Nanoporous anodic alumina 3d-fdtd modelling optical behaviour for long interpore distance

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Abstract

Modeling the optical properties of nanoporous anodic alumina (NAA) is interesting in order to study and design photonics applications of this nanomaterial. The optical properties of NAA are related to their geometric characteristics (interpore distance, pore diameter, barrier layer thickness, etc.) which depend of the fabrication conditions (acid electrolyte, anodization voltage or current, pH and temperature) [1]. Numerical methods for optical modelling such as the transfer-matrix method are not adequate since cannot take into account features such as the texturization of the metal-oxide interface, the great range of interpore distances, or the inhomogeneities in the chemical composition of the oxide [2].
In this work we show that FDTD is an adequate method to solve these issues as it permits to take into account all the geometrical and composition characteristics. Figure 1 illustrates some of the results: it shows the comparison of the calculated reflectance spectra using TMM and FDTD with the spectrum of a real sample, for short-interpore distance (Figures 1a,c) and for long interpore distance (Figures 1b,c). It can be seen that FDTD, taking into account the texturization of the metal-oxide interface permits to simulate all the range of structures.
These results validate the method for the simulation of such structures, thus, we apply it to the evaluation of the sensitivity of a NAA-based nanostructure in detecting the binding of a biological-related molecule to the surface of the pores. Figure 2 shows the obtained results: the structure consists of a NAA thin film with a 5 nm thick conformal coating of gold (Figure 2a, inset). The bound molecule is modeled by considering a second 5 nm conformal coating with a refractive index slightly different than the medium filling the pores. The spectrum in figure 2a shows a sharp reflectance valley around 800 nm. This valley shifts with the refractive index of the second coating, as illustrated in Figure 2b, what demonstrates the possibility of using the structure as a sensor.

References
[1] T. Kumeria et al., Sensors, **14** (2014) 11878-11918.
[2] W. Lee et al., Chemical reviews, **114** (2014) 7487 -7556.

Acknowledgements
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Figures

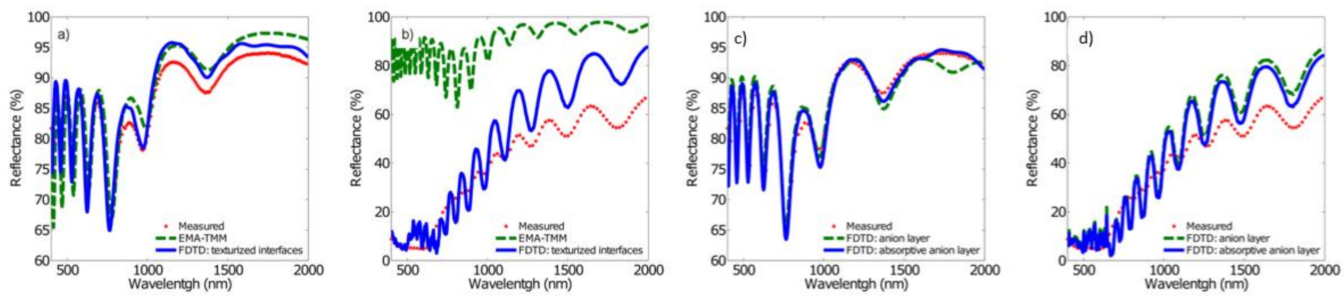

Figure 1: Comparison of the measured reflectances with the simulated ones for NAA structures.

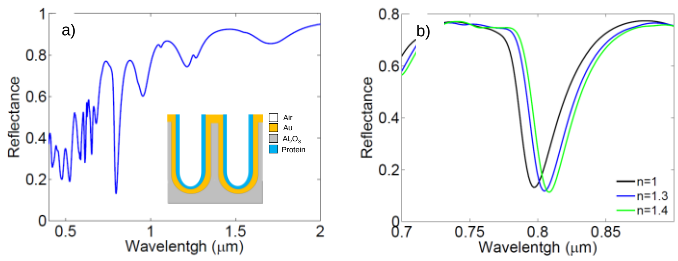

Figure 2: Study of sensing with a gold-coated NAA film.