Summary

The interest in developing highly sensitive biosensors to identify and quantify a wide range of molecules has remarkably been increasing during the last decades in numerous application fields. Among them, medical diagnosis is probably the most demanded, which has been driven by the discovery of new biomarkers of diseases, such as miRNAs. However, most of the existing techniques to perform the detection require the use of labels due to the lack of sensitivity to detect analytes at low concentrations. Evanescent-wave optical structures, where light is used to transduce biochemical interactions into variations of the optical signals, are an interesting alternative for the development of this type of biosensors allowing a label-free detection. Specifically, the planar integrated photonic structures based on Silicon On Insulator technology exhibit an extremely high sensitivity, a low detection limit and a high level of multiplexing in detection applications, especially when using materials and processes based on silicon and being CMOS compatible.

This PhD Thesis is focused on the development of label-free integrated photonic biosensors for the detection of oligonucleotides, and more specifically miRNA cancer biomarkers. This biosensor is based on the combination of photonic band gap structures and the immobilization of molecular beacon probes on its surface. The combination of both transduction and biorecognition elements has provided a very high sensitivity towards the detection of target oligonucleotides while keeping a sensor footprint below 100 μm^2. The use of this photonic biosensor also allowed the experimental study of a novel detection amplification technique. This technique exploits the conformational change suffered by the molecular beacon probe after hybridization with its complementary oligonucleotide, allowing the displacement of a particle/molecule away from the sensor surface, what might be used for amplifying the sensor's detection response.

Finally, an online regeneration strategy for nanophotonic biosensors developed through a chemical strategy based on the use of formamide is proposed. This strategy not only saves time but also reduces the variation between measurements obtained in different experiments, being especially useful when testing similar levels of analyte.