThO48 Fig. 2. Output spectra of the dynamically wavelength-switching FBG ring lasers. OSW switched to port 1 (a), port 2 (b), or port 3 [(c), (d)], but a microbender for gain-equal control has been inserted in (d).



CThO48 Fig. 3. Measured linewidth of the FBG ring lasers by using a self-heterodyne method.

respectively, whereas another two FBGs with the same reflective wavelengths were cascaded to port 3 of the OSW.

When the OSW was switched to port 1 (FBG a 1534.0 nm) or port 2 (FBG at 1549.2 nm), the output signal was about −3 dBm, as shown in Fig. 2(a) and (b), respectively. The SNRs were as high as 63 dB, which may contribute to a narrow 3-dB bandwidth of FBGs, and most of the unlasing amplified spontaneous emissions (ASEs) several nanometers away from 1534.0/1549.2 nm have passed through the FBG and come out another side. There were two cascaded FBGs with high reflective wavelengths at 1534.0 and 1549.2 nm at port 3. When the OSW was switched to port 3, it was difficult to make more than dual-wavelength lasing simultaneously once the gain was clamped by the cavity loss of only one lasing wavelength. The output signals are shown in Fig. 2(c). A microbender was used to adjust the cavity losses and make the equal effective gain between the two lasing signals, as shown in Fig. 2(d). Both the signal output power and the ASE level were ~3 dB below those of single-wavelength operation. The SNRs were still as high as 63 dB. By using a passive mode-locked method to suppress the side modes and facilitate single-mode operation, the ring-laser linewidth was estimated to be <2 kHz, as shown in Fig. 3. The OSW was switched to port N, where several cascading FBGs with high reflectivity at different central wavelengths and several microbenders as variable attenuators were inserted between FBGs. The wavelengths of the corresponding FBGs with less cavity lasing gain were located at the left-hand side of the others, and so on. Although FBGs for lasing at other than 1534.0 and 1549.2 nm were not available in this experiment, the result obtained in the dual-wavelength operation case has clearly demonstrated the feasibility of simultaneously multiwavelength (say, 8 wavelengths) operation. The output power was calculated to be −12 dBm/ch., i.e., 9 dB below that of single-wavelength operation. This proposed gain-equal laser array is more cost-effective than that described in Ref. 5.

In summary, we have demonstrated a dynamically switching, equal-power, high-SNR (63 dB), narrow-linewidth (<2 KHz) ring lasers. The wavelengths can be precisely and dynamically selected by using an OSW and FBGs with different reflective wavelengths. Equal-power dual wavelengths could be easily achieved by inserting a microbender between these two FBGs to adjust the cavity loss of the wavelengths. In addition, a comb generator from which eight wavelengths could be produced simultaneously was theoretically calculated and proposed. The gain-equalized laser sources find potential applications in WDM transmission systems.

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CThO49

Passively mode-locked fiber laser with dispersion-imbalanced nonlinear loop mirrors

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Generation of ultrashort pulses is important as a potential source for high-speed time-division multiplexing (TDM) telecommunication. Duling[1] demonstrated the first passively mode-locked fiber laser using asymmetric elements of the nonlinear amplifying loop mirror (NALM). Later researchers use the nonlinear optical loop mirror (NOLM) to construct a passively mode-locked laser.[2] They use an unbalanced phase between two counterclockwise beams in the loop by an asymmetrically placed gain element and by an asymmetric fiber coupler, respectively, which produce nonlinear phase differences between clockwise and counterclockwise beams. In this paper, we propose a new laser scheme of passive mode locking where the nonlinear phase difference achieves nonreciprocal asymmetric imbalance of dispersion in a loop mirror. The dispersion-imbalanced nonlinear loop mirror (DINLM) is constructed with one segment of high anomalous dispersion and another segment of much lower dispersion. The pulses in clockwise direction disperse quickly and then remain broad in the second segment; on the other hand, pulses in counterclockwise direction remain short for the entire first segment and thus obtain a large amount of nonlinear phase shift. Recently, DINLM has been demonstrated as a nonlinear switch for optical pulse.[3]