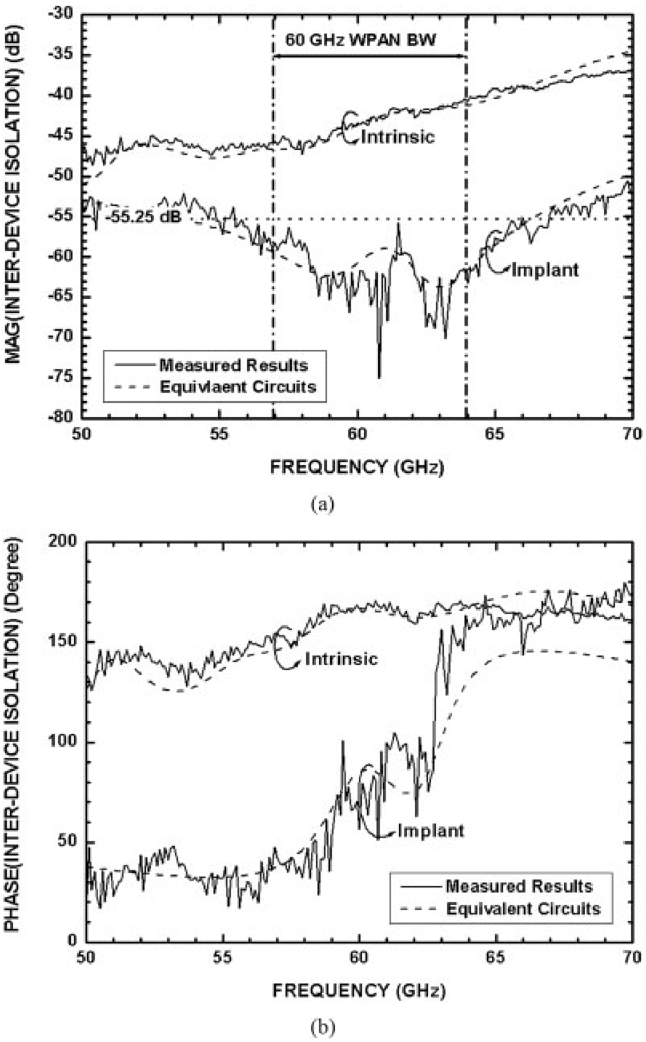

Figure 4 The measured results and equivalent circuit results of (a) the magnitude and (b) phase of the interdevice isolation levels

circuit of the implant has higher inductances and resistances and lower capacitances than those of the others. In Figure 4, the measured results agree with the data obtained by the equivalent circuits.

From these results, in the case of the implant with $S = 200\ \mu$m, the interdevice isolation levels is less than -55.25 dB at 10^{-4} BER in 60-GHz WPAN BW. Therefore, the feasibility of the implant isolation technique has confirmed to apply the 60-GHz WPAN SoC having better interdevice isolation and keeping fabrication advantages.

4. CONCLUSIONS

Using InP substrate, we have studied the interdevice isolation characteristics for 60-GHz WPAN SoCs applications and have found the feasibility of implant for high interdevice isolation levels in mm-wave frequencies. Based on the proposals in IEEE 802.15 WPAN task group 3c, we have calculated the proper interdevice isolation levels. In the case of LOS cases of CM1, CM3, and CM5 scenarios with 5-m communication range, the interdevice isolation levels have to maintain less than -55.25 dB at 10^{-4} BER for high rates OFDM systems of 60-GHz WPAN in frequency rage from 57 to 64 GHz. From measurement results, in the case of the implant with 20 μm $\times$ 1 μm implant area and 200-μm distances between measurement pads, the interdevice isolation levels is less than -55.25 dB in 60-GHz WPAN BW. The equivalent circuits of the intrinsic, the trench, and the implant, derived from the measured results. The measured results agree with the fitted data obtained by equivalent circuits. Consequently, we have confirmed the feasibility of the implant isolation technique to be applicable to secure the receiver sensitivity in the mm-wave SoC. Also, these results can be useful to design and fabrication of mm-wave SoCs for 60-GHz WPAN as the basic data.

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LINEAR OPTICAL AMPLIFIER-BASED SEMICONDUCTOR FIBER RING LASER WITH 93-NM TUNING RANGE

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ABSTRACT: *We propose a simple configuration of a traveling wave tunable semiconductor fiber ring laser. The proposed laser can be tuned over 93 nm with an output power of 1.3 dBm using a thin film fiber Fabry Pérot filter.* © 2008 Wiley Periodicals, Inc. Microwave Opt Technol Lett 50: 1702–1704, 2008; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.23469

Key words: *fiber ring laser; linear optical amplifier*

1. INTRODUCTION

Fiber ring laser has a ring structure whereby some of the output light is fed back to its input. The gain media in a ring laser can be provided by a section of excited rare-earth ions doped fiber or a current-driven semiconductor optical amplifier (SOA) or a combination of both. Different rare-earth ions, such as erbium, neodymium, ytterbium, and lanthanum can be used to realize FRLs capable of operating over a wide wavelength range. For optical fiber communication systems, semiconductor fiber ring lasers (SFRLs) and erbium-doped fiber ring lasers (EDFRLs) are of interest because they operate in the 1.55-μm spectral region, which coincides with the low-loss region of silica fibers. However, it is to be noted that the SFRL can be realized both at 1.3- or 1.55-μm wavelength regimes due to the availability of SOAs at these wavelengths. Chawki et al., demonstrated the first all fiber tunable semiconductor ring laser working at 1550-nm regime [1]. Broad tuning over 50 nm was electronically achieved by using a fiber Fabry Pérot filter as a wavelength selective element. Single wavelength operation was demonstrated with a side mode suppression ratio (SMSR) higher than 35 dB. However, the scheme suffers from ~12-dB coupling loss at the facets of the semiconductor amplifier. A FRL that includes a semiconductor near-traveling wave amplifier at 1300 nm tuned by an intracavity electrooptic birefringent filter was proposed by Porte et al., [2] demonstrated. The tuning range thus obtained was 20 nm and the tuning rate was 0.05 nm/V. The measured output power is improved by use of an intracavity polarization element. The fiber configuration improves the stability of the laser compared with previous extended-cavity lasers with an external mirror. The major drawback of this scheme is the small reflectivity from the facet of the amplifier chip, yielding a multimode lasing emission and wavelength tuning by mode hopping. Zhou et al., [3] also demonstrated wavelength tunable semiconductor laser oscillation at 1300-nm regime. The laser was capable of tuning over the 28-nm width of the gain medium. The combination of the linear polarizer, polarization controllers, highly birefringent components such as PM fibers, and the polarization-dependent gain medium such as SOA provided the wavelength selective mechanism. Different wavelengths have different losses due to the polarization-dependent loss through the linear polarizer. A wavelength with its electrical field vector lined up with the linear polarizer experienced the least loss. Hence, the combination of a polarization controller and linear polarizer provided a wavelength selection mechanism to generate a tunable laser output. A composite cavity semiconductor FRL was proposed by Hu et al., [4]. A passive subring cavity with the same length as the main ring cavity was added to maximize the longitudinal-mode frequency separation as a vernier configuration. Increasing the frequency separation improved the stability of the laser system. Tuning over a range of 20 nm from 1291 to 1311 nm was achieved by applying voltage (0- to 30-V DC) to the piezoelectric transducer (PZT) placed in the subring cavity.

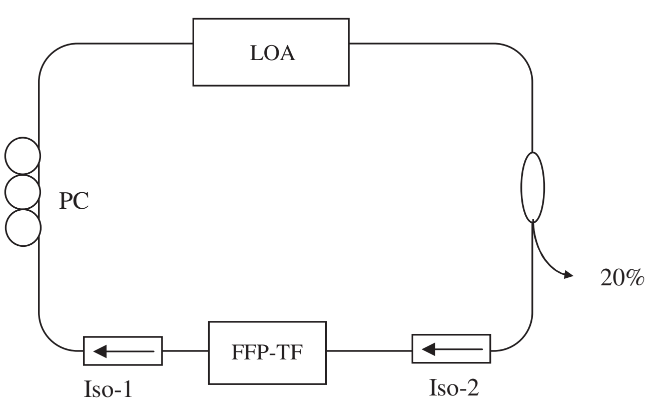

Figure 1 Experimental setup of tunable semiconductor fiber ring laser. LOA, linear optical amplifier; FFP-TF, fiber fabry pérot-tunable filter; PC, polarization controller; Iso, isolator

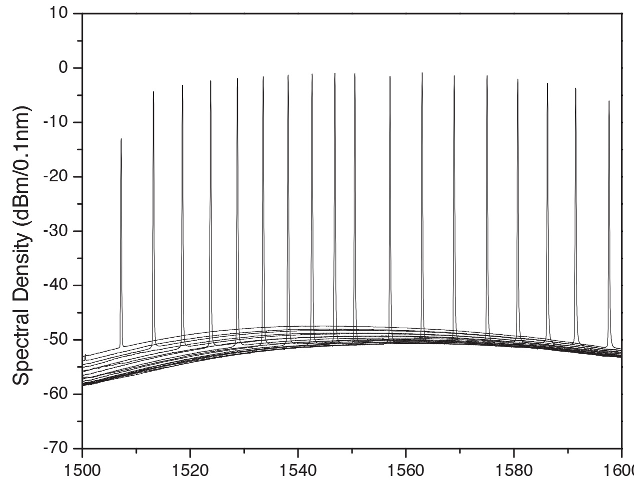

Figure 2 Superimposed laser spectra (resolution of optical spectrum analyzer = 0.1 nm)

In this letter we propose and demonstrate a widely tunable single frequency SFRL. The laser is constructed utilizing a linear optical amplifier (LOA) introduced by the Finisar Corporation [5].

2. EXPERIMENTAL SETUP

The configuration of a traveling wave tunable SFRL constructed with an LOA is shown in Figure 1. The ring consists of an LOA, polarization controller (PC), 20% fused fiber coupler, two polarization independent isolators, and a fiber Fabry Pérot tunable filter (FFP-TF). The polarization controller is used to control the state of polarization in the laser cavity and to maximize the signal to noise ratio (SNR). Two isolators are used in the cavity to avoid reflections from the input and output ends of FFP-TF to the LOA and also to ensure the unidirectional operation of the ring cavity. A broad free spectral range (FSR), FFP-TF from the Micron optics Corporation is employed to tune the feedback lasing wavelength over a very broad range.

3. EXPERIMENTAL RESULTS AND DISCUSSIONS

By varying the voltage applied to the FFP-TF, the laser was tuned over 90 nm. The operable temperature range of FFP-TF is from −20 to +80°C and its tuning Voltage/FSR is from (0–16) Volts. The optical three-bandwidth of this filter is 30 pm (3.75 GHz) and its FSR is around 102 nm, hence the Finesse of the FFP-TF is 3400. The insertion loss at the peak of its pass-band is about 2.2 dB. The LOA is introduced in the cavity to provide the optical gain. The LOA is a metal-organic chemical vapor deposition (MOCVD) grown InP-based semiconductor device that integrates an active waveguide and a vertical-cavity surface-emitting laser (VCSEL) on the same chip. The VCSEL has been elongated to coincide with the active waveguide along its entire length. The LOA was pumped with a biasing current of 140 mA. Figure 2 shows the output spectra of the FRL obtained from the 20% taper, which was measured with an optical spectrum analyzer (OSA)

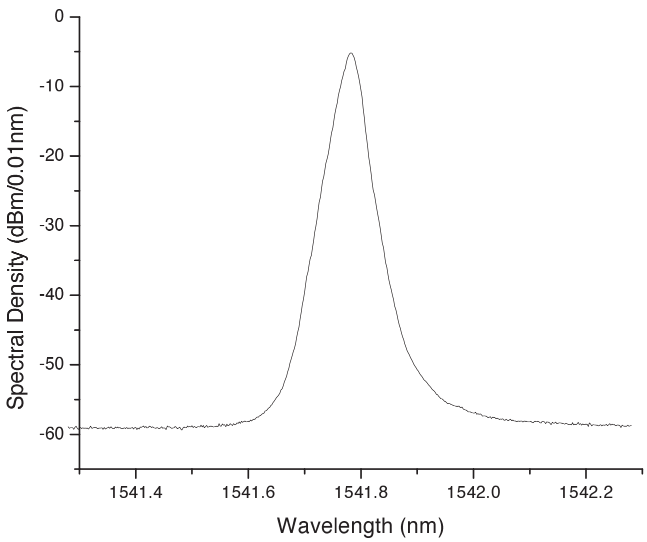

Figure 3 Output spectrum of the tunable laser tuned at 1541.8 nm (resolution of optical spectrum analyzer = 0.01 nm)

with a resolution of 0.1 nm. By tuning the pass-band of the FFP-TF, the laser wavelength was tuned from 1507 to 1600 nm, exhibiting a broad tuning range of 93 nm. Figure 2 also reveals that over the wavelength range from 1525 to 1595 nm, the extinction ratio is over 45 dB and the average output power is greater than −2 dBm. However, outside this range, both the output power and the extinction ratio were reduced due to the smaller gain provided by the LOA. The total output power of this laser is 1.3 dBm. The extinction ratio and the output power can be further improved by increasing the biasing current applied to the LOA. It is worth noting that the ASE level in the output spectra increases when the lasing wavelength is tuned away from the wavelength range where the LOA provides higher flat optical gain. A typical lasing spectrum was measured by an OSA using 0.01-nm resolution and is shown in Figure 3. The asymmetric shape of the laser is mainly caused by the response of OSA. The laser at 1541.80 nm has a 3-dB bandwidth of around 0.022 nm, limited by the resolution of OSA. Figure 4 shows the output power versus the lasing wavelengths at the output of the laser. The average output power of each

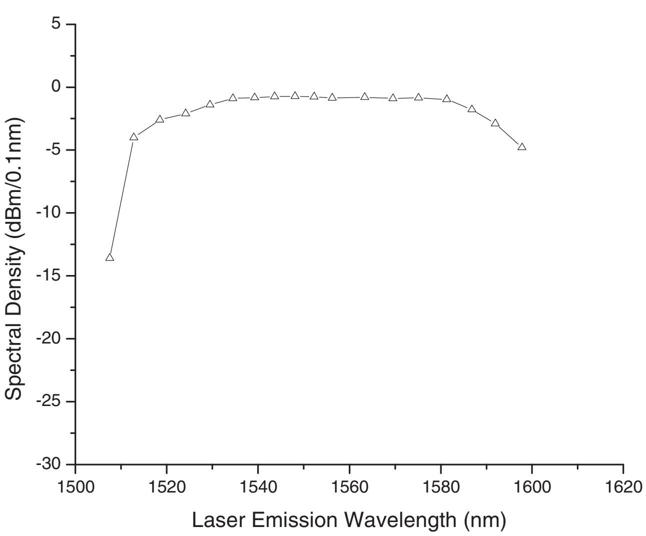

Figure 4 Output laser powers at different wavelengths

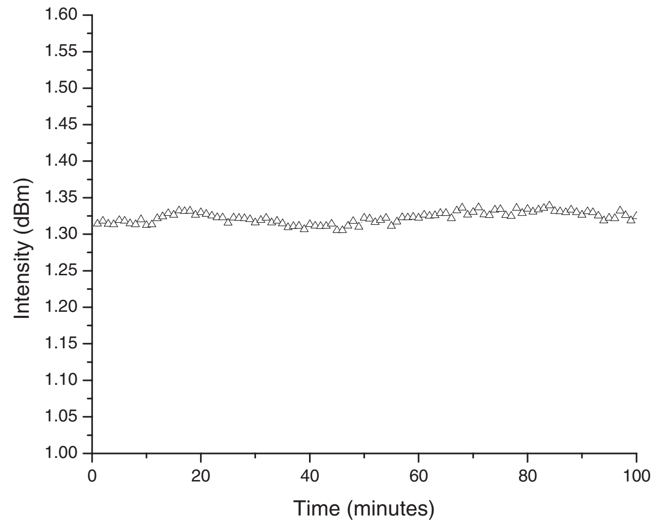

Figure 5 Power variations of the fiber ring laser over a period of 100 min

lasing line is very flat over the entire range. An important parameter that determines the performance of the laser is the output power stability. Figure 5 shows the measured total power fluctuation of the fiber laser when its output was maintained at one lasing wavelength for a period of 1 h and 40 min. The wavelength under test was 1545.8 nm. The power fluctuation was less than 0.05 dB, confirming the stability of the laser source. It is worth noting that the experiment was conducted under a laboratory environment and no precautions were taken to isolate the setup from thermal and vibration perturbations. Therefore, even better stability is expected if the short-cavity fiber ring laser is properly packaged.

4. CONCLUSION

We have experimentally demonstrated widely tunable SFRL employing LOA. The laser could be tuned over 93 nm with an output power of 1.3 dB. The power fluctuation was within 0.05 dB.

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