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Influence irradiation argon ion SnO_2 on optical and electrical characteristics

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Abstract. Tin oxide in the form of films has been deposited by reactive magnetron sputtering on glass substrates a room temperature .Process was carried out in such mode when the deposited films were conductive. The deposited films were irradiated with argon ions. Have been studied happening at that the changes optical and electric properties of films. Have been investigated optical properties of films in the range of 300-1100 nanometers by means of photometry. For research structure of films was used the x-ray diffractometry. Diffractometric researches have shown that the films deposited on a substrate have crystal structure from shares of a quasicrystal phase and after influence of argon ions she completely became quasicrystal. It is established that change transmission of a film correlates with change her electric resistance. Average value transmission in the range of 380-1100 nanometers as well as the electric resistance of a film with growth of irradiation time increases to the values exceeding initial. At the same time at irradiation time ~ 13,2 sec. are observed their slight decrease. To this value of irradiation time there corresponds the minimum value of electric resistance and transmission films. Change of transmission coefficient correlates with change of surface resistance.

1. Introduction

The transparent conductive oxide (TCO) films are widely used in various industries [1-4]. These optically transparent electrodes are for displays, solar panels, photoelectric devices, touch panels, etc. One of them is tin oxide, which has found wide practical application. In some practical applications, there is no need to simultaneously achieve high value of transmittance and low resistance. In such cases it is possible to use an undoped tin oxide. Pure tin oxide has conductivity and transparency. This is due to the existence of intrinsic point defects that act as vacancies [5,6]. Annealing deposited films leads to a modificated in the optical and electrical properties. Annealing films at an air, the between O and Sn ratio changed that leads to a decrease in their resistance [7,8]. However, the transmission and resistance depends on the duration of the annealing. Annealing the tin oxide films in a vacuum results in a significant reduction of resistance [9]. In work [10] it is shown that the optimization of oxygen content and the substrate temperature one can receive films with improved transmittance and resistance values. Tin oxide can be in the form of SnO2 and SnO. Under heating, these phases interact with one another that leads to the modification of films properties [9,11,12]. The effect of films annealing in various atmospheres (air, vacuum or hydrogen atmosphere) is studied in work [9]. The correlation was found between the structural and optical properties of SnO2 films. In the work [11] tin oxide films were annealed at different time period, however the correlation between the electrical specific resistivity and optical and structural properties was not found. In works [13], it was studied

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the effect of oxygen content in a reactive gas mixture on the properties of the deposited tin oxide films. It is shown that films consist of an amorphous and crystal phase [14]. The formation of textured films in the course of the sedimentation of tin oxides and its transformation into polycrystalline SnO2 at a low temperature (~ 200 °C) is investigated in [15]. Stoichiometry of films depending on the oxygen content and its influence on electric properties were investigated in [16]. The influence of sedimentation rate of a film on specific electric resistance has been studied in [17]. The mechanism of conductivity of pure oxide tin films deposited at various temperatures of a substrate has been investigated in work [18]. In work [19] the influence of the application of an external constant magnetic field on resistance and an optical transmission of the deposited films is investigated. Oxygen negative ions of the magnetron discharge [20] also have an impact on the films properties. The influence of ionic stimulation in the course of films sedimentation on optical properties of a film is considered in [21]. The properties modification of already deposited films happens at the irradiation by an ionic beam of already deposited films [22-24]. In this research, the tin oxide films were deposited by a reactive magnetron dispersion, and the films after sedimentation were irradiated by a bunch of argon ions.

2. Experimental details

Thin films of tin oxide were deposited on the glass substrates using reactive magnetron sputtering on the target in size 700x100x5 mm from tin (purity of 99,5%). The sputtering was carried out at a working pressure of 0.3 Pa in the gas mix O2 and Ar (O2 – 60%, Ar – 40%). The voltage of the magnetron discharge was ~ 275 V. Under these conditions the deposited films were dielectric. The power the discharge at sedimentation was stabilized at the level 1.2 kW. The heating of substrates was not carry out. The substrates were placed on a carrier that was able to carry out a reciprocating motion under the magnetron and the ion source in a vacuum chamber. The distance between a sample and a target was 8 cm. Speed movement of the carriage was 3.62 cm/sec. After the deposition, tin oxide films were irradiated with argon ions. The ions beam was located at an angle 90o to a substrate surface. Ions were generated by a source of ions with the closed drift of electrons at a voltage 2800 V and discharge current 0.28 A. The current density on a surface of samples was 2.4 *10-3 A/cm2. However, the pressure in a chamber was 0.166 Pa. The thickness of the deposited films was measured using profilometer MicroMeasure 3D Station. The measurement a spectrum of a transmission in the range of 300-1100 nanometers the was used spectrophotometer SF-256. The structure of films was studied on the x-ray diffractometer XRD6000. The average size of crystallites was estimated by half of width of x-ray diffraction lines.

3. Results and discussion

Conductive films of tin oxide were deposited on a glass substrate. For research of a structural films SnO2 was deposited thickness ~800 nm, and for optical and electrical – 264 nm.

Figure 1 shows the diffractogram films of tin oxide before and after irradiation by Ar ions. It is found that the films SnO2 after magnetron deposition have crystal structure with shares of amorphous (quasicrystal). The analysis of XRD data showed that the deposited films consist of pure SnO2 tetragonal structure without the presence of other phases – SnO and Sn. Similar results were observed.

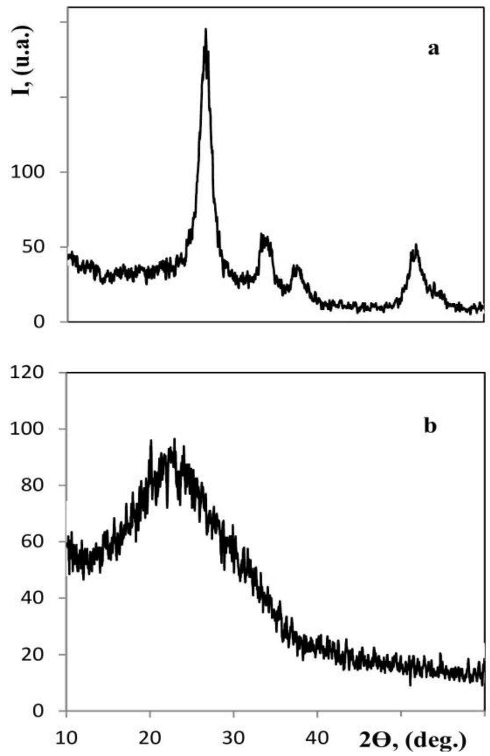

Figure 1. XRD diagram samples of SnO_2:
a- before irradiation: b-after irradiation

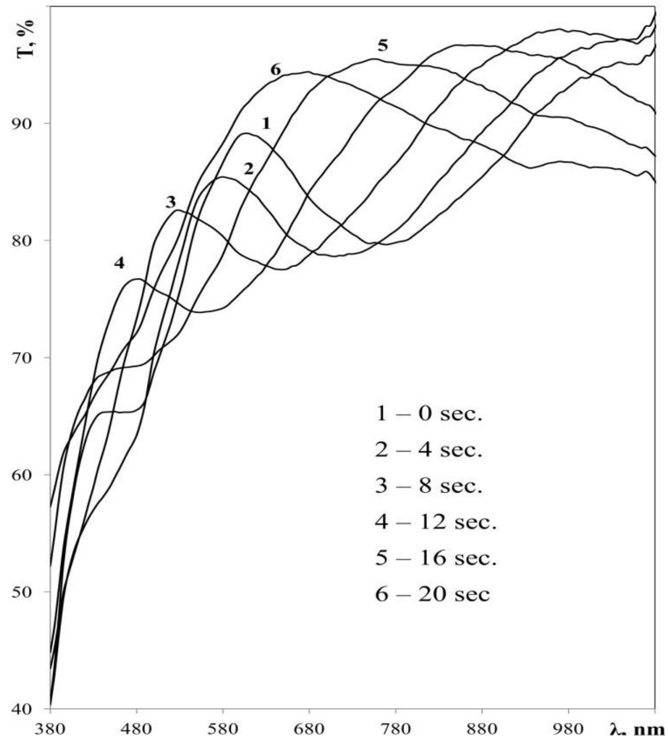

Figure 2. Dependence of the transmission on the irradiation time

in work [17]. Moreover, presence of other phases of tin oxide in films it was not revealed. The size of crystallites makes ~ 10 nanometers. After irradiation of structure became quasicrystal (amorphous).
Figure 2 shows the results measurement transmission of films SnO2 at various of irradiation times. It is found that the transmission T (λ) in depending on irradiation time it has different character. On the impact at 0 to 13.2 sec., the dependences T (λ) have similar qualitative nature. For these times is characteristic existence of area of a maximum transmission.

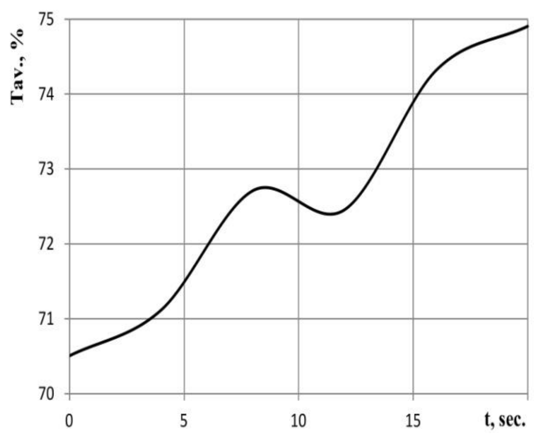

Figure 3. Dependence of the average value of the transmission on the irradiation time

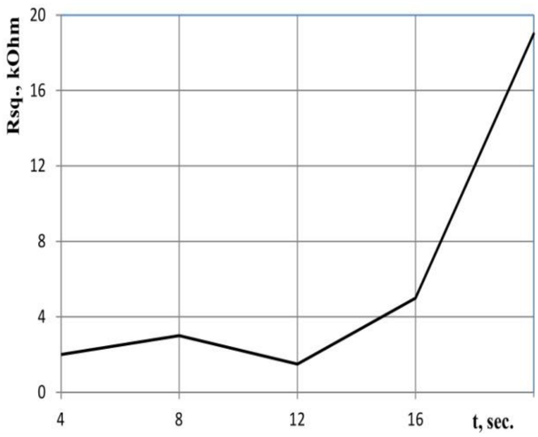

Figure 4. Dependence of surface resistance on the irradiation time

Shift of a maximum transmission to the area short lengths waves at time of exposure an ionic beam less than 13.2 sec. are possible, is connected with formation of polycrystalline structure SnO2 of [12] nanodisperse sizes. Decrease in the maximum value transmission at influence time of an argon ions beam from 0 to 13.2 sec. is possible, connected with destruction chemical bond of Sn-O. However, in the surface layer is formed metal tin and free oxygen which is sorbed. The formation in the surface layer of metal particles of Sn leads to growth of reflection a light stream and as a result – to decrease in a transmission. At further influence of an ionic beam there is a desorption of the formed oxygen and the composition of a film becomes closer to stoichiometric that provides to improvement it transparency of a film.

Figure 3 shows the change of size average value transmission of samples with the deposited SnO2 films in the range of 380-1100 nm depending on irradiation time ions Ar. It if found that the transmission with increase in influence time of ions first decreases, and then increases. The minimum transmission is observed at influence time of a beam ~ 13.2 sec. Generally, increase value average transmission happens improvements transmission in the field of lengths waves of 500-900 nm. It is connected with improvement stoichiometry composition of a films as a result of a desorption of tin metal. Small decrease transmission is connected with destruction of the existing communications and education new under the influence of the bombarding argon ions.

Fig. 4 demonstrates the measurements of a film surface resistance depending on the influence time of an ion beam. It correlates with the change of average transmission. On an initial the plot resistance of a films increases. It on all visibilities is connected with a desorption of metal tin from a surface. At further impact of an ionic beam on a films happens some decrease of resistance at the expense of oxygen desorption. At big times of impact of an ionic beam the composition of a film approaches stoichiometric and resistance of a film increases up to a condition of dielectric.

4. Conclusions

Conductive polycrystalline films of pure SnO2 were deposited at the room temperature using reactive magnetron sputtering. After deposition of a films SnO2 were irradiated the argon ions in the result what films became quasicrystal. With increase in of irradiation time average value transmission of a film increases from 70% up to 75%. However, at irradiation time ~ 13.2 sec. are observed insignificant decrease (to 72. 45%). This time there corresponds the minimum value of superficial resistance. At other irradiation times resistance of a films grows with growth of irradiation time. Is observed the correlation between optical and electrical properties of films SnO2. Results research show that optical and electrical properties of films can be changed after deposition.

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