TiO_2 highly ordered quantum dots prepared by anodization techniques on Si wafer

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Quantum dots (QDs) from semiconductor material are very promising candidates for medicinal purposes, mainly as biosensors and labels in biological imaging. QDs exhibit unique physical and optical properties and moreover, there is a possibility of various biomolecules attaching to their surface [1], which allows the detection of DNA and proteins [2, 3].

QDs designed for usage in biological systems are mostly applied in solution (colloidal form) [4, 5]. Nevertheless a demand of deposited QDs on various solid surfaces for biomedical application was also emphasized in some papers [6, 7]. It was found that traditional top–down patterning methods as photolithography and e-beam lithography are time-consuming and expensive processes; therefore there is a demand for new more sophisticated techniques for QDs fabrication [8].

The template-based nanoengineering techniques are probably the most favorable techniques from the price availability point of view. Concerning the templates, many different materials such as porous alumina, polymer gel, surfactant, activated carbon and carbon fiber have been used to synthesize different kinds of nanostructured porous materials. It could be very promising and interesting to use the template-based techniques for fabrication of QDs as a sensor array for in situ biosensing applications mainly due to the simplicity of biomolecules detection [9]. Thanks to this sensors arrangement, where each sensor can be created from QDs emitting the light at the different wavelength, it could be possible to easily detect many different biomolecules at the same time.

This work focuses on developing TiO_2 planar nanostructures (quantum dots, eventually nanowires) for detection of various biomolecules (DNA, proteins) in vitro, which may replace currently used slow and low-sensible methods of detection in medicine. The new way of QDs synthesis is employing of electrochemical deposition through high-ordered nanoporous ceramic template, which belongs to low-cost and rapid preparation technique compared to traditionally used ones, photolithographic or epitaxial depositions. Ordered arrays of titania nanodots can be achieved by successive anodization and utilization of different anodizing conditions of evaporated aluminium (2 μm) and sputtered titanium (200 nm) layers in the same electrolyte. We observed the sulphuric acid solution used as electrolyte provides smaller dimensions of pores and hence of QDs compared to oxalic acid (30 nm vs 50 nm). Finally, the titania QDs were heat treated in order to obtain thermodynamically stable phase, anatase and the anodic alumina mask was removed by etching in mixture of H_3PO_4 and CrO_3 at 60 °C. The following figures (Fig. 1, Fig. 2) represent the nanostructures deposition process using anodically prepared template. Raman spectroscopy measurement will be used to characterize the titania nanodots crystallographic composition. Fluorescence spectra and AFM characterization of prepared samples will be discussed.

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References

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Figures

Fig. 1: SEM image of hexagonal pores in alumina template prepared by anodization

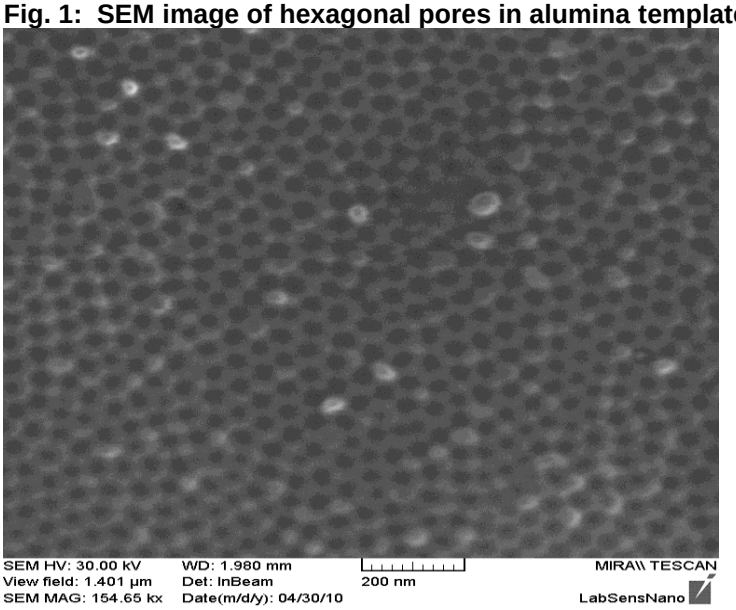

Fig. 2: SEM image of TiO_2 nanodots after alumina template dissolving