IMMUNOSENSORS: NOVEL DIAGNOSTIC TOOLS BASED ON BIO-HYBRID MATERIALS

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Novel molecular diagnostic approaches to refine and extend the limits of detection have emerged as consequence of the combination of nanotechnological and biotechnological advances. Biosensors are between the potential applications of new materials and devices. Thus, subtle changes on properties such as the dielectric field or the refractive index produced after biomolecular recognition can be detected if they are taking place at the surface appropriately developed transducers. Nowadays, new knowledge on the unique properties of nanostructured materials has opened up the possibility to investigate the influence that biorecognition phenomena produce on the new optical and/or electrical properties of these systems, pointing to the possibility to develop more sensitive and flexible biosensing systems.

Immunosensors using antibodies as biorecognition elements have fascinating features such as the possibility to respond selectively and quantitatively to the presence of a particular target. The unique properties of certain nanomaterials combined with the excellent features of the antibodies have allowed envisaging novel exquisitely sensitive chemical and biological sensors. Thus, antibodies are natural molecules with inherent capabilities to specifically react with their counter antigen. Antibodies can be produced, in principle against all kind of substances and their features can be tailored according to the requirements of each application. Their homogeneity regarding chemical structure and properties allow standardization of several procedures. Moreover, antibodies show greater improved stability, if compared to other biomolecules.

Nanostructured surfaces and nanoparticles have been the base for the construction of functional hybrid materials consisting of both organic (biomolecules) and inorganic components. The electrochemical, magnetic or optical features of these bio-hybrid materials can be used to develop biosensor devices with potential applicability for clinical diagnostics, environmental monitoring, food safety and industrial process control. In this communication we will present examples of the research developed at the Applied Molecular Receptors Group (AMRg) during the last years regarding development of electrochemical and optical immunosensor devices. The goal has been to achieve improved analytical features in relation to speed, reliability, detectability, multiplexing capabilities, flexibility or possibility of automation.

Electrochemical amperometric devices based on the use of magnetic nanoparticles to capture the target analyte from complex samples have been developed to determine bioactive substances. The current generated at the electrode is produced by a redox reaction catalyzed by an enzyme[1, 2]. Alternatively, the biomolecular recognition reaction can be recorded measuring the changes in the impedimetric spectrum of interdigitated microelectrodes (IDμE) in which specific antibodies or antigens have been covalently immobilized within the electrodes[3, 4]. In this case a response is obtained without the use of any label.

Using a different approach, biomolecules integrated on optical microfabricated devices are able to provide label-free response to the presence of a particular target analyte, based on the change in the refractive index produced. Grating couplers have been implemented in a variety of configurations (input, output, and reflective modes and resonance approaches. As an example, the WIOS (wavelength interrogating optical sensor system) uses the evanescent field of light to probe changes in the refractive index at the surface of a waveguide surface by scanning the resonance condition of the waveguide grating through the wavelength modulation of a laser diode. The operating principle is shown in figure 1. Continuous monitoring the resonance wavelength will provide information on the variations of the refractive index produced as consequence of biomolecular interactions if the waveguide contains on the surface a selective bioreceptor[5].

Similarly, biosensors based on surfaces plasmon resonance (SPR) have demonstrated a significant commercial success exemplified by devices such as Biacore™. Superficial plasmons are very sensitive to the optical properties of the dielectric media that surrounds the noble metal. Most of the examples found in the literature make use of gold thin layers; however, the potential of using noble metal nanoparticles is still starting. The particle confinement of the surface plasmon gives rise to a spectral resonance in the light scattering that does not occur in thin films. Thus, optical properties of the nanoparticles are not only affected by the dielectric media but also from features such as size, material and shape. These particular features have open the door to the possibility to develop miniaturized multiplexed devices based on the use of noble metal nanoparticles incorporating selective bioreceptors on their surface[6].

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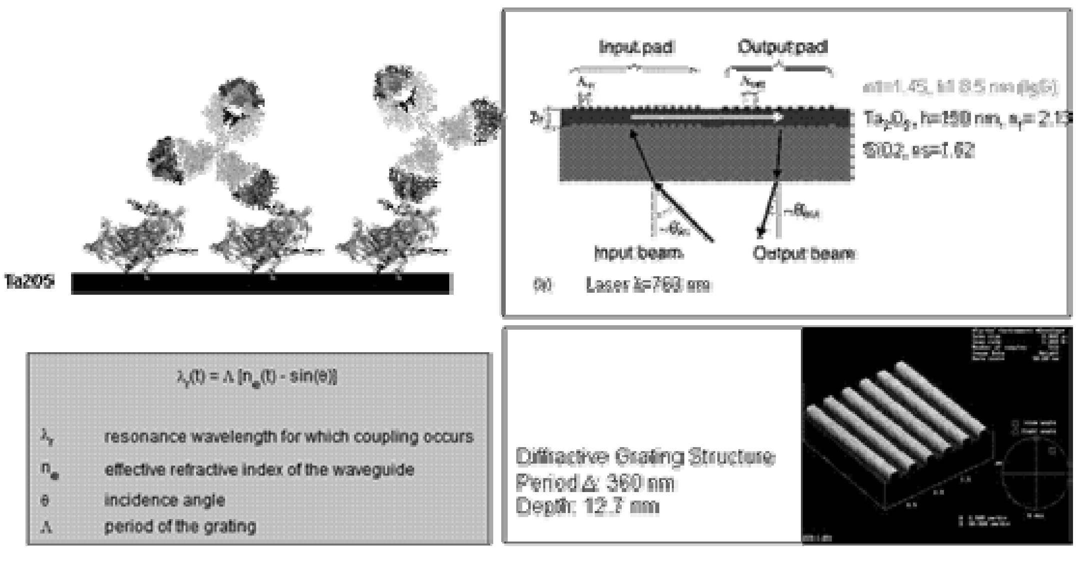

Figure 1. Scheme of the WIOS principle. Biorecognition events at the surface of the grating can be recorded due to a variation of the resonance condition.