Abstract

Silicon photonics is one of the most exciting and fastest growing photonic technologies in recent years. The salient feature of this technology is its compatibility with the mature silicon IC manufacturing based on complementary metal-oxide semiconductor (CMOS) processes widely used in microelectronic industry. Another motivation is the availability of high-quality silicon-on-insulator (SOI) planar waveguide circuits that offer strong optical confinement due to the high index contrast between silicon (n=3.45) and SiO_2 (n=1.45). This opens up miniaturization and very large scale integration of photonic devices allowing photonic integrated circuits for a wide range of applications and markets, from optical telecommunications to bio-photonic devices or precise fibre sensors. Optical modulators are key building-blocks for high speed signal transmission and information processing in any photonic interconnection solution. The work developed in this thesis, as part of the objectives of the European project HELIOS in which it is framed, is essentially focused on realizing compact and efficient modulators integrated on silicon chips.

The thesis consists of three main chapters as well as the concluding section on the work accomplished. Chapter one is aimed at giving a general description of the benefits of using silicon photonics, showing its challenges and opportunities as well as at giving a deeply overview of all issues related to the electro-optic modulation. Chapter two is devoted to develop silicon modulators with high features for digital applications. Specifically, new optical structures different to the conventional ones are presented with the aim of enhancing the modulation performance or at least several critical parameters in the modulation. Chapter three is dedicated to the analog applications. The concept of microwave photonics is described as well as different researches carried out in the analog scope for application in the field of integrated microwave photonics, all of them using CMOS-compatible electro-optic silicon modulators which validate the potential of silicon photonics as a promising approach for enabling the development of integrated microwave photonics applications. Finally, conclusions on the work realized are provided in Chapter 4.