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Immobilization of Biomolecules Using Aminated Zinc Oxide Functionalized by Plasma Processing

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The remarkable properties of the nanomaterials influence the modern technical society in many interesting aspects. Zinc oxide biofunctionalization by plasma processing is a new approach that offers simple and fast method toward the development of new bioimaging applications. Zinc oxide is a well studied material and thus we promote it as a suitable candidate for developing novel imaging application by making use not only of its intrinsic properties but also of its new and enhanced properties that arise after plasma processing. Amination of zinc oxide by surface wave plasma and also optimization of the process play an important role for better introduction of the functionalities on the surface of zinc oxide.

1. Introduction

Zinc oxide is an II-VI semiconductor material that attracted a big interest in the research community due to its interesting properties [1] that promoted it as a suitable material for developing diverse applications.

To be able to understand and control the biological processes it is mandatory to make use of materials that pose the same size as the biomolecular components of interest. Recent advances in nanomaterials and nanotechnology provide useful information about different quantum dots that can be used to provide essential information about biological processes.

Currently we focus on the use of biomolecules that can bind with the amine functionalities grafted on the surface of zinc oxide, to be able to put the bases for development of new bioimaging techniques that can detect some specific biological processes. We promote the use of zinc oxide due to his low toxicity compared with other semiconductor based materials and his optical properties, as photoluminescence, at room temperature.

2. Experimental

Plasma processing has already been proven its numerous advantages in the functionalization of different materials both inorganic and organic [2-5].

Surface modification of the zinc oxide commercial powder was realized by employing surface wave plasma (SWP) schematically presented in Fig. 1.

SWP is produced by launching 2.45 GHz microwaves through quartz windows via slot antennas and exciting different mixtures of ammonia and argon gases.

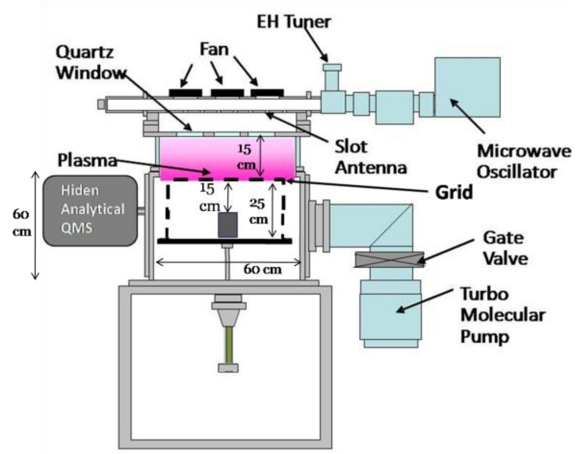

Figure 1.Schematic draw of Surface Wave Plasma device.

The amine groups grafted on the surface of the zinc oxide are used as reactive sites for further connection with biomolecules that can serve as spacing molecules, having the ability of further binding biomolecules. This can enhance the biocompatibility properties and provide higher stability.

3. Results and discussions

In our previous studies we proved the functionalization of the zinc oxide materials, commercial powder and self-prepared nanoparticles in our laboratory by laser ablation, by employing different techniques of investigation like X-ray Photoelectron Spectroscopy correlated with chemical derivatization methods [6]. We also showed that the functionaslization efficiency of the zinc oxide is directly correlated with the mixture of ammonia and argon gas mixture used to excite the surface wave plasma for the generation of the species that are responsible for amination [7].

Quantification of the number of newly created reactive sites, represented by the amine groups, is an important step that was achieved by employing chemical derivatization method. By using Sulfo-LC-SPDP from Thermo Scientific the absorbance of Pyridine 2-thione molecules can be measured at 343nm and the molar concentration of these molecules can be calculated. Figure 2 shows the concentration of pyridine 2-thione molecules measured from the absorbance at 343 nm that is equal with the number of amine groups introduced on the surface of the zinc oxide by plasma processing.

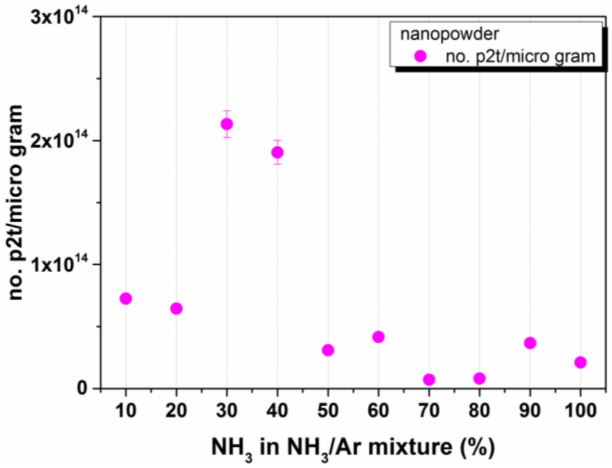

Figure 2. Quantification of the number of amine groups per microgram introduced on the surface of nanopowder ZnO by plasma processing.

As it can be seen from the plot of amine groups number versus the percentage of argon and ammonia in the mixture used to excited the surface wave plasma, the maximum is obtained for the 30% NH_3 and 70% Ar. Once again these results are in strong correlation with the previous ones [7].

The possibility of connecting biomolecules with the amine groups was tested by employing different sugar chains. This biomolecules can serve as spacing molecules, having the ability of further binding biomolecules, and thus offering enhanced stability and biocompatibility.

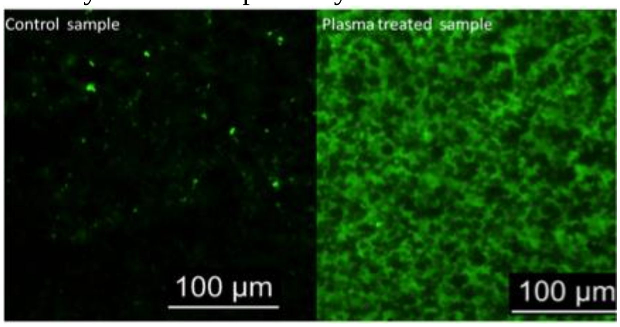

Figure 3. Fluorescence microscopy: (left) unprocessed sample and (right) plasma processed zinc oxide connected with labeled FITC-dextran

Connection of amine functionalizaties with sugar chains, in our case FTIC-dextran, can be monitored by fluorescence microscopy. When exciting with 494 nm wavelength it is possible to measure the fluorescence at 518. In Fig. 3 it can be seen that the unprocessed zinc oxide has no ability to connect the labeled dextran and thus no fluorescence can be observed. Despite that, the plasma treated zinc oxide has the ability to connect with the biomolecules as it can be seen from the right picture in Fig. 3.

These results offers us the good premises that the functionalized zinc oxide can be further used to connect with biomolecules and thus opening new opportunities for development of novel bioimaging techniques.

4. Conclusions

In our studies we were able to achieve the functionalization of the zinc oxide materials by plasma processing and also we were able to optimize this process.

Quantification of the amine groups was perform and the results show a good correlation with the results of the optimization of the plasma conditions.

It was showed that plasma functionalized zinc oxide has the ability to connect biomolecules through the reactive sites, represented by the amine groups, grafted on the material surface.

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