Demonstration of Silicon-On-Insulator Coherent receiver for Radio-Over-Fiber applications

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Radio-Over-Fiber transmission has emerged during the last years as a promising technology allowing the seamless integration of optical and wireless technologies. One of the most relevant applications of RoF systems is found in mobile networks, specifically in the transmission of RF signals from the base station (BS) to the central office (CO), as shown in figure 1 (a). Most of the current approaches are based on intensity-modulation/direct-detection (IM-DD) systems [1]. On the other hand, schemes based on complex modulation formats, i.e. phase modulation and coherent detection (PM-CD), have also been proposed, overcoming the limited dynamic range of the IM-DD systems, and offering the coherent detection advantages, such as mitigation of fiber transmission impairments through signal processing, coherent gain, etc. [2]. Moreover, in coherent reception schemes, by properly tuning the local oscillator, down-conversion of the RF signal can also be performed, thus relaxing the electronics. Furthermore, taking advantage of the coherent gain, the RF amplifier usually located at the base station can be theoretically omitted, reducing the operation costs. In this contribution, a Silicon-On-Insulator (SOI) coherent receiver with low power consumption [3] is demonstrated, shown in Figure 1(b), for the reception of RoF signals in the uplink, from the BS to the CO, for the first time. In this proof of concept, coherent gain and improved error magnitude (EVM) compared to IM-DD is demonstrated.

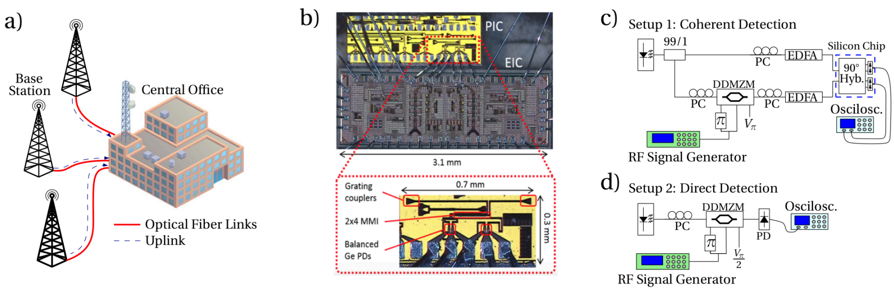

Fig. 1. a) Application of RoF transmission in the mobile access network; b) Microscope picture of the silicon photonic coherent receiver with integrated transimpedance amplifier; c) Setup 1, used for coherent reception of RoF signals; d) Setup 2, used for direct-detection reception of RoF signals.

Figure 1 (c) and (d) show the two different setups employed for the demonstration. Setup 1, shown in Fig. 1 (c), has been used for the demonstration of RoF coherent reception. In this setup light from a laser source is split, in a 1/99 power divider. The smaller fraction is used for the local oscillator signal, and the rest is sent to a dual drive Mach-Zehnder modulator (DDMZM). The modulated RF signal is generated at 3.5GHz using a vector signal generator. This RF signal is divided in two branches, introducing a 180º phase shift in one of them.

The bias point of the DDMZM is set to V_π so that the RF signal linearly modulates the optical field. Due to the insertion losses of the grating couplers in the coherent receiver ($IL \approx 15\ dB$) it has been necessary to employ an EDFA amplifier in each of the optical coherent receiver inputs. Setup 2, shown in Fig. 1 (d), is used to evaluate the operation of an IM-DD scheme, in order to compare the performances of both scenarios. In this case the MZM is biased in its quadrature point, pursuing intensity modulation.

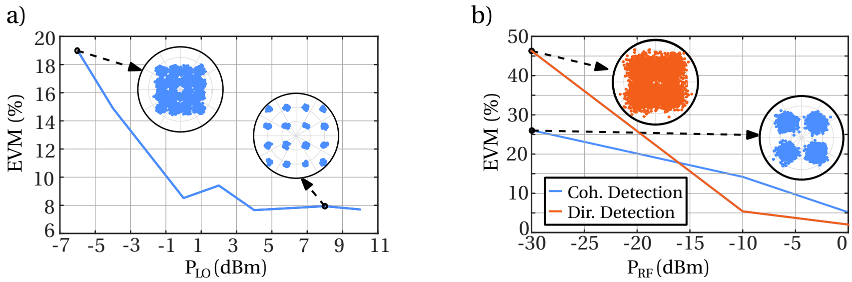

Fig. 2. a) EVM as a function of the on-chip LO power (P_{LO}). Representative received constellations are shown (P_{RF} is set to 0 dBm); b) EVM for coherent vs. direct detection. At low P_{RF} coherent detection, (on-chip P_{LO} of 10 dBm), exhibits better performance.

In a first experiment, the performance improvement due to the coherent gain is demonstrated in setup 1, using a 160 Mbps 16QAM as baseband signal. The error vector magnitude (EVM) of the received constellation was measured as a function of the power of the local oscillator. Figure 2 a) shows the result of this experiment, where the on-chip power of the local oscillator is swept from -6 to 10 dBm. It can be observed that as the LO power increases, the EVM becomes smaller, thus demonstrating the improvement in the performance. The second experiment consists in demonstrating that in similar conditions, for low RF signal power (as it happens in real scenarios), coherent reception presents better performance than direct detection. In this case, a 160 Mbps QPSK baseband signal is employed in both setups. In order to fairly compare both schemes, measurements are done for the same optical signal power at the input of the receivers. Figure 2 b) shows the measured EVM in both cases, as a function of the RF signal power. It can be seen how for lower RF signal power the direct detection exhibits higher EVM than the coherent detection, demonstrating that coherent reception can be a better alternative. In summary, the results presented in this work demonstrate the operation of a SOI integrated coherent receiver for RoF signal reception. Coherent gain is demonstrated, which can imply the substitution of the RF amplifier located in the base stations. Furthermore, the operation of the coherent receiver has been compared with a direct detection scheme, showing better performance for low power RF signals.

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