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Widely tunable laser source operating at 2µm realized as monolithic InP photonic integrated circuit

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Session ID, 2-17: Widely tunable laser source operating at 2µm realized as monolithic InP photonic integrated circuit

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Abstract: A tunable laser operating from 2011 – 2042 nm realized as a monolithic InP photonic integrated circuit and fabricated within a multi project wafer run is presented. The laser is tuned using an intracavity filter based on nested asymmetric Mach-Zehnder interferometers with electro-refractive modulators. The device is intended for a single line gas spectroscopy and was designed and realized using a generic integration technology.

1. Introduction

The generic photonic integration technology platforms [1] provide application oriented specialists with means of design and fabrication of application specific photonic integrated circuits (ASPIC) at relatively low cost. The main factor defining the scope of potential applications results from the range of accessible wavelengths. For most of the platforms these are guaranteed at the wavelengths covering the telecom C-band around 1.55µm. Should other wavelength bands become available by such integration technology, it would become attractive for a wider field of applications. In particular the area of gas spectroscopy would benefit if the mid-infrared wavelengths at around 2µm become accessible due to the presence of stronger absorption profiles of several gas species. It has been demonstrated that such wavelengths can be generated and amplified using InP based strained quantum well [2]. A development towards implementation of such functionality using strained quantum wells into the COBRA active – passive integration technology platform was undertaken [3].

A tunable laser realized on a monolithic, indium phosphide (InP) photonic integrated circuit (PIC) operating at wavelengths range around 2027 nm is presented. For the wavelength tuning an intra-cavity filter based on nested asymmetric Mach-Zehnder interferometers (AMZI) with electro-refractive modulators (ERM) is implemented [4,5]. This enables a single mode operation of the laser and in combination with the gain bandwidth of the strained quantum well based layer-stack [3] provides a record tuning range of 31 nm.

2. Monolithic photonic integrated circuit

The ring laser cavity has an average physical length of 9 mm and its topology is shown in Figure 1(a). The cavity consists of several basic building blocks connected with deeply etched passive waveguides. The optical gain is provided by a 4 mm long semiconductor optical amplifier (SOA). The wavelength tunable filter inside the laser cavity is a nested configuration of asymmetric Mach-Zehnder interferometers (AMZI). The AMZI stages are formed by passive waveguides and multimode interference couplers (2x2, 1x2, MMI) with 2 mm long ERM sections added in each branch in order to enable its tuning. Two inner AMZI stages of the filter have photodiodes (PD) added on both sides of each stage for on-chip monitoring and calibration functionalities. The ring cavity is closed with passive waveguides and the signals are coupled out from the laser cavity with two 1x2 MMI elements. The light is routed to the output ports which are angled with respect to the cleaved edges of the chip to reduce reflections. The resulting mask layout for one device occupies an area of 3.4 mm^2 as is shown in Figure 1(b). The chip was designed following the generic integration approach using the COBRA long wavelength extension of COBRA active-passive technology [1] and the laser cavity is defined using a predefined set of basic building blocks (BB) [1, 4]. The chip was fabricated within a multi-project wafer (MPW) run using NanoLab@TU/e cleanroom services [6] using a long wavelength generic integration technology developed at the COBRA research institute.

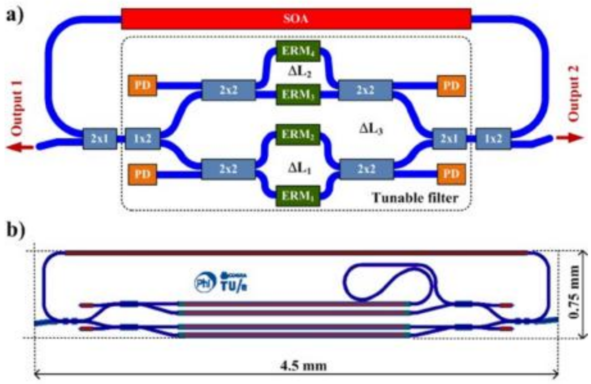

Figure 1 : (a) Schematic diagram of the photonic integrated circuit based tunable ring laser featuring an intracavity tunable wavelength filter based on nested asymmetric Mach-Zehnder interferometers indicated with a dashed box. (b) Mask layout of the laser caity with area of 3.4 mm^2.

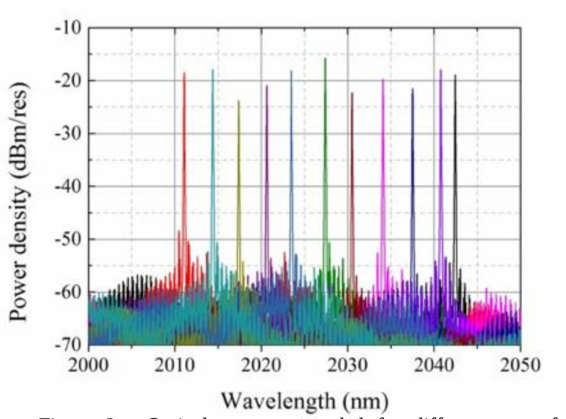

Figure 2 : Optical spectra recorded for different sets of reverse biases applied to the ERMs. Both the injection current into the SOA section and temperature were kept constant at I_{SOA}=450 mA and T= 18ºC respectively.

3. Experimental results

The fabricated chip is mounted on an aluminum block and all electrical contacts are wire bonded to a signal distribution printed circuit board (PCB). The sub-mount is temperature stabilized with a passive water cooling system at 18°C. Optical signals are collected with an antireflection coated lensed fiber and fed with a standard single mode fiber and via an optical isolator to the measurement equipment. An extended InGaAs amplified photodiode was used to record the total optical output power coupled into the fiber as a function of bias current injected into the SOA section. The LI characteristic shows the lasing threshold point to be at 350 mA (3.34 kA/cm^2). A Yokogawa AQ6375 optical spectrum analyzer with a 0.05 nm resolution was used to record the optical spectra for different sets of reverse bias voltages applied to the ERM sections with the SOA current and temperature being constant at I_{SOA} = 500 mA and T= 18°C respectively, which are presented in Figure 2. The laser provides single-mode output (side mode suppression ratio of more than 30dB) with the wavelengths range centered at around 2027 nm and spanning over 31 nm.

4. Conclusion

A fully functional photonic integrated circuit realized using monolithic active-passive integration technology at wavelengths around 2µm has been presented. The laser provides a single longitudinal mode output at wavelengths around 2027 nm and with a record tuning range.

5. References

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