Abstract

The most promising technology expected to alleviate the intra-chip and chip-to-chip interconnection bottleneck is silicon photonics, in which electronics and photonics can be integrated monolithically, only requiring standard CMOS processing lines for fabrication. Nonlinear interaction can provide all-optical processing capabilities, which do not have the bandwidth limitations imposed by electronics. Silicon has a Kerr coefficient which is 100 times higher than silica; this fact, together with the strong confinement because its high refractive index difference, makes nonlinear effects take place at relatively low optical powers.

However, at 1.5 μm, silicon undergoes two-photon absorption too, generating carriers with slower dynamics that can mask the ultrafast nonlinear Kerr effect. There are different strategies to reduce the effect of carriers, such as carrier sweeping through a PN junction or reduction of carrier lifetime through introduction of recombination centers. Another possibility is using a slot waveguide, with most light confined in the slot and not in the silicon, allows having a highly nonlinear material inside the slot, such as silicon nanocrystals [1–3]. Amorphous silicon should also be considered because its high nonlinearity and low carrier effects [4]. In this thesis, we consider all these different materials, waveguides and devices (ring resonator and Mach Zehnder interferometer) for making all-optical switches that can work at 40 Gb/s bitrates or higher.