Biosensing is an ever-growing field of research, giving the floor to more and more innovations over the years to address the increasing needs of our society. Nowadays, research trends are essentially on the demand from medical, environmental, and agri-food industries. Biosensing is also undoubtedly highly multidisciplinary, blending closely Physics, Chemistry, Biology, Engineering and Biochemistry, as well as Electronic and Computer Sciences. Opportunities in terms of target analytes (proteins, hormones, enzymes, saccharides, etc.), designs and strategies are endless and new prototypes are constantly emerging. Focus is on developing more accurate, sensitive, and affordable biosensing tools for rapid and reliable Point-of-Care (POC) home-diagnoses. Integrations in current technologies such as smartphones or connected watches also play an important role. Sensors based on the surface plasmon resonance (SPR) phenomenon are well-adapted to meet the demand. Since their advent in the early nineties with first commercial devices, SPR-based biosensing technologies never ceased to progress. This involves recent classes of biosensors built on optical fibers such as plasmonic tilted fiber Bragg grating (TFBG) biosensors.

This thesis has aimed to investigate new strategies in plasmonic TFBG technology to enhance performances and practicability in cancer biomarkers biosensing. A TFBG enables to build biocompatible and minimally invasive biosensors suitable for accurate and highly sensitive diagnoses. Its structure makes the optical fiber sensitive to its close surroundings while keeping all its advantages in terms of flexibility, resistance to harsh environment (temperature and pH), real-time monitoring and miniaturization. Once covered with a finely tailored gold layer, the SPR phenomenon can occur, and the sensitivity is drastically amplified. The SPR-TFBG is a versatile platform that can host miscellaneous biofunctionalization strategies (antibodies, aptamers, enzymes, etc.) to various analytes of interest such as biomarkers, highly relevant targets in a pathology diagnosis context. The specific biodetection of lung (CK17) and breast (HER2) cancers biomarkers has been here mainly considered using antibodies and aptamers as bioreceptors.

The usual telecommunication single mode fiber (SMF) has been substituted by other fiber types to improve the SPR-TFBG capabilities. A multimode fiber (MMF) and a single polarization fiber (SPF) were especially chosen for their intrinsic properties. The MMF exhibits a narrow band response in wavelength, ideal for multiplexed detection of several biomarkers at the time. SPF leads to a passive selection of the polarization state required for SPR generation and limits the use of an external cumbersome light polarizer. Both fibers can potentially strengthen the practicability and the robustness of POC diagnosis.

The SPR-TFBG response is a comb-like spectrum made up of tens of wavelength peaks (modes) with an attenuation which is very sensitive to surrounding refractive index (SRI) changes. To get the maximum sensitivity and make easier the data processing in comparison with conventional methods, new demodulation techniques have been developed. These methods have been based on the tracking of special features in the envelope fits of the spectral SPR signature during the biodetection. These novel techniques provide a simple and optimized response analysis which is very desired for on-site testing.

An original electro-plasmonic concept has also been developed to increase the performances of biosensing. The plasmonic TFBG has been used as a working electrode in an electrochemical cell to directly perform an electrophoresis onto the fiber. Driving an electric current on the metal coating has brought the opportunity to play on the probe polarity to influence the biological targets in solution. An optimized cyclic voltammetry method has greatly enhanced the limit of detection (2 orders of magnitude) by giving the possibility to attract biomarkers and specifically catch them on a biofunctionalized SPR-TFBG. Promising results have also been obtained in specific biosensing of breast cancer cells.

The different works achieved all along this thesis pave the way for the next future of fiber grating-based biosensing. The novel developed analysis techniques and concepts provide significant advances in the improvement of the sensitivity and reliability of SPR-TFBG biosensors. This allows to better glimpse the application of this lab-on-chip technology to support *in situ* diagnoses in a more convenient way.