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Integrated Long Cavity Mode Locked Ring Laser

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Abstract: We report an integrated 30 mm long cavity mode locked ring laser at 1555 nm, with a low repetition rate at 2.7 GHz. The device uses InP-based active-passive integration technology and integrated multimode interference reflectors. Passive (PML) and hybrid mode locked (HML) operation are experimentally demonstrated, with picosecond pulses of 4.65 ps and 4.23 ps pulse-widths respectively. The device exhibits a very narrow RF linewidth of the beat note of few KHz.

Introduction: There are different techniques for generating radiofrequencies. Photonic techniques have a number of advantages over electronic, among which is the possibility of using fiber optics to transport signal with very low propagation loss. Furthermore, photonic techniques have additional advantages such as the quality of the signal generated (low phase noise), the tuning range of the generated frequency and bandwidth modulation [1]. Photonic signal generation techniques are based on optical heterodyning (Dual Wavelength Laser Source), or pulsed lasers (Mode-Locked Laser Source). Each of the techniques has its own quality features and tuning range [2]. The main advantage of the solution provided by the pulsed lasers is that they offer stable signal generation, directly producing a frequency comb. There are extensive references on integrated mode locking lasers [3]. However, few solutions operating within the frequency range of our interest (10 MHz to 14 GHz). The most recent reference is a mode-locked extended cavity in a ring configuration with a repetition rate of 2.5 GHz. The length cavity is 33 mm and the area is 4 mm^2 [4]. One way to lower the repetition rate is increasing the length of the cavity. However, due to the propagation loss in the InP, they must be performed by hybrid integration. An example is presented in[5], whose cavity length is 9 cm. The use of photonic integration technologies circuits implementing optical signal sources to improve the quality of the signal generated. Also reduces system size. We aim to develop photonic integrated circuits (PICs) for the generation and distribution of frequency standards and calibration signals of very high quality by photonic techniques.

Design of device: We have designed a chip with multiple devices mode-locked. The PIC was designed using standardized building blocks and fabricated within a commercial MPW run through an InP active-passive integration foundry service. The mask manufacturing carried shown in figure 1, where we have the ring structure.

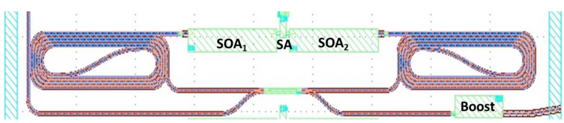

Fig. 13. Layout of the photonic integrated circuit .

The ring laser has a cavity length of 30 mm, corresponding to a frequency spacing of 2.7 GHz. It has two 750 μm semiconductor optical amplifier (SOA) with intermediate 50 μm saturable absorber (SA). At both ends of the SOA, we designed a waveguide passive, whose length is generated by a spiral-shaped structure ("snail"). Both guides on each side of the amplifiers are joined through a 2x2 MMI coupler, forming a ring. At the outputs, we place a Mach Zehnder modulator or another SOA (booster), for modulate the signal inside of the cavity.

Experimental results: The results of this device, both mode-locked regime passive (PML) and hybrid (HML) are presented in figure 2 and figure 3. Electrical spectra are generated frequency combs, where the fundamental harmonic appears repetition frequency (2.7 GHz), with higher harmonics. The fundamental harmonic appears in detail being clearly hybrid mode in which the device is more stable. The device exhibits a very narrow RF linewidth of the beat note (11.52 and 5.43 KHz @-3dB, for PML and HML, respectively).

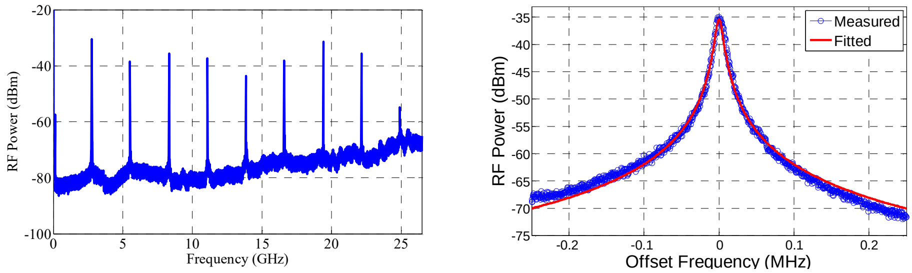

Fig. 2. PML: Electrical spectrum, Isoa = 115 mA, Iboost = 10 mA, Vsa = -2.28 V .

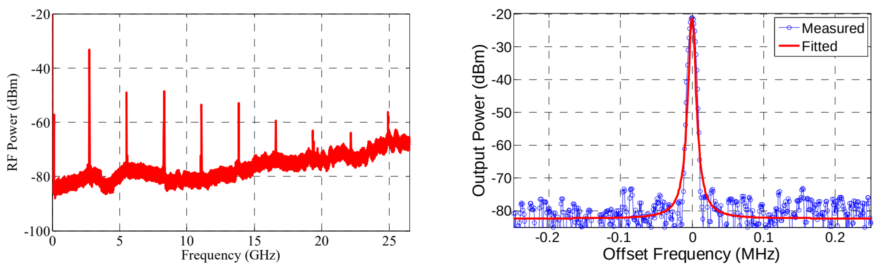

Fig. 3. HML: Electrical spectrum, Isoa = 115 mA, Iboost = 10 mA, Vsa = -2.28 V .

References

[1] G. Carpintero et al, "Photonic Integrated Circuits for Radio-frequency signal generation", Journal of Lightwave Technology, VOL.34, No. 2, pp. 508-515, 2016.

[2] T. Nagatsuma and G. Carpintero, "Recent progress and Future Prospect of Photonics-Enabled Terahertz Communication Research", IEICE Trans. Electron., VOL.E98-C, No. 12, pp. 1060-1070, 2015.

[3] K A Williams et al, "Long-wavelength monolithic mode-locked diode lasers", New Journal of Physics 6 (2004) 179.

[4] S. Latkowski, et al, "Monolithically integrated 2.5 GHz extended cavity mode-locked ring laser with intracavity phase modulators", OPTICS LETTERS, Vol. 40, no. 1, pp.77-80, January 1, 2015.

[5] Martijn J.R. Heck et al, "Ultra-Long Cavity Hybrid Silicon Mode-locked Laser Diode Operating at 930 MHz", Conference OFC.2010, OMI5, Marzo, 2010.