Magneto-Plasmonic Nanostructured Materials For Gas Sensors Applications

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Surface plasmon resonance (SPR) spectroscopy has emerged as a powerful technique which permits real-time monitoring of chemical and bio-chemical interactions occurring at the interface between a thin gold film and a dielectric interface, without the need for labelling of reagents [1]. In recent years it has been used for detection and analysis of chemical and biological substances in many research areas and industrial applications, such as surface science, biotechnology, medicine, environment, and drug and food monitoring. In all these applications, improving the resolution and limits of detection is of vital importance and is the primary goal of the research in this field in the last years.

The sensitivity and limits of detection of the SPR sensors can show variations depending on the method used to excite the surface plasmon (prism coupling, grating coupling, optical fibers etc.).In the widely used Kretschmann configuration, a prism is coated with a metal of suitable thickness. A beam of p-polarized light is allowed to fall on the metal–dielectric interface and the intensity of the reflected light is detected as a function of the angle of incidence. At a particular angle of incidence the resonance condition is satisfied and the resonance is observed as a sharp fall in the reflectivity. The plasmon resonance is extremely sensitive to the changes in the refractive index and the thickness of the dielectric medium adjacent to the metal layer. In the intensity-interrogated configuration, the most widely employed, such changes are monitored by measuring the intensity of the reflected p-polarized monochromatic light at a fixed angle of incidence.

In order to boost up SPR detection sensitivity, various efforts have been made, including construction of SPR equipment and setups with improved measurement modes: incorporation of fluorescent spectroscopy into SPR, signal amplification using functionalized nanoparticles, localized SPR (LSPR) using periodic nanowires and nanoposts, phase-sensitive detection schemes [2-4].

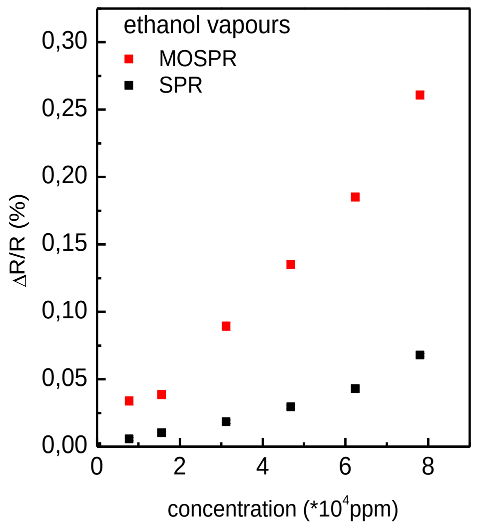
Recently, it has been proposed in the literature a novel Magneto-Optic Surface Plasmon Resonance (MOSPR) sensor [5] which sensor performances can be greatly enhanced with respect to traditional SPR sensors (an improvement by a factor of 3 in the limit of detection is demonstrated) . The novel device is based on the combination of the magneto-optic (MO) effects of the magnetic materials and the surface plasmon resonance. This combination can be achieved by realizing a transducing sensing layer constituted by a multilayer Au/Co/Au deposited onto glass substrates. A magnetic actuator is used to control the magnetization state of the magnetic layer in the transversal configuration, and the relative variations of the reflectivity are detected. By this way, a great enhancement of the magneto-optic effects in the p-polarized light is produced when the resonant condition is satisfied. Such enhancement is strongly localized at the surface plasmon resonance and strongly depends on the refractive index of the dielectric medium, allowing its use for optical sensing and to greatly improve the sensitivity with respect to "standard" SPR sensors. Since this MOSPR seems very promising, we have undertaken the analysis of this configuration both for biosensing purposes and for gas sensing (for the first time in a MOSPR sensor).

In this work, some preliminary results for gas sensing scheme are shown. TiO2 thin film have been deposited by GLAD (Glancing Angle deposition) onto the last gold surface and its interaction with Volatile Organic Compounds has been monitored both in a standard SPR and in MOSPR configurations in order to compare their sensing performances. Measurements performed in controlled atmosphere demonstrate that the sensitivity results greatly improved in MOSPR sensor for ethanol, methanol and isopropanol vapours. These first results represent a good starting point for the demonstration of the use of the prepared magneto-plasmonic materials in thin film form as candidates for sensitive optical gas sensors, by greatly enhancing the performances of traditional SPR optical sensors operating at the same conditions.

References

[1] A J. Homola, S. Yee, D. Myszka, in: F.S. Ligler, C.A.R. Taitt (Eds.), Elsevier, The Netherlands, 207, (2002).
[2] F. Yu, B. Persson, S. Lofas, W. Knoll, Jacs comm, 126, (2004) 8902
[3] L. Malic, B. Cui, T. Veres, and M. Tabrizian, Opt. Lett. 32 (2007) 3092
[4] S. Y. Wu, H. P. Ho, W. C. Law, C. Lin, and S. K. Kong, Opt. Lett. 29 (2004) 2378
[5] B. Sepúlveda, A. Calle, L. M. Lechuga and G. Armelles, Opt. Lett. 31, (2006) 1085.

Figures



Sensor response towards ethanol alcohol vapours corresponding to the “standard” SPR configuration and to the MO-SPR configuration demonstrating an increase in sensitivity