Resonant Dielectric Nanostructures for biosensor applications

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In the last decade, many technologies based on electrochemistry, enzymatic, fluorescence, and novel materials have been developed for the fabrication of highly sensitive biosensors. Fluorescence detection techniques are probably the most used one in this field but it remains a great challenge to detect fluorescent targets with the lowest detection threshold and best sensitivity, which is critical in early diagnostics and therapies. On the other hand, the relatively high cost of the detection and the fabrication of the materials limit their practical applications. The goal of our study is to make novel bio-array substrates which use concentrated optical near-fields with remarkably enhanced field intensity by means of integrated periodic nanostructures. Beside the sensitivity enhancement in comparison to commonly used chips, the new substrate is fabricated by using low-cost materials achieved by innovative nano-structuring procedures.

In this work, we report the fabrication of dielectric materials such as SiO_2, ZnO and TiO_2 nanopillar arrays and study of their electromagnetic resonance behavior for near field-induced fluorescence enhancement and their application in the optical biosensing technology. To study the strong field intensity enhancement, several optical and geometric parameters of ZnO and SiO_2 periodic nanopillars were systematically varied and manufactured via innovative lithographic and replication processes. Reproducible high quality nanostructures can also be obtained for different structural parameters (i.e. periods, diameters and heights) on transparent glass slides coated with a thin layer of Indium Tin Oxide (ITO).

The field enhancement generated from the dielectric nanostructures was also theoretically analyzed by fully 3-D calculations, using an in-house developed code. All in all, experimental and computational results show strong fluorescence enhancement, which can contribute to development of more efficient and sensitive biosensors.

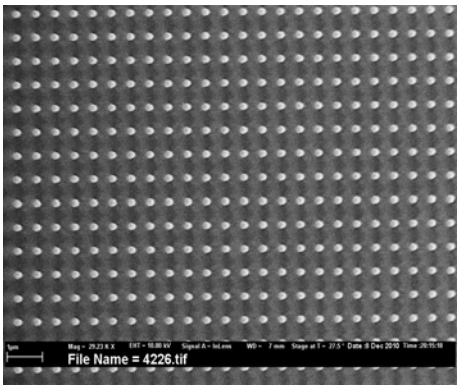

Figure 1. SEM images of SiO_2 nanopillars array on glass slides.

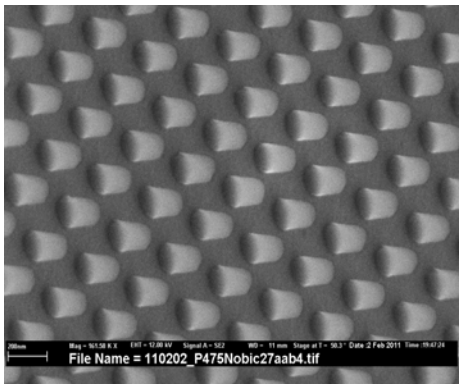

Figure 2. SEM images of ZnO nanopillars array on glass slides.

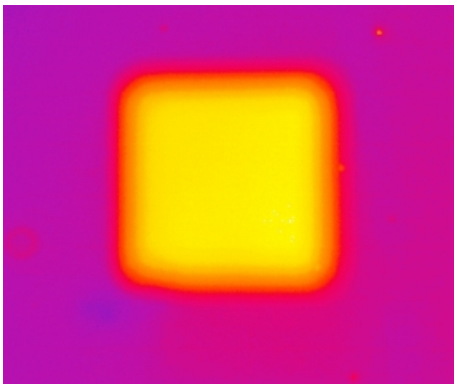

Figure 3. High fluorescence enhancement observed for ZnO nanostructures

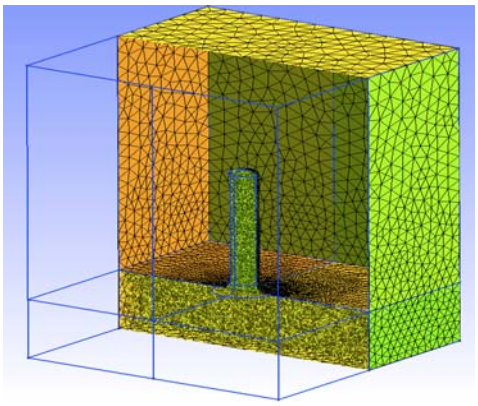

Figure 4. View of the tetrahedral mesh used for the 3-D calculations.