Abstract

The necessity of using extremely high sensitivity biosensors in certain research areas has remarkably increased during the last two decades. Optical structures, where light is used to transduce biochemical interactions into optical signals, are a very interesting approach for the development of this type of biosensors. Within optical sensors, photonic integrated architectures are probably the most promising platform to develop novel lab-on-a-chip devices. Such planar structures exhibit an extremely high sensitivity, a significantly reduced footprint and a high multiplexing potential for sensing applications. Furthermore, their compatibility with CMOS processes and materials, such as silicon, opens the route to mass production, thus reducing drastically the cost of the final devices. Optical sensors achieve their specificity and label-free operation by means of a proper chemical functionalization of their surfaces. The selective attachment of the receptors allows the detection of the target analytes within a complex matrix.

This PhD Thesis is focused on the development of label-free photonic integrated sensors in which the detection is based on the interaction of the target analytes with the evanescent field that travels along the structures. Herein, we studied several photonic structures for sensing purposes, such as photonic crystals and ring resonators. Photonic crystals, where their periodicity provokes the appearance of multiple back and forth reflections, exhibits the so-called slow-light phenomenon that allows an increase of the interaction between the light and the target matter. On the other hand, the circulating nature of the resonant modes in a ring resonator offers a multiple interaction with the matter near the structure, providing a longer effective length.

We have also proposed a novel approach for the interrogation of photonic bandgap sensing structures where simply the output power needs to measured, contrary to current approaches based on the spectral interrogation of the photonic structures. This novel technique consists on measuring the overlap between a broadband source and the band edge from a SOI-based corrugated waveguide, so that we can determine indirectly its spectral position in real-time. Since there is no need to employ tunable equipment, we obtain a lighter, simpler and a cost-effective platform, as well as a real-time observation of the molecular interactions. The experimental demonstration with antibody detection measurements has shown the potential of this technique for sensing purposes.