

Optimization of interferometric photonic cells for biochemical sensing based on advanced high sensitivity optical techniques

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1. Abstract

The integration between micro-nano fluidics and optics is a new emerging research field, with promising high impact applications in the area of optical biosensing devices. This is the case of tunable Mach-Zehnder interferometers, photonic crystals and ring resonators, which have been demonstrated recently.

Recent investigations¹ have demonstrated that by combination of the simultaneous use of Ellipsometry, Reflectometry and Spectrometry based technologies broadly used in semiconductor industry at sub-micron spot-size level and advanced photonic structures, a relevant improvement can be achieved at the level of performance of the current state of the art for label-free biosensing and nano-fluidics metrology. The variation in the effective index of refraction can be easily detected in micron/sub-micron domains due to the fact of using several reflectivity profiles and optical responses simultaneously, making possible to remove ambiguities in the sensing interrogation process.

To achieve this novel bio-chemical sensing system, it is proposed to combine the miniaturization of sub-micro-holes based Interferometric photonic structures in combination with sub-micron spot size advance optical techniques holistically. Thus, optical sensing system is based on the observation of external reflectivity profile of the high sensitive photonic structures.

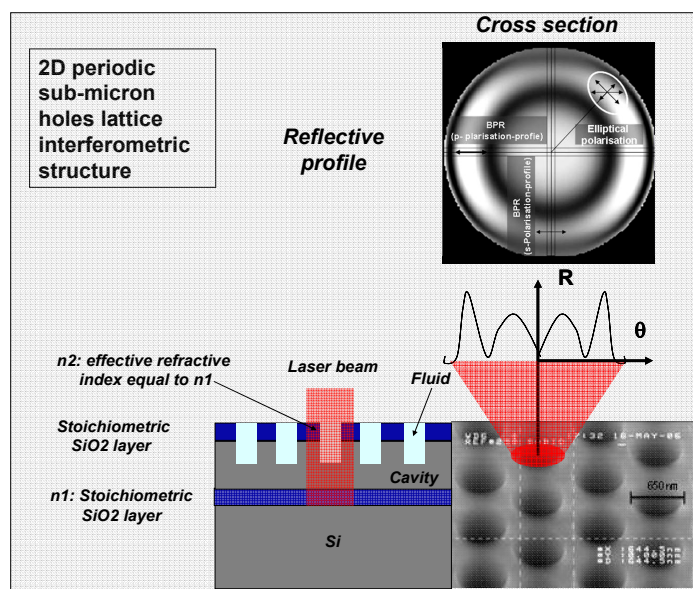


Fig.1. Schematic representation of a sensing cell based on periodic sub-micro-holes lattice embedded in an interferometric planar structure. The stoichiometric layers permit to design the photonic structure to maximize the interferometric response when evaluating simultaneously by Ellipsometry, Reflectometry and spectrometry based techniques.

The reflectivity profile provides four magnitudes which can be used to assess the photonic structures response. These are the reflected amplitude and phase of the electric field components polarized parallel (p) and perpendicular (s) to the plane incidence. The reflected light of the photonic structures produce spectra interference patterns as a function of the angle of incidence for p and s polarization directions and as a function of the spectral range. These patterns are the fundamental source of information to detect the biomolecules binding in the sensing surfaces, ultra small fraction of volumes and flow control in sub-micron domains. Theoretical calculations at CLUPM demonstrate that a detection limit of 10^{-7} R.I.U. and surface concentration detection limit of 0.1 pg/mm^2 are feasible.

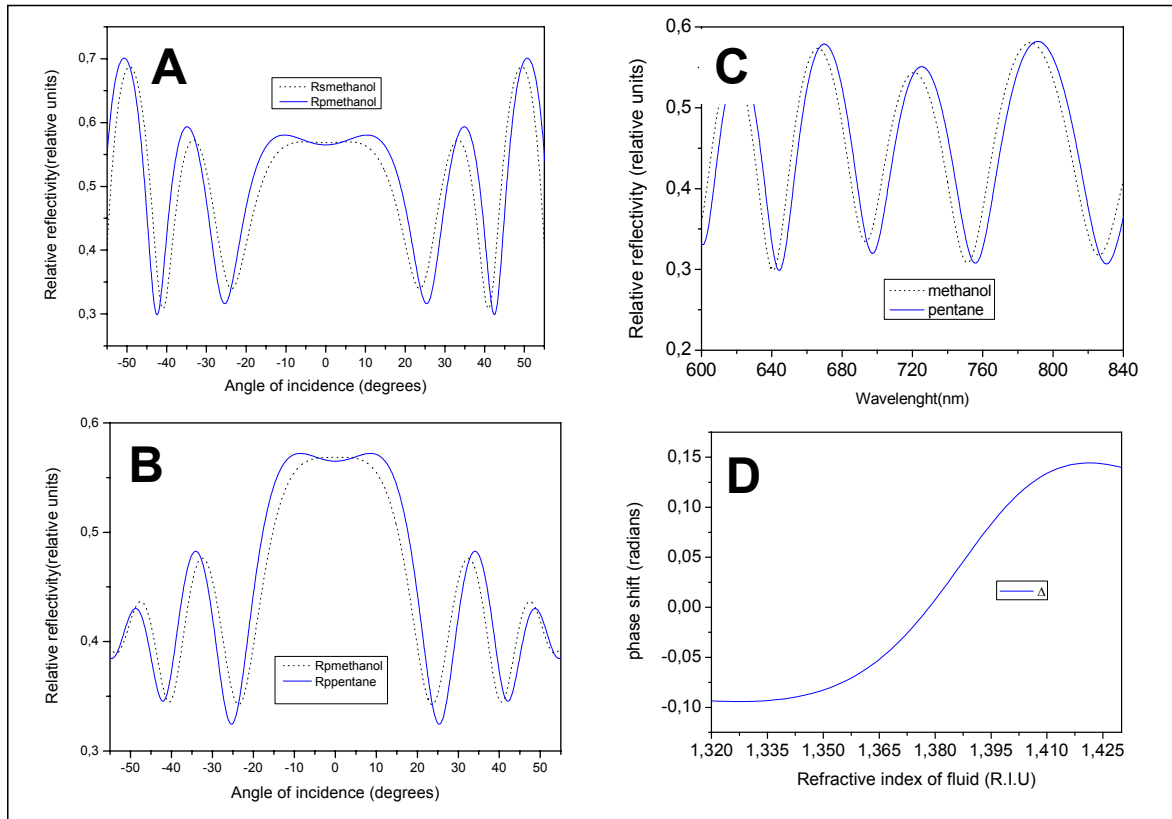


Fig.2. A and B: Reflectivity profiles for S and P polarization, C: Spectrometry profile and D: Phase phase shift (Δ)

References:

- [1] M. Holgado, R. Casquel, C. Molpeceres, M. Morales, J.L. Ocaña, OPTICS EXPRESS, Vol.: 15 (2007) 13318.
- [2] Carlos A. Barrios, Kristinn B. Gylfason, B. Sánchez, Amadeu Griol, H. Sohlstrom, M. Holgado, R. Casquel, OPTICS EXPRESS, Vol.: 32 (2207), 3080.
- [3] X. D. Hoa, A. G. Kirk, M. Tabrizian, Biosensors and Bioelectronics, Vol.: 23 (2007), 151.
- [4] B. Sepúlveda, J. Sánchez del Río, M. Moreno, F. J. Blanco, K. Mayora, C. Domínguez, L. M. Lechuga, Journal of Optics A: Pure Applied Optic, Vol.: 8 (2006) 561.