Periodic Nanohole Arrays for Localized Surface Plasmon Resonance Label-Free Biosensing by Thermal Nanoimprint Lithography

D. Otaduy[1,2], J. Martínez-Perdiguero[2], A. Retolaza[1,2], A. Juarros[1,2], R. Diez-Ahedo[1,2] and S. Merino[1,2].

[1] IK4-Tekniker, Micro and Nano Fabrication Unit, C/ Iñaki Goenaga 5, Eibar 20600, Spain.

[2] CIC microGUNE, Goiru Kalea 9 Polo Innovación Garaia, 20500 Arrasate-Mondragón, Spain.

dotaduy@cicmicrogune.es

Abstract

Surface plasmon resonance (SPR) sensors are a common tool for real-time label-free biosensing because of their ease of use and good performance. The Kretschmann configuration [1] is the most used commercial SPR systems requiring a somehow complex non-collinear optical set-up. The use of enhanced transmission through metallic sub-wavelength nanohole arrays [2] to couple the incoming light to surface polaritons has proven to be a very good alternative because of its simple linear set-up and boasts higher spatial resolution [4], making it feasible for the miniaturization of the sensing device.

Ordered nanoholes arrays are usually fabricated by Focused Ion Beam (FIB) [2] [3], or Electron Beam Lithography (EBL) [4]. However, although these techniques have very high resolution, the fabrication of arrays require long processing times, that means, low throughput and the associated high cost and therefore, they are not suitable for mass-production. Nanoimprint Lithography (NIL) is high throughput, low-cost, and high fidelity pattern transfer technique which allows obtaining nanometer scale features on large size wafers [5], having a great potential to be scaled up to real production.

Here, we report on the fabrication of periodic gold nanohole arrays on glass substrates using thermal NIL process on a single resist layer, with 400nm and 500nm periodicities and hole diameters of ranging from 150 to 200nm (figure 1). The footprints of the arrays vary from 20µm up to 600µm, proving the feasibility of imprinting over large areas. The fabrication process was optimized and the arrays were fully characterized. It has been proved to be repetitive and the quality of the arrays similar to those manufactured using FIB or ELB.

The extraordinary optical transmission through the nanohole arrays was measured in a designed optical set-up and the sensitivity, 126nm/RIU, was calculated using solutions of known refractive index (n), figure 2. Moreover, the biosensing capabilities of the fabricated arrays have been demonstrated monitoring in real-time the absorption of bovine serum albumina (BSA) protein onto the gold surface without the necessity of labels. In figure 3 it can be seen that the injection of BSA protein at t=120s results in a change of the transmitted spectra which can be measured as an intensity change at a given wavelength and at t≈800s the gold surface was saturated with BSA and no further absorption took place.

References

[1] E. C. Nice and B. Catimel, “Instrumental biosensors: new perspectives for the analysis of biomolecular interactions” BioEssays. **vol. 21**, no. 4, Apr. (1999), pp. 339–52.

[2] T. W. Ebbesen, H. J. Lezec, H. F. Ghaemi, T. Thio, and P. A. Wolff, “Extraordinary optical transmission through sub-wavelength hole arrays,” Nature, **vol. 391**, Feb. (1998), pp. 667–669.

[3] A. Lesuffleur, H. Im, N. C. Lindquist, and S.-H. Oh, “Periodic nanohole arrays with shape-enhanced plasmon resonance as real-time biosensors,” Applied Physics Letters, **vol. 90**, no. 24, (2007), p. 243110.

[4] J. C. Sharpe, J. S. Mitchell, L. Lin, N. Sedoglavich, and R. J. Blaikie, “Gold nanohole array substrates as immunobiosensors.,” Analytical chemistry, **vol. 80**, no. 6, (2008), pp. 2244–9.

[5] S. Y. Chou, et al., “Nanoimprint lithography,” **vol. 14**, no. June, (1996), pp. 4129–4133.

Figures

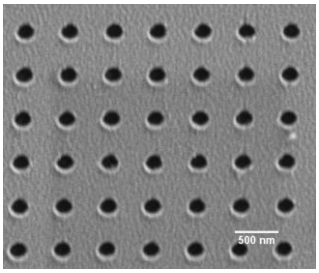

Figure 2: SEM image of a gold nanohole array fabricated by NIL (hole diameter 155nm, periodicity 500 nm)

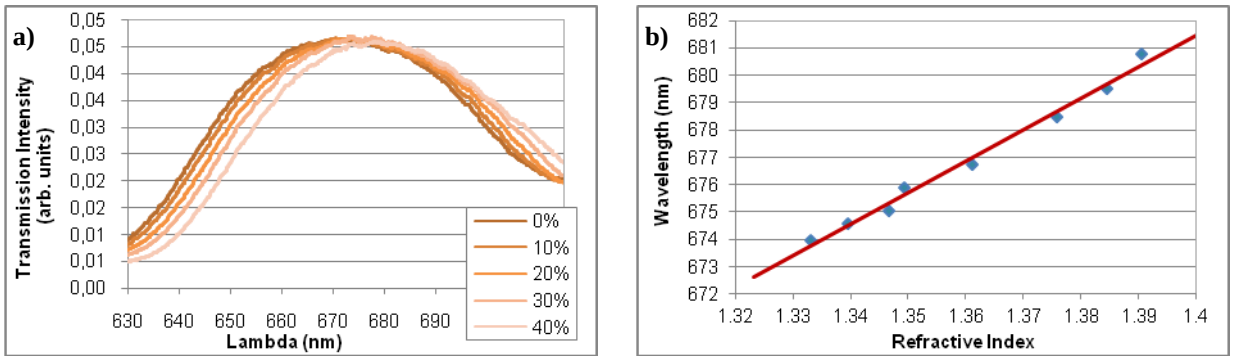

Figure 2: a) Transmission spectra through four sucrose solutions at different concentrations. A clear red shift with increasing concentration (or n value) can be observed; b) Wavelength shift vs. solution refractive index, linear change of the peak can be observed. From the linear regression, 126 nm/RIU sensitivity was obtained.

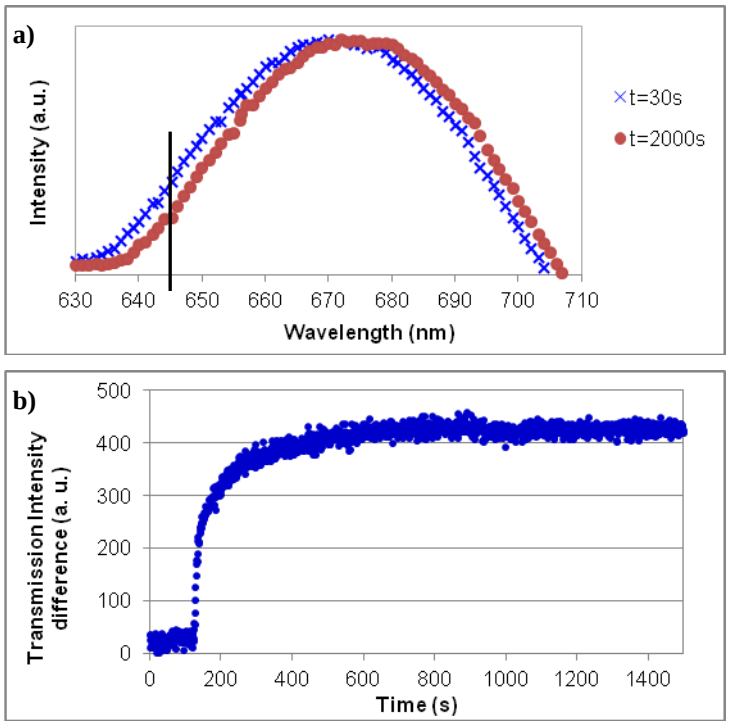

Figure 3: a) Transmission spectra through a gold nanohole array in contact with PBS buffer (crosses) and after 1 hour incubation of a solution of 50 μg/ml BSA solution in PBS buffer (circles) b) Real-time label-free monitoring of the BSA adsorption to the gold surface. The injection of BSA protein at t=150 results in a change of the transmitted spectra which can be measured as an intensity change at a given wavelength. In this case λ=645nm was chosen because it gave the maximum change (see vertical line in (a)). It can be observed that at after 800s the surface was saturated with BSA and no further adsorption took place.