DESCRIPTION OF THE LAYERS OF BIOCOMPATIBLE MATERIALS IN LIQUID ENVIRONMENTS

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Abstract: *The paper presents a study regarding the description of biocompatible materials in different liquid environments. The studies especially refer to those materials used in medicine and which, due to the liquid environments, can modify their structure and properties in a short amount of time. The paper presents the results obtained after comparing different materials that have been investigated.*

Keywords: *biocompatible, liquid environments, Atomic force microscopy.*

1. INTRODUCTION

The principle of operation of an Atomic force microscopy (AFM) is based on a sharp tip (radius at the tip is between 5-40nm), which is scanned over the surface of the sample. The forces between the tip and the sample surface are measured by tracking the deflection of the cantilever. Although there are several design solutions, the basic components of the AFM are the cantilever with a sharp tip at its end, the laser, the detector, the feedback and control electronic system, and the sample-cantilever relative movement system (piezoelectric material).

Operation of the AFM is shown in figure1 (Binnig *et al.*, 1986:930-933; Henderson, 1992:445-447).

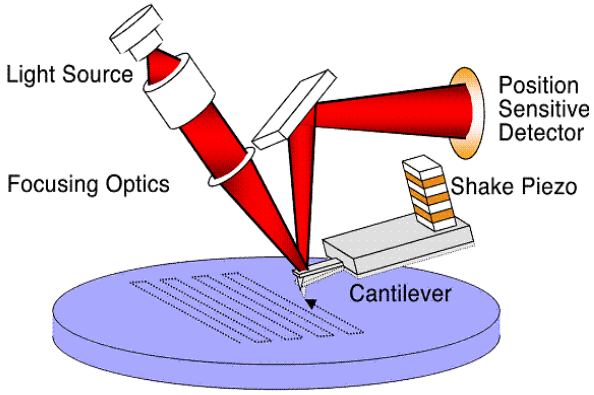


Fig. 1 Atomic Force Microscope Operation

The tip is moved through the scanning area where the surface topology at each point is evaluated. Fine stepping between the points on the surface is essential to achieve high resolution.

This is attained by using piezoelectric materials. By definition piezoelectric crystals, when subjected to an externally applied voltage, can change shape by a small amount. The deformation is of the order of nanometers. This property of the piezoelectric materials makes them suitable for fine displacement of the tip. Over the years, several modes of AFM operation have been developed.

The different modes are the following:

a) Contact mode. In this mode the force between the tip and the surface is constant. Deflection of the cantilever provides information about the sample surface. When the AFM operates in contact mode, the tip touches the surface of the sample with a constant force controlled by a feedback loop.

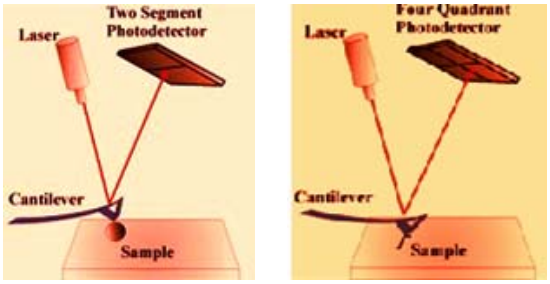
b) Non-contact mode. The cantilever oscillates at its resonant frequency. The oscillation is modified by the tip sample interaction forces. These changes in oscillation with respect to the external reference oscillation provide information about the sample's characteristics.

c) Dynamic contact mode. In this mode the cantilever oscillates so that it comes in contact with the sample with each cycle. Then, a

sufficient force is applied to detach the tip from the sample.

Friction imaging is a method, where the cantilever can measure the friction between the tip and the sample. This imaging method uses torsional deflection. When the tip touches the sample, friction occurs, and it causes the cantilever to twist. A four quadrant photo detector can distinguish the resulting left-and-right motion of the reflected laser beam from the up-and-down motion caused by topographic variations. Therefore, AFMs can measure tip-sample lateral deflection while imaging sample topography.

Figure 2 illustrates the differences between an AFM and a frictional force microscope.



(a) (b)

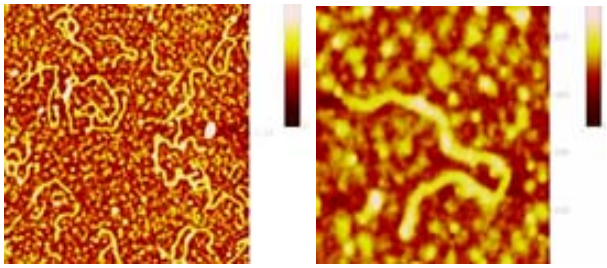
Fig. 2 Atomic Force Microscopy (a) and Frictional Force Microscopy Imaging (b)

2. SEMICONDUCTOR TITANIUM DIOXIDE PARTICLES SYNTHESIS AND APPLICATIONS

Titanium dioxide has been widely used in many areas such as the paint industry, biomedicine, electronics an environmental engineering.

In recent decades, TiO2 nanoparticles (NPs) have had direct applications in the preparation of biosensors because of their biocompatibility, large surface area, stability and strong adsorptive ability on various electrode materials TiO2 NPs were used for the modification of a screen printed carbon electrode (SPE).

The resulting. TiO2 film coated SPE was used to immobilize flavin adenine dinucleotide (FAD). The flavin enzyme firmly attached onto the metal oxide surface and this modified electrode showed promising electro catalytic activities towards the reduction of hydrogen peroxide (H2O2) in physiological conditions.



a) b)

Fig. 3 3D AFM images (10 μm × 10 μm) of (a) TiO2NPs, and (b) FAD/TiO2NPs films

3. MB/ZNO HYBRID FILM

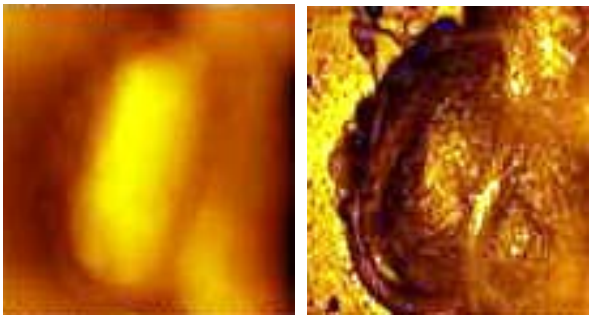
Nicotinamide adenine dinucleotide (NADH) is one of the most important coenzymes in the human brain and body (Hansma *et al*., 1992:1980-1984; Zenhausern et al., 1992: 69-73).

This coenzyme is a common cofactor of about 500 dehydrogenises and its reversible regeneration is a key step in the development of amperometric sensors.

The electrochemical oxidation of NADH in aqueous solution has attracted considerable interest in order to develop amperometric biosensors for the detection of biomolecules. Zinc oxide (ZnO) is an important member of the II–VI group of semiconductors. It has applications in optics, optoelectronics, sensors and actuators due to its emiconducting, piezoelectric and pyroelectric properties. On the other hand, ZnO is a biocompatible material with a high isoelectric point (IEP) of about 9.5 which make it suitable for absorption of proteins with low IEPs and the protein immobilization is primarily driven by electrostatic interactions.

We developed a new amperometric biosensor for detection of NADH based on ZnO/dye hybrid films. Meldola's blue and toluidine blue have been used as mediator. We currently active on metal oxides based electrodes for chemical sensor applications. The following figure shows the SEM images of hybrid film made of ZnO/Meldola's dye modified electrode.

This hybrid film modified electrode shown excellent electro-catalytic oxidation of NADH.



(a) (b)

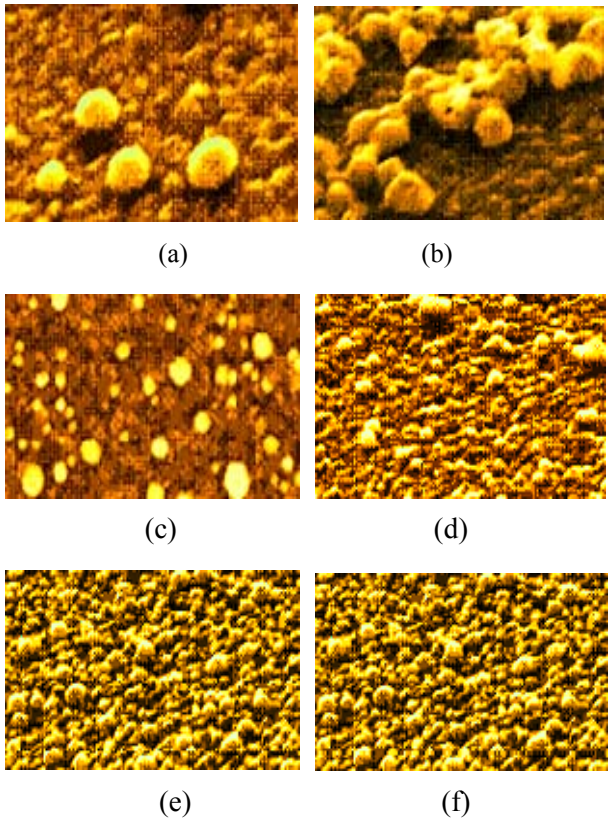
Fig. 4 SEM image of ZnO film (a), and MB/ZnO hybrid film (b)

4. CHEMICAL AND ELECTROCHEMICAL SYNTHESIS OF METALLIC AND BI-METALLIC NANOPARTICLES FOR ELECTROCHEMICAL BIOSENSING APPLICATIONS

PtAu Hybrid Film (Fig. 5).

The fabrication of mono and bi-metallic nanoparticles (Pt, Au, Ag and Pd) by chemical and electrochemical synthesis methods are interesting investigations in the field of nano science. Mono metallic and bi-metallic nanoparticles have their wide range of electrocatalytic activities which can be applied as electrochemical sensors and biosensors. We have developed a PtAu hybrid film modified electrochemical biosensors using L-cysteine as binder.

The developed PtAu bi-metallic nanoparticles modified sensors could be applied for the individual and simultaneous detection of dopamine, ascorbic acid and uric acid and for the selective detection of epinephrine, nor epinephrine, respectively. This PtAu bimetallic hybrid film could be produced on gold, indium ion oxide electrodes for different kind of studies such as electrochemical quartz crystal microbalance (EQCM), scanning electron microscopy (SEM), atomic force microscopy (AFM) and X-ray diffraction (XRD) and direct electrochemical studies (Binnig *et al*., 1986: 930-933, 1982:57-61; Lyubchenko *et al*., 1992:3983-3986).



(a) (b)

(c) (d)

(e) (f)

Fig. 5 (a) SEM images of the Pt particles deposited on ITO from 0.5 M H2SO4 containing 1×10−3 M K2PtCl6 (magnification 25K); (b) NanoAu particles deposited on ITO from 0.5 M H2SO4 containing 1×10−3 M KAuCl4·3H2O (magnification 25K); (c) PtAu hybrid film deposited on ITO from 0.5 M H2SO4 containing 1×10−3 M KAuCl4·3H2O and 1×10−3 M K2PtCl6 (100 µM L-Cysteine, magnification 20K, 30 cycles); (d) PtAu hybrid film (magnification 20K, 60 cycles); (e) PtAu hybrid film (magnification 20K, 30 cycles, 60 deg); (f) PtAu hybrid film (magnification 20K, 60 cycles, 60 deg)

5. CONCLUSIONS

Over the years, several modes of the AFM operation have been developed. He different modes are the following: contact mode (in this mode the force between the tip and the surface is constant); non-contact mode (the cantilever oscillates at its resonant frequency); dynamic contact mode (in this mode the cantilever oscillates so that it comes in contact with the sample of each cycle). Friction imaging is a

method, where the cantilever can measure the friction between the tip and the sample.

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