Armenian Journal of Physics, vol. 1, 2008, pp. 142-145

PREPARATION OF ZnO<AL> NANO-SIZE LAYERS BY MAGNETRON SPUTTERING

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Kyewords: gas sensor, semiconductor, ceramic sample

1. Introduction

ZnO thin films have been extensively investigated over last 30 years. They draw a rapidly growing interest due to their wide range of scientific and technological applications, such as thin-film gas sensors [1], surface acoustic wave (SAW) devices, transparent conductive coatings, optical waveguides and laser deflectors, light modulators and optical sensors [2].

As is known, ZnO is a direct band gap semiconductor, which gap size at room temperature is equal to 3.3 eV [3]. ZnO has a high binding energy of exciton (60 eV at room temperature). This permits to consider ZnO as a perspective material for semiconductor lasers of the near UV and Blue ranges. For preparation of ZnO layers various methods are used: molecular beam epitaxy, deposition from gas phase, pulsed-laser deposition, and magnetron deposition [4, 5].

2. Experimental

As is known, ZnO has a relatively high resistivity $\sim 10^{12}$ Ohm. To increase the conductivity of ZnO it was doped with 1% Al. The semiconductor ceramic samples of ZnO, doped with 1 at.% aluminum have been synthesized by the method of solid phase reactions in air under the program: rise of temperature up to 800^0C for two hours, the soaking at this temperature during 3 hours, the subsequent slow cooling. Obtained samples of ZnO<Al> had a surface conductivity $\sim 1.2\times10^3 - 2\times10^3$ Ohm. The obtained ZnO<Al> samples were polished and underwent chemical treatment. For obtaining homogeneous thin films on the base of Zn<Al> by magnetron spattering, the following technological cycles were processed: (i) the distance between the target and substrate was kept in constant change from 40 mm to 100 mm, (ii) for each fixed distance the deposition time-length was varied from 30 min to 80 min, and the magnetron's power supply power was changed from 50 to 100 W. The thickness of the obtained layers was measured by profilometer (Ambios XP-1 Stylus Profiler). The surface of layers was scanned by SEM microscope (VEGA 5130 MM TESCAN).

3. Results and discussion

After the measurements of the samples thickness, which were manufactured via different technological cycles and after scanning their surfaces by SEM an analysis of the obtained results was carried out; it made possible to select those deposition regimes at which homogeneous layers could be obtained. The homogeneous layers were obtained for cases when the distance between the target and substrate was equal to 90 mm, and the power of the magnetron power supply was equal to 80 W.

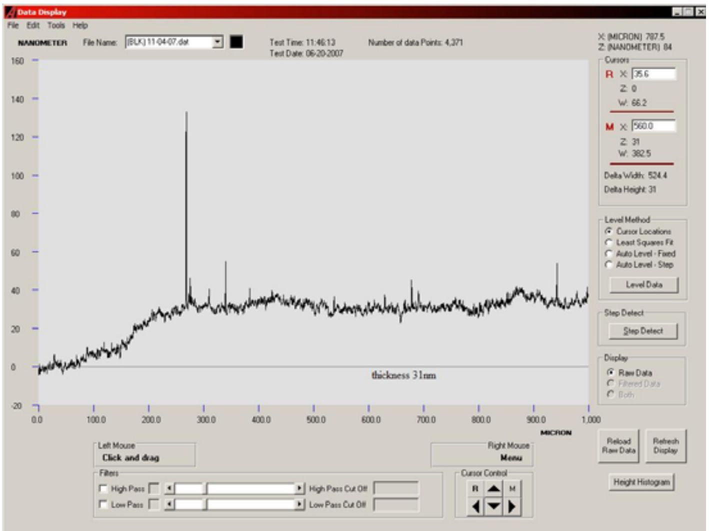

Fig. 1a.

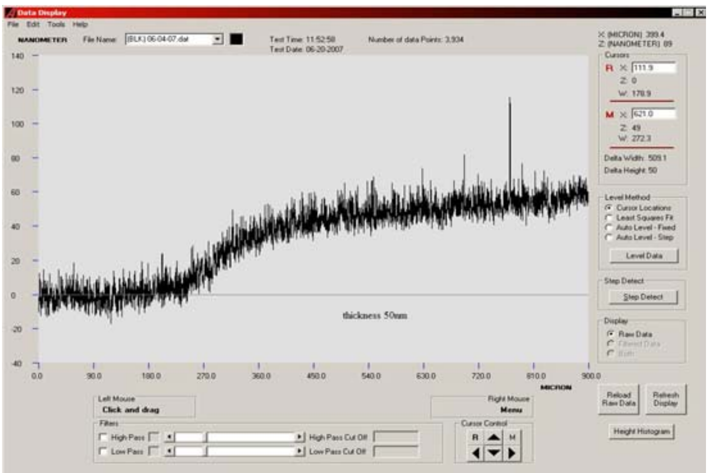

Fig. 1b.

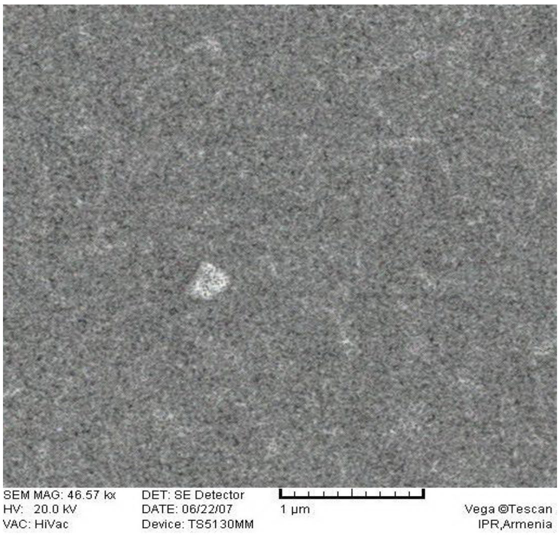

Fig.2. a) SEM image of obtained ZnO<Al> samples.

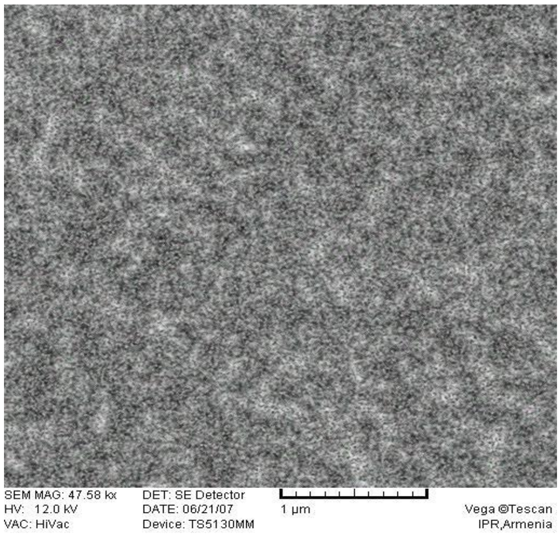

Fig.2. b) SEM image of obtained ZnO<Al> samples.

Figs. 1a and 1b depict measurements of the thicknesses of 31 nm and 50 nm layers carried out by profilometers. Fig. 2 describes the surface profile taken by SEM system. As is seen in Fig. 2 a and b, the sizes of grains assembling the sample are equal to 20–30 nm.

With the help of "Mathematica 5.2" package of Wolfram Research Inc., the experimental curves of layer thickness dependence on the deposition time were approximated, the obtained dependence has the following form: d=1.58932$\times$(t-5)(nm) (d is a thickness of film). The curve behavior is illustrated in Fig. 3.

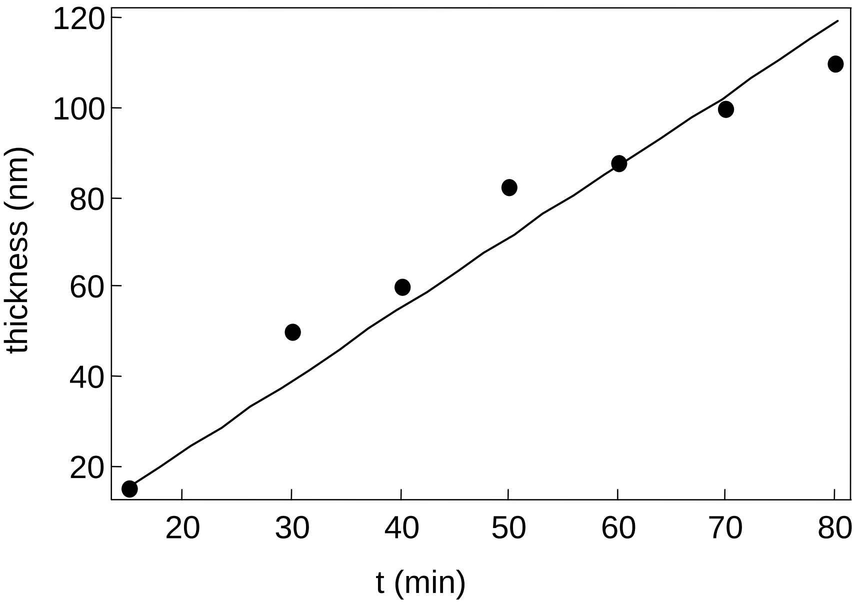

Fig.3. Layers thickness dependence on the magnetron sputtering time.

3. Conclusion

In this article nano-dimensional thin layers were obtained which thicknesses vary from 15 nm to 110 nm. As is seen from the scans of the SEM, the grain sizes vary from 20 nm to 30 nm.

During recent years there is a high demand in hydrogen and hazardous gases sensors having high sensitivity, response and recovery short times able to operate at relatively low temperatures. For development of such sensors thin–film structures based on metal-oxide materials are under intensive studies today. To ensure high sensitivity, response and recover short times, the thicknesses of the sensitive layers must be from 10 nm to several hundreds of nanometers and the grain sizes should be from 1 nm to several dozens of nanometers. Recent investigations [6] demonstrated that ZnO is a perspective material for development of highly reliable gas sensors.

Acknowledgments: This investigation was carried out in the framework of the Armenian National Program ”Semiconductor Nanoelectronics” no 041030 and ISTC A-1232 grant.

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