Atom Force Microscopy of SnO2 Nano Layers. // IEEE International Semiconductor Conference (CAS 2006), 2006, p.p...

Conference Paper *in* Conference Digest - IEEE International Semiconductor Laser Conference · September 2006

DOI: 10.1109/SMICND.2006.283932

CITATIONS
0

READS
13

3 authors:

Liudmila Filevska
Odessa National University
37 PUBLICATIONS **33** CITATIONS
SEE PROFILE

V. Smyntyna
Odessa National University
276 PUBLICATIONS **621** CITATIONS
SEE PROFILE

Viktor Grinevich
Odessa National University
48 PUBLICATIONS **38** CITATIONS
SEE PROFILE

Some of the authors of this publication are also working on these related projects:

13. Coordinator of BIOSENSORS Agricult - FP7-PEOPLES-2012-IRSES project, contract Nr.316177 - “DEVELOPMENT OF NANOTECHNOLOGY BASED BIOSENSORS FOR AGRICULTURE”, 01.09.2012-31.08.2016. View project

ATOM FORCE MICROSCOPY OF SnO_2 NANO LAYERS

L.N. Filevskaya, V.A. Smyntyna, V.S. Grinevich

Odessa National I.I. Mechnikov University, 2, Dvoryanskaya str., Odessa 65082,
tel/fax: 38-048-731-74-03,
E-mail: grinevich@onu.edu.ua

Abstract-*The gas sensitivity applied problems solutions need a consideration and detailed investigation of the material's electronic and ionic subsystems' behavior. These systems' behavior at their own turn is tightly connected with the structure and morphology of surfaces. The morphology investigations results are given for the SnO_2 layers obtained with the polymers usage.*

1. INTRODUCTION

The nanoscaled materials have physical properties principally differing from the corresponding ones of microscaled objects, and are widely used in electronic, optical and magnetic devices such as gas, optical sensors, photodiodes, sun cells, monoelectron transistors and memory units [1]. The nanomaterials' specific peculiarity is their great active surface which defines the crucial time and temperature decrease for the chemical reactions proceeding [2]. The mentioned property is widely used for the constructing of the new gas sensors' generation with perfect speed of response and low energy consumption. In connection with the said it is reasonable to elaborate the nanograins materials, with controlled development surface for the gas analysis. The technique using polymers as the components assisting in structuring is proposed for the aims of obtaining of well developed surface layers having the nanoscaled grains. The nanocrystallized tin dioxide having the electroconductivity highly sensible to the state of the surface in the (300-800) K temperature region specific for the oxidizing-recollecting reactions has the most practical use in the gas analysis[3]. It is one of not many materials, which may be obtained in highly dispersed state (crystallite sizes 5-20 nm). The tin dioxide surface has perfect adsorptive properties and reaction ability which are defined by the surface and bulk oxygen vacancies and active chemisorbed oxygen [3] and are tightly connected with the surface morphology. These ideas predefined the SnO_2 surface morphology investigation.

2. THE LAYERS PREPARATION METHODS

The transparent thin nanostructured tin dioxide films were prepared using polymer materials in the sol-gel method. The production technique had several stages: preparation of the Tin containing organic fillers, preparation of polymer material sol in the solution and, finally, insertion the tin containing compounds into it. Further, the gel obtained was deposited on the substrate and finally annealed in the muffle stove. Theannealing time and temperature were choused with the consideration of the polymer'sdecomposition time. After the polymer's decay products full removal during the annealing and the following it oxidation, the thin Tin dioxide layers with developed nanostuctured surface were formed. The films obtained had different degrees of transparency (from milk-white to fully transparent) and different adhesive properties. Having obtained these results, it is clear that the preparation of such films needs both different solvents (water, acetone), polymer materials (polyvinyl spirits, cellulose, poly methylmetacrilat and others) and Tin containing fillers. The films based on the polyvinyl spirits gel had

1-4244-0109-7/06/$20.00 © 2006 IEEE

weak coherence with substrates and were of milk-white color. This witnesses about presence in the film of not only Tin dioxide, but and other reaction's products. Films based on the cellulose had the dark brown color, which is specific for the bivalent tin oxide – SnO. The darkening of the films may be caused by the extremely great carbon contain, which stays in the film after the cellulose was burn away. The films based on poly vinyl acetate (PVA) with the addition of acetylacetonate of tin appeared to be fully transparent with tight adhesion with the substrate. The initial sol was prepared as following. PVA was cleaned by 25% ammonia (NH_4OH) solution, was washed three times in a distilled water, then was dried by the $CaCl_2$ dryer, then was polymerized by means of 1% benzoil peroxide solution and finally was grinded. Then the PVA obtained was inserted into the dissolver (acetone) at the room temperature. In a case of polymer's insolubility in the solvent, the monomer of the same substance may be used. The geltype structure was formed after 20-60 minutes of thorough mixing. The solution of $Sn(AcAc)_4$ powder in acetone was inserted into the gel obtained. After special preparations of the glass substrate it was covered by the mono layer of the film. Then it was kept for 5 minutes in the open air for the acetone may evaporate. The annealing at 500_0 C was provided in the muffle stove for 3 hours. The polymer, which was within the gel decomposed, and the decay products evaporated. The film's surfaces structural and morphology investigations were conducted after the preparations procedure was fulfilled.

3. EXPERIMENTAL RESULTS

The films obtained could not be investigated by the X-ray technique, because the films' thickness and their grains' nano scale were less than 100nm which is critical limitation for the X-rays methods. The atomic force microscope (AFM) is being widely used to measure interatomic potentials of a sharp probe in the nearfield of a specimen overcomes the diffraction limit by nearfield observation of the specimen, thus permitting sub-micrometer of nanoscale measurement [4]. The tin dioxide layer's surface morphology was investigated by means of Atom Force Microscope (AFM) NanoScope III a (Digital Instruments, USA). The measurements were fulfilled by silicon tips (from NT-MDT, Russia) with the nominal radius ~ 10 nm in the TappingMode^{tm}. The investigated surface areas were 500x500 nm^2. The film's surface top view is presented at Fig. 1.

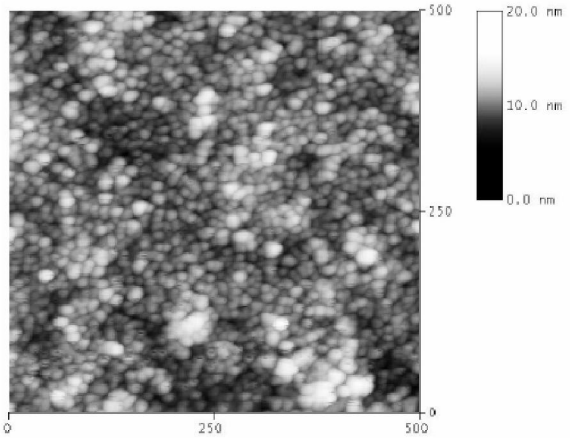

Fig. 1. Tin dioxide layer's surface (top view).

As it may be seen, the films investigated is enough uniform and consists of nanograins of of narrow size distribution. The mean grains' size is 10-15 nm and Z-range about ~ 10.5 nm. The appropriate phase image confirms the homogeneity of viscosity-elastic films' properties. The film's cross-section with surface features is presented at Fig. 2.

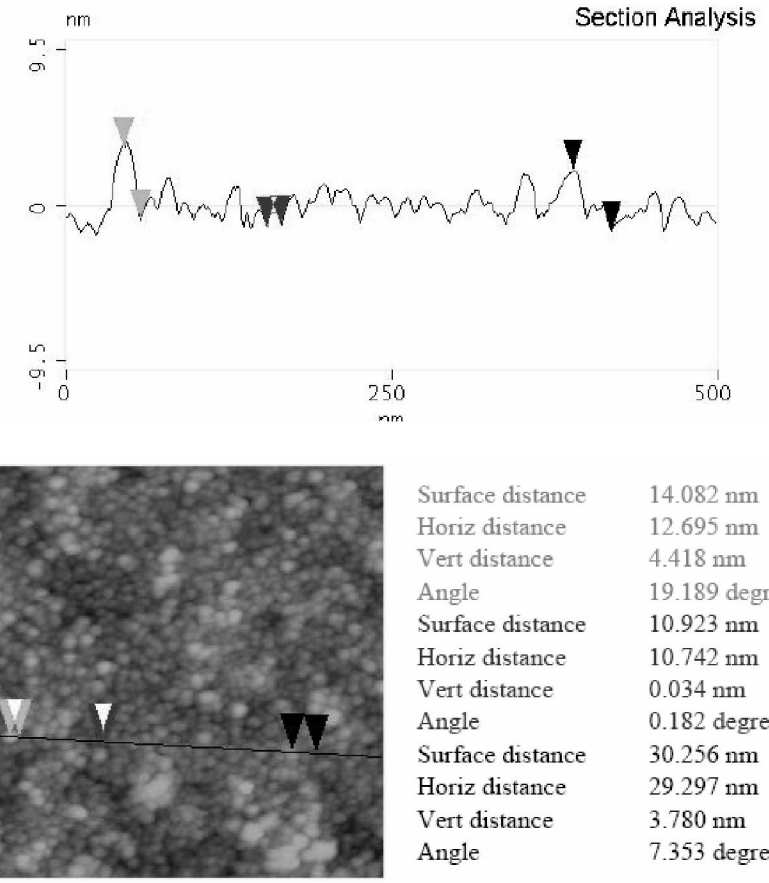

Fig. 2. The film's cross-section (a), with inter benchmarks sizes indication (b): the grey colour nuances of the text corresponds to the grey colour nuances of the benchmarks.

Evaluating the grain's size and height distribution it is possible to conclude that the film investigated is nanostructured and for the used gel's composition is continues, but not of isle type. The 3D view of the film is given at Fig. 3.

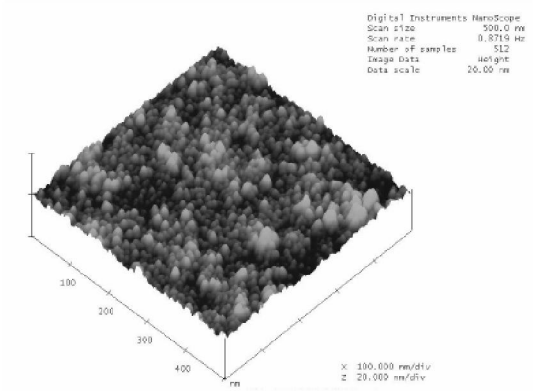

Fig. 3. Three dimensional tin dioxide film's surface view.

4. CONCLUSIONS

The main results of the presented work may be given as following the SnO2 films were obtained using the polymeric substance and have nanosizes; it was established that the principal surface morphology peculiarity is a developed films' surfaces having grains of 10-15 nm sizes The film's surface morphology investigations fulfilled give the possibility to predict the surface electrical potential distribution. Thus, this permits to show the regions of charge nonuniformity. Such regions' presence seriously defines charges exchange processes. Especially it becomes important when the film's surface interacts with different chemically active molecules. It means that the processes of chemisorption are taken into consideration. The understanding of the principal

mechanisms of electronic subsystem behavior peculiarities at gas system contacts makes it the basis for sensitive elements construction principles.

Acknowledgement-Authors are thankful to our colleague Oksana Lytvin, from the V.E. Lashkarev Institute for Physics of Semiconductors, National Academy of Sciences of Ukraine, Kiev for her support in AFM investigations.

References

[1] H. Fissan, M.K. Kennedy, F.E. Kruis. Nanoparticles from the gas phase as building blocks for electrical devices// Book of abstracts of International Symposium on "Nanoparticles: Technology and Sustainable Develoupment", Taipei, Taiwan, September 9-10, 2002, p.1-6.

[2] Sergeev G.B. Nanohimiya.- M. Moscow State University edition, Russia, 2003, 288 p.

[3] Rumyantseva M.N., Safonova O.V., Bulova M.N., Ryabova L.I., Gaskov A.M. Russian Journal "Sensor", 2003, ed. 8., P.P.27-35.

[4] H. Xie, A. Asundi, Z. Liu, H. Shang, F. Dai. Micro- and Nano-Methods for Microscopy of Electronic Nanostructures// Microscopy and analysis. November 2005.- P. 21-23.