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Noise Insensitive Transparent Light Monitoring on a Silicon Photonics Chip

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The complexity scaling up of photonic integrated circuits (PICs) enables the manipulation of many optical signals on a photonic chip, to perform operation like channel (de)multiplexing, routing, and switching. For these applications, it is useful to be able to identify each data channel inside the PIC, regardless of the presence of other concurrent channels and optical noise. In this work, we report on the optical signal to noise (OSNR) tolerance of on-chip channel monitoring performed with a transparent detector, namely ContactLess Integrated Photonic Probe (CLIPP) [1], which is integrated in a silicon photonics (SiP) waveguide. We show that, regardless of noise, the CLIPP can measure the power of optical channels that are suitably labelled through a weak modulation tone. An accuracy as high as 0.2 dB is demonstrated for an on-chip OSNR as low as 5 dB/0.1nm, with a power sensitivity of about -28 dBm.

The CLIPP device used in the experiment is shown in Fig. 1a. The CLIPP consists of two metal electrodes (20 μm × 50 μm size, 50 μm spacing) deposited on top of a straight SiP channel waveguide, with a 480 nm × 220 nm Si core buried in a SiO_2 cladding. The light intensity in the waveguide is monitored by measuring the change of the Si resistivity R_{wg} (Fig 1b) induced by surface state absorption at the core-cladding interface [1]. For the CLIPP read-out, one electrode of the CLIPP is driven with a voltage V_e = 2 V (at 100 kHz), while at the second electrode a current signal i_e providing information on the light intensity in the waveguide is detected with a low-noise lock-in system [1].

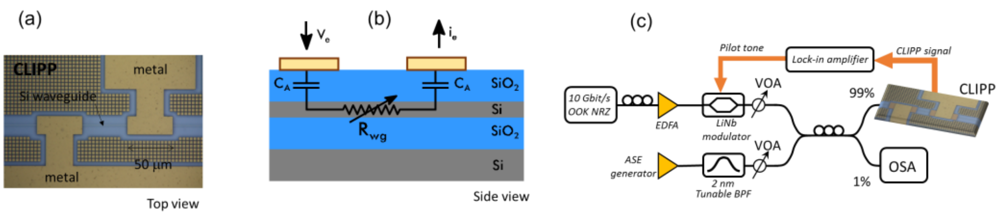

Fig. 1. (a) Top view photograph of a CLIPP integrated on a straight SiP waveguide; (b) Side view sketch of the CLIPP device; (c) experimental setup used in the experiment.

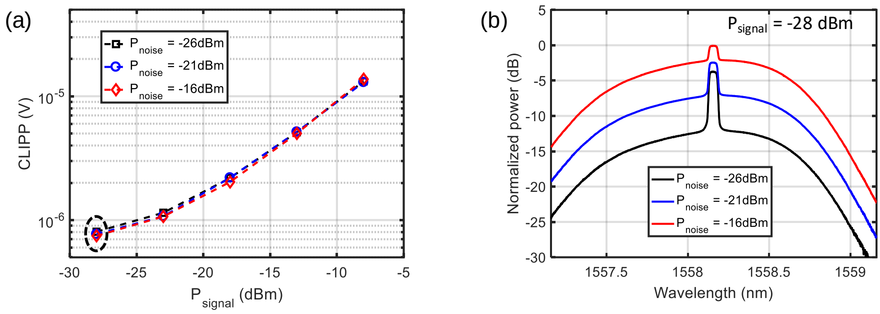

Fig. 2. (a) CLIPP signal vs on-chip signal power (P_{signal}) for different levels of noise power. (b) Spectra of the noisy signal measured when P_{signal} = -28 dBm, for different level of noise.

The experimental setup used in the experiment is shown in Fig. 1c. A pilot tone with a low modulation index at 3 kHz is superimposed to a 10 Gbps OOK signal generated by a commercial $LiNbO_3$ modulator. An ASE noise source (not labelled with tones) is coupled to this signal via a 90/10 fiber coupler, after being filtered by a 2 nm tuneable filter. Variable optical attenuators (VOAs) are used to control the *off-chip* OSNR level between 2 dB (worst case, on-chip signal power P_{signal} = -8 dBm) and 32 dB (best case, P_{signal} = -28 dBm), evaluated over a 0.1 nm bandwidth. Since the noisy signal is coupled to the SiP through polarization selective grating couplers working on TE polarization, the *on-chip* OSNR level is 3dB higher than the off-chip OSNR monitored with the optical spectrum analyser (OSA). As the ASE signal is not labelled with a tone, demodulation of the CLIPP at the frequency of the pilot tone can provide direct information on the signal power [2].

Figure 2a shows that, the electrical signal provided by the CLIPP (after demodulation at the tone frequency) is insensitive to the noise level, whose on-chip total power P_{noise} is increased from -26 dBm (black squares) to -16 dBm (red diamonds). Accurate signal monitoring is achieved even when the on-chip signal power drops to -28 dBm, at this level the noise power being more than 10 dB higher than the signal power. The spectra in Fig. 2b show that when P_{signal} = -28 dBm, the off-chip OSNR is as low as 2 dB (5 dB on-chip OSNR). From the horizontal drift of the curves in Fig. 2a, we estimate an accuracy of about 0.5 dB in the signal power monitoring, regardless of the noise power level.

Our results demonstrate the possibility to perform accurate on-chip monitoring of a noisy signal through a transparent detector. We demonstrated power measurement of signals with on-chip OSNR as low as 5 dB/0.1 nm with an accuracy of 0.5 dB, a sensitivity of -28 dBm and a dynamic range of 20 dB. Applications of the proposed technique to the on-chip monitoring of the OSNR are also expected. This could be particularly useful in III-V platforms, where the CLIPP concept has been demonstrated, to monitor the noise level of integrated amplifiers.

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[1] F. Morichetti, et al., "Non-invasive on-chip light observation by contactless waveguide conductivity monitoring," IEEE J. Sel. Topics Quantum Electron. 20, 292-301 (2014).

[2] S. Grillanda, et al. "Non-Invasive Monitoring of Mode-Division Multiplexed Channels on a Silicon Photonic Chip," J. Lightwave Technol. 33, 1197-1201 (2015).