AWG based wavelength-meter with pm resolution

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Abstract: This work reports an integrated circuit for the measurement of the wavelength of a coherent light source. The circuit is based on a 1x8 AWG with a 50 nm Free Spectral Range, connected to an array of photo detectors. A change in wavelength can be monitored by evaluation of the photocurrent variation in detectors connected to two adjacent AWG channels. We demonstrate first characterization results obtained from a demonstrator circuit fabricated in a generic foundry process.

1. Introduction

Accurate wavelength measurement is crucial for a high number of applications related to optical sensing. Prominent examples are gas detection and strain sensing based on Fiber-Bragg-Gratings[1,2]. Recently, fiber based monitoring solutions showed great advances with relatively simple fabrication methods[3,4]. However, the high polarization sensitivity of fibers and the necessity of additional equipment is a limiting factor. In this paper we propose a cost efficient Arrayed Waveguide Grating (AWG) approach for accurate and high-speed wavelength measurements. By designing the AWG such that two adjacent channels overlap, a change in wavelength can be monitored by evaluating the photo current of the corresponding photo detectors (PDs). First measurement results of a circuit based on a 1x8 AWG with a 50 nm FSR are presented.

2. Circuit Layout

The circuit is schematically depicted in Fig. 1(a). For simple packaging a straight input is connected to a 1x2 MMI splitter, with one output connected to a reference diode and the other to the AWG. At each of the eight outputs of the AWG, a photo detector is placed. The AWG design employs widened pass bands to increase the crosstalk level between adjacent channels. The wavelength meter is operated around the intersection of adjacent pass bands using balanced detection for increased output power. In Fig. 1(b) we display a photograph of the chip fabricated in the COBRA generic process. The chip contains different AWGs, varying the number of channels employed (three AWGs with eight and one with 16 channels). The metal contacts are conveniently routed to the edge of the chip.

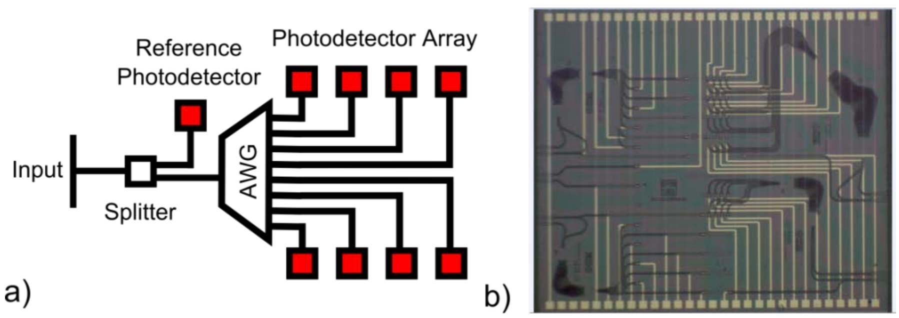

Fig. 1: Schematic of photonic circuit containing integrated detectors, (a) Photo of PIC, containing four AWG based wavelength-meter with up to 16-Channels (b)

3. Measurements

The device has been characterized using the setup depicted in the schematic of Fig. 2 (a). A tunable laser (Agilent 81600B) is coupled via a collimating lense to free space. After passing through the polarizer, the collimated beam is coupled to the device via a microscope objective. A fiberized polarization controler is used to maximize the transmission throught the polarizer set to TE. The device is mounted on a copper element, which is cooled down to 293 K by a water cooler. Small temperature fluctuations are compensated with a Peltier element which is connected to a temperature controler.

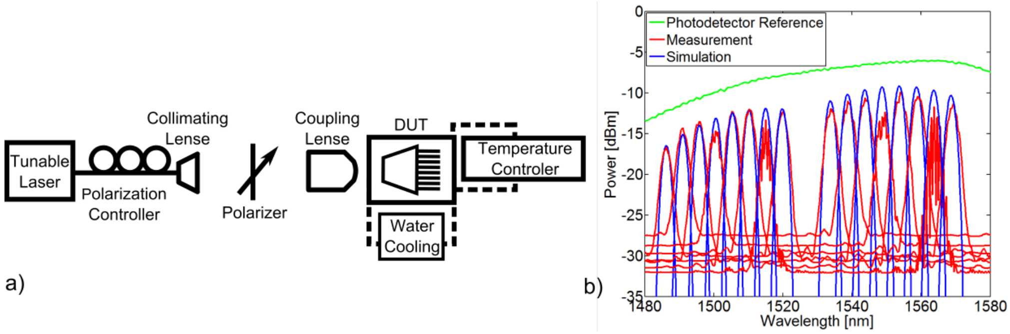

Fig. 2: Schematic of experimental setup, containing water cooling and electrical temperature control via a Peltier element (a). Integrated measurement of 8-channel AWG via detector array (b)

Based on the integrated photo detector array, we measured two FSRs of the AWG, displayed in Fig. 2(b). The response of the photo detectors is sufficient to resolve the pass bands of the AWG over 100 nm. The simulated transmission is calibrated using the detector response and matched to the measurement. The noise floor in the figure is caused by the noise level of the photo detectors and their readout.The sensitivity of the system is tested by using two inverted slopes of adjacent AWG channels, as indicated in Fig. 3 (a). The laser wavelength is set to match the pass band intersection for a time period of 5 s, after which the wavelength is tuned discretely by 5, 10 or 20 pm. The detectors are analysed in steps of 0.1s without averaging. Typical results are displayed in Fig. 3(b). Wavelength steps of a few pm can be clearly distinguished. The resolution limit is given by the standard deviation of the measured signal over time. We measure a typical standard deviation of 0.8 pm over a 10 s period.

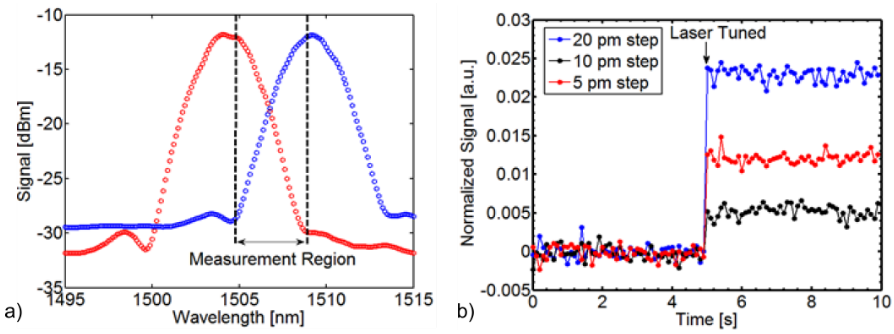

Fig. 3: Integrated measurement of two adjacent AWG pass bands, with indicated wavelength measurement region (a), 5, 10 and 20 pm wavelength steps measured at the crossing point of the AWG channels (b)

5. Conclusion

We fabricated a wavelength interrogator circuit based on a 1x8 AWG connected to an array of photo detectors. By evaluating the photocurrent variation in detectors connected to two adjacent AWG channels, we were able to clearly measure 5 pm changes in the wavelength of a tuneable laser. The standard deviation over a measurement period of 10 s is 0.8 pm. Considering the spectral periodicity of the AWG, the same circuit can be potentially applied over an operating range of above 100 nm.

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