Abstract

Due to the relentless emergence of multifunction mobile devices with applications that require increasingly greater bandwidth at anytime and anywhere, future access networks must be capable of providing both wireless and wired services. The use of optical communications systems as transport medium of wireless signals over fiber radio links is a steady solution to be taken into account. This will make possible a convergence to an optical domain reducing and alleviating the bottleneck between wireless access standards and current wired access.

In this thesis, as part of the objectives of the European project HELIOS in which it is framed, we have investigated and developed the basic functional blocks needed to achieve an integrated photonic transceiver working in the range of millimetre wavelengths, and using robust modulation formats that best fit the scope considered.

The work presented in this thesis can be basically divided into three parts. The first one provides an overview of the benefits of using silicon photonics for the development of wireless links at rates of Gbps, and the state of the art of the transceivers reported by the most important research groups in order to meet the increasingly demanding needs' market.

The second part focuses on the study and development of millimetre-wave integrated transmitter. First we provide a brief theoretical introduction of the operation principles of the devices involved in the transmitter such as a modulation formats, focusing on the phase shift keying (PSK) which is the one that will be used, particularly the (differential) quadrature phase shift keying ((D) QPSK). We also present the building blocks involved in our transmitter and we set the specifications that must be met by these devices in order to achieve an error-free transmission. The transmitter includes a filter/demultiplexer which must separate two optical carriers 60 GHz separated. One of these optical carriers is modulated by passing through a DQPSK Mach-Zehnder-based modulator (MZM) by arranging two MZMs in a nested configuration. Using a combiner, the modulated optical signal and the un-modulated carrier are combined and photodetected to be transmitted wirelessly.

In the third part of this thesis, we investigate the use of a polarization diversity scheme with an integrated DQPSK receiver for demodulating of the wireless signal. The

polarization diversity scheme basically consists of two blocks: a polarization splitter in order to separate the random polarization state of the incoming light into its two orthogonal components, and a polarization rotator.

Regarding the DQPSK receiver itself, all the functional blocks that comprise it have been investigated and optimized. It basically includes a thermo-optically tunable MZ interferometer power splitter, in series with a MZ interferometer that introduces, in one of its arms, a delay of one bit length in order to obtain a correct differential demodulation. The next building block of our DQPSK receiver is a 2x4 multimode interference coupler acting as a 90 degree hybrid, whose outputs are connected to two balanced germanium photodetectors.

The main contributions of this thesis are:

- Demonstration of a filter/demultiplexer with three degrees of tuning and an extinction ratio greater than 25dB.
- Demonstration of a polarization rotator with a length of only 25μm and CMOS compatible.
- Demonstration of a DPSK modulator at a maximum rate of 20 Gbit/s.
- Demonstration of a DQPSK demodulator to a maximum rate of 20 Gbit/s.