Dual-Wavelength AWG based Lasers for Narrow Linewidth Heterodyne Beat-Note Generation

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Abstract: Multi-wavelength laser sources based on Arrayed waveguide grating have been shown in order to provide simultaneously multiples wavelengths with a narrow optical linewidth. Two different laser structures have been developed for the millimeter wave signal generation, monolithically integrated using photonic integrated circuits. In this work we report the characteristics of the heterodyne signal in the millimeter wave range. The optical linewidth measured from the modes generated by different channels on each structure can become less than 150 KHz.

Introduction: Millimeter-wave (MMW) frequencies (30 GHz - 300 GHz) have attracted a great interest from industries involved in the development of broadband wireless communication systems because they can provide short range communications with data rates above 1 Gbp/s[1, 2]. Dual wavelength laser sources are useful devices for the generation of high frequency electrical signals over a very wide-range from MHz up to terahertz using heterodyne mixing on a photodiode or another type of opto-electronic transducer. As the beat-note is insensitive to dispersion in optical fiber, it is possible to carry this signal over a long single mode fiber length with very low signal power degradation[3]. The devices presented in this paper were developed within the European Union FP7 iPHOS project to implement an optical technique to generate millimeter waves. The idea is to create 100 GHz and 120 GHz carrier waves with a narrow optical linewidth from each structure. The work described in this paper analyzes to AWG sources, from the point of view of the linewidth of the optical modes, which at the end, determine the electrical beat-note linewidth.

Dual wavelength AWG based lasers (AWGLs): The first device that we studies is an extended cavity laser, based on an array of semiconductor optical amplifiers (SOA) and an AWG. As shown in Fig. 1 (on the right side), the device tested consists of sixteen separated SOAs, one per channel, labeled Channel N (with N = 1 to 16). An additional SOA is located at AWG's common output waveguide arm, to boost the output optical power of the outgoing light. All the SOAs used for the channel waveguide selection are 600 µm long. The length of the Boost SOA is 750 µm. The AWG acts as an intra-cavity filter, to establish the lasing wavelengths by filtering the modes in the laser cavity formed between the cleaved facets of the chip. The AWG central wavelength is $\lambda = 1550$ nm, the channel spacing $\Delta\lambda = 100$ GHz (0.8 nm) and the free spectral range (FSR) is 900 GHz (7.2 nm).

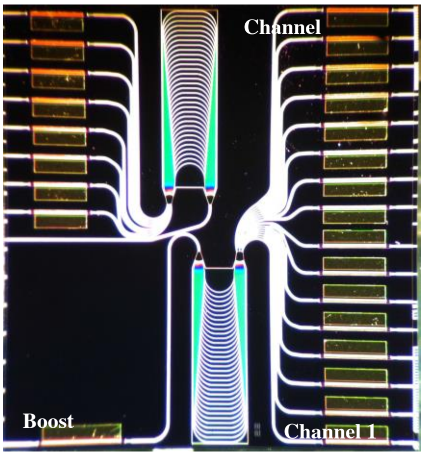

Fig. 1: Monolithically integrated AWG multi-wavelength laser

The second device is the same type of structure, based on an AWG, with 4 input channels and one common output (CO). The main difference is that MMI reflectors are used instead of the chip facets to define the mirrors of the AWG laser, thus producing a fully monolithic device. The dual wavelength output from the CO can now be modulated or processed within the chip, as shown in Fig. 2. In our chip, we placed a Boost SOA to increase the dual mode optical power. Also, the MMI reflectors allow us to reduce the FP cavity length of the laser, increasing the longitudinal mode spacing among the FP cavity modes. An anti-reflective (AR) coating was placed at the cleaved facets to improve the performance of the chip. The AWG designed has a channel spacing (Δλ) and free spectral range are 0.961 nm (120 GHz) and 5.61 nm (700 GHz), respectively. All the SOAs used both for the channel selection and the common output are 400 μm long. The lengths of the EOPMs are 1000 μm.

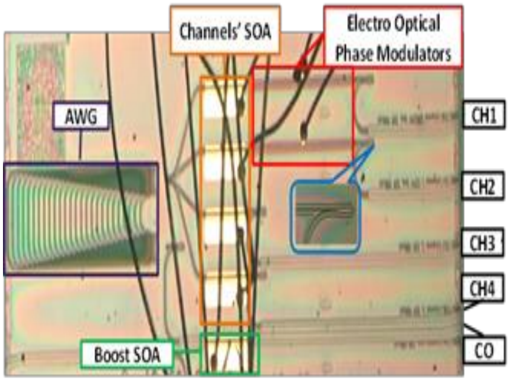

Fig. 2: AWG based laser source using MMI reflectors mirrors.

Linewidth measurements: In order to obtain a single channel emission for both AWG based lasers, the current injected on each separated SOA channel was chosen to achieve single mode operation on the central FSR order, while setting a constant current on the Boost SOA. We obtained the single mode operation for each channel with a side-mode suppression ratio better than 30 dB. We have measured the optical linewidth of the AWG based lasers emission using a self-heterodyne measurement setup, with an optical isolator (OI), an 11 GHz fibered electro-optical phase modulator (EOPM) and a length of 6.8 km of single mode optical fiber between the two arms of the interferometer, as shown in Fig. 3. A polarizer (PC) is included in order to obtain matching of the polarization of light coming from the two arms of the interferometer maximizing the signal at the photo-detector. The beat-note at 11 GHz is sent to an electrical spectrum analyzer (ESA). The -3 dB linewidth of each of the two channels of the AWGLs are evaluated by measuring the beat note spectrum centered at 11 GHz. The red traces in Fig. 4 show the experimental results both for the AWGL1 (Channel 8 and Boost SOA are biased at 38 mA and 50 mA, respectively), and the AWGL2 (Channel 2 and Boost SOA are biased at 60 mA and 30 mA, respectively). The linewidth are extracted assuming a Lorentzian shape, shown as the blue traces in Fig. 4, and the optical -3 dB linewidth is then assumed to be half the -3 dB linewidth of the electrical signal. The optical linewidth measured on both channels give as result 109 KHz and 64 KHz both AWGL1 and AWGL2, respectively. The optical linewidth is below the best figures reported for a dual wavelength source based on two 2,500 μm long DFB lasers and a combiner[3].

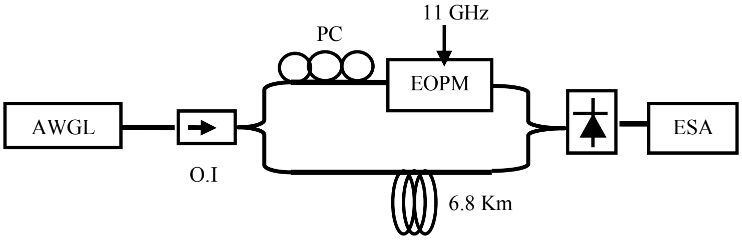

Fig. 3: Optical self-heterodyne linewidth measurement system.

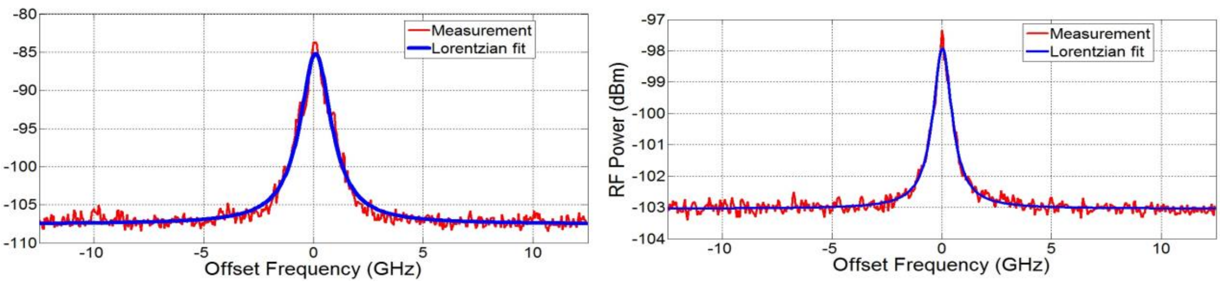

Fig. 4: Optical self-heterodyne linewidth measurement setup both for AWGL1(at the left side, Channel 8 and Boost SOA are biased at 38 mA and 50 mA, respectively (red) and Lorentzian fit (blue)) and AWGL2 (at the right side, Channel 2 and Boost SOA are biased at 60 mA and 30 mA, respectively (red) and Lorentzian fit (blue)).

References

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