The study of humidity sensors having sandwich structure based on chalcogenide glasses

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Abstract

This article is devoted to the study of the influence of moisture in sandwich structure Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$-Te, Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx-Te (x=1 at%).It is clear from the analysis of schedules, after thermal annealing time characteristics is improved for the sample doped by Sm.After thermal annealing decreases 2-4 times inertia inAs$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx (x=1 at%).This increases the possibility applying of humidity sensors.

INTRODUCTION

Studies have shown that, the preparation humidity sensors of various types having superior parameters and physical technical capabilities are very importantfor modern technologies. In chalcogenide glass-like semiconductors occurs change of the conductivity with influence of the humidity, which since the electron process is quite fast observed sensors on based chalcogenide glass-like semiconductors are high sensitive and the sizes compact, in addition to being low-cost and energy consumption work at room temperature[1-2,3]. The analysisof studieshas shown that, mainly humidity sensors are divided into two types: relative and absolute humidity sensors. For the former included in on the based sensors of ceramics, polymers, semiconductors and the second with the dew point and aluminum oxide sensors. These sensors have a number of disadvantages (observation of deformation during adsorption of the water vapor, the long reversibility and reaction time, the smallworking rangeHumidity sensors based on semiconductor materials chalcogenide glassy following may be considered as perspective superior physical and technological characteristics.

The main aim of paper is study of humidity sensors based on sandwich structure Al- As$_{33.3}$Se$_{33.3}$S$_{33.4}$ -Te, Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx -Te.

The sample manufacturing technology of sensors on based chalcogenide glass semiconductors having the high homogeneous. During adsorption of the water vapor deformation isn't observed and their parameters are stable. The reversibility and reaction time is quite small (a few seconds) in the humidity sensors made from these materials.

EXPERIMENTAL TECHNIQUE AND PREPARATION OF SAMPLES

The synthesis of CVS materials As$_{33.3}$Se$_{33.3}$S$_{33.4}$ and with samarium impurity (x=1 at%) is fulfilled as follows: element substances (high purity grade) and samarium in the indicated atomic percentages were placed into quartz ampoules and after evacuation to a pressure of 10^{-4} mm Hg were heated for 3 h to a temperature of 900–950°C and stored for about 12 h at this temperature. In order to achieve homogeneity of the samples,the synthesis was carried out in a rotating furnace and cooling was carried out in the mode of furnace disabling. The samples were fabricated by the thermal evaporation method in vacuum »10^{-6}mm Hg as the"sandwich" structures with Al and Te electrodes. Films of 2µm thickness used in the studies were obtained by thermal evaporation at a rate of 0.4– 0.5 µm/min onto glass substrates.. The temperature of the substrate did not exceed 310–320 K. Special annealing of the film and substrate was not carried out. Investigations into the aggregate state and structure of the synthesized substances and deposited films are carried out on a powder diffractometer D8 ADVANCE produced by Brucker (Germany) in a mode of 40 kV, 40 mA, 0° <2θ <80°. A special software program, Evaluation, was used for the analysis of the first sharp diffraction maximum. The area, amplitude, maximum position, and the width corresponding to its half (full width at half maximum (FWHM)) were determined.

RESULTS AND DISCUSSION

The figures present X -ray pictures of the sensitive films As$_{33.3}$Se$_{33.3}$S$_{33.4}$ and containing samarium impurity(Fig. 1). The broad maxima on the diffractogram pictures indicate the film's amorphism. As can be seen from the X-ray of the samples, the first one is the most intense (first sharp diffraction peak (FSDP)). This is also typical for most other glass [4–5].
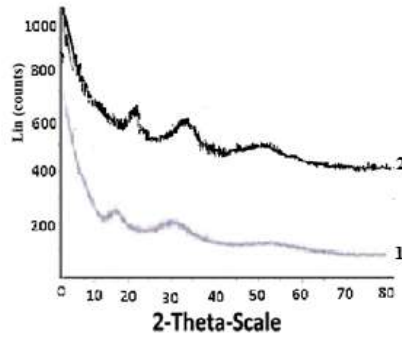
I S S N 2 3 4 7 - 3 4 8 7
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Fig. 1.X-ray pictures of thermally deposited

films containing samarium.1-$As_{33.3}Se_{33.3}S_{33.4}$; 2-$As_{33.3}Se_{33.3}S_{33.4}$:Smx(x=1 at%).

In figures are presented the three-dimensional-3D (Fig. 2) AFMimages of the surfaceof materialsCGS$As_{33.3}Se_{33.3}S_{33.4}$(a) and doped withsamarium.
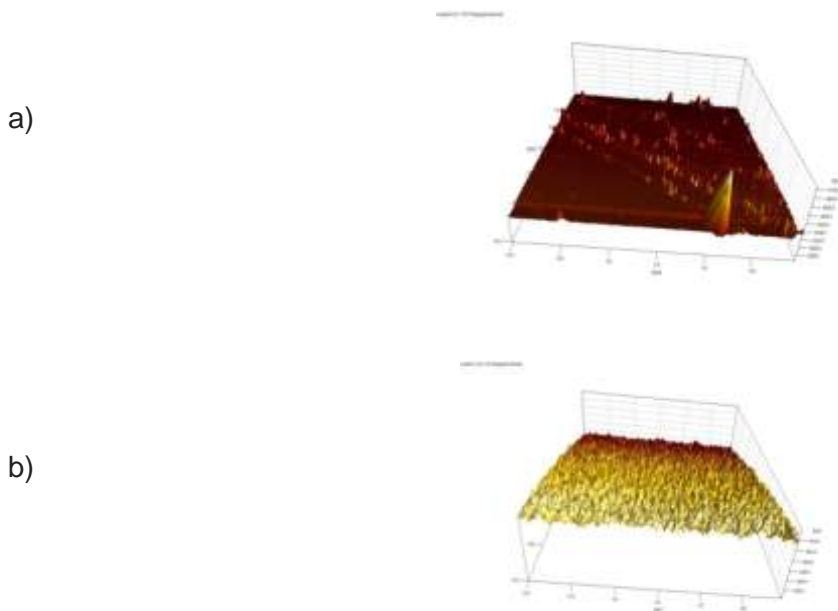
a)

b)

Fig. 23D AFM images of the surface .$As_{33.3}Se_{33.3}S_{33.4}$(a); $As_{33.3}Se_{33.3}S_{33.4}$:Smx(x=1 at%)(b).

As shown in Fig.2the AFM-imageare undergoingsignificant changesdepending onthe chemical composition andalloying.The parameters characterizing themorphological characteristics ofthe surfacewere calculatedthe application ofV6.0.2.0softwareSPIP,whose results are presented in Tables1.

WhereR_a -arithmetic meanroughness, i.e.the arithmetic mean ofthe absolutevalue of the verticaldeviation from the meanline throughthe profile,R_q-mean squareroughness, is the square rootofthe arithmetic meansquaredeviation fromthe verticalreference line.The surface morphology of $As_{33.3}Se_{33.3}S_{33.4}$films has been investigated by AFM method and also the changes happening in them at an alloying samarium. As a result doping by samarium decrease the amplitude roughness (R_a and the average arithmetic mean square - R_q roughness, the maximum roughness.

Parameters	$As_{33.3}Se_{33.3}S_{33.4}$	$As_{33.3}Se_{33.3}S_{33.4}$:$Sm_1$ at%
Ra, nm	15,2347	12,5865
Rq, nm	28,2347	15,7176

Influence of a dopingof samariumon the surface morphologycan be interpretedin view of theiractivity anddistribution feature. In thecomposition of$As_{33.3}Se_{33.3}S_{33.4}$Smatomsinsmall amountsmostlyfillempty spacesanddue to the chemical activity ofcross linkedchain moleculesandbroken bonds by reducing theroughness.

In fig.3 are presented dependence potential difference from relative humidity in sandwich structure Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$-Te, Al- As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx-Te.
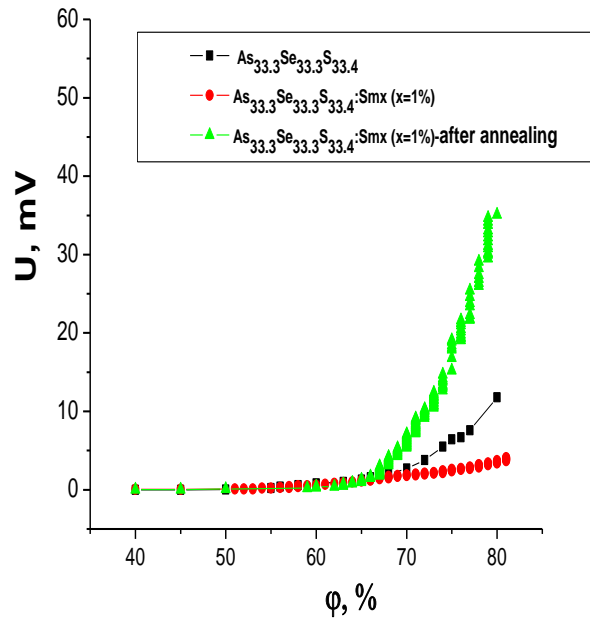

Fig.3 The dependence potential difference from relative humidity in sandwich structure Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$-Te, Al- As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx -Te.

The emergence of potential difference under the influence of humidity is associated with adsorption of hydroxyl groups at the top sensor layerand oxygen sub at conductive layer.

As you can see from the figure dependence of both composition up to 62% humidity are the same.However, the dependency rate of dependency(n) with the increase of φ is n=0.7 for As$_{33.3}$Se$_{33.3}$S$_{33.4}$, which this valume decrease under the influence of samariumunand is equal to n=0.12 for As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx(x=1 at%).

In fig.4 are presented dependence potential difference from time in sandwich structure Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$-Te, Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx -Te.It seems that increase potential from 0 to 10.5 with the influence of vapor is spent 560 second in Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$-Te.Note that, in all cases the the speed of evaporation is quite low.
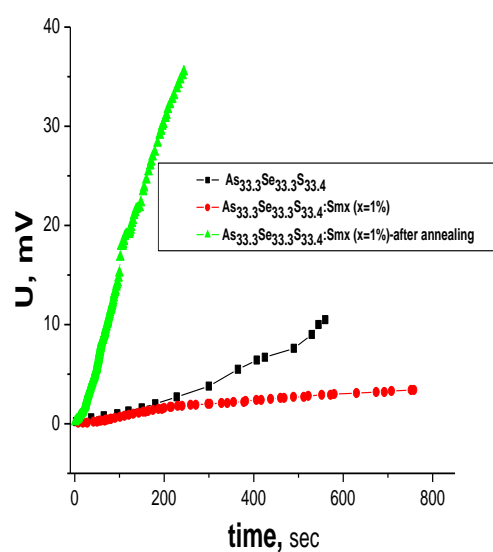

Fig.4 Thedependence potential difference from time in sandwich structure Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$-Te, Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx–Te(x=1at%).

Approximately, twice is reduced inertia in Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$-Te.

In fig.5 are presented relative humidity from time in sandwich structure Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$-Te, Al- As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx -Te.
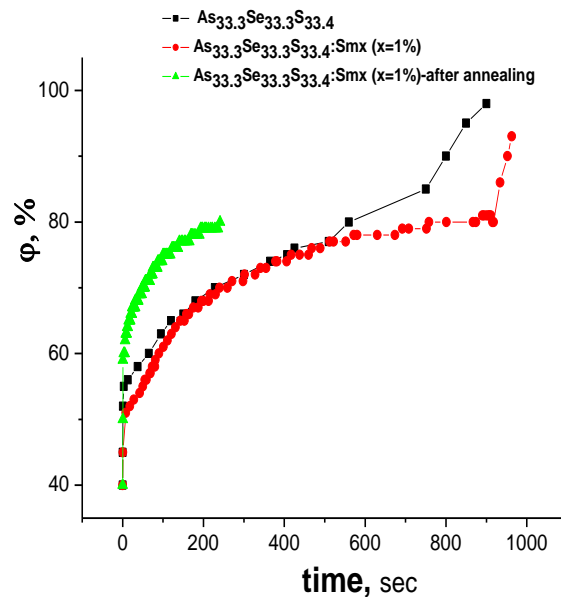

Fig.5 The dependence of relative humidity from time in sandwich structure Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$-Te, Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx -Te.

Research shows that increase of relative humidity depending from time is a relatively fast for Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$-Te. It is clear from the analysis of schedules, after thermal annealing time characteristics is improved for As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx(x=1 at%).Thus, after thermal annealing compared to other samples decreases 2-4 timesinertia inAs$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx (x=1 at%).This increases the possibility applying of humidity sensors on the base As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx (x=1 at%).

As an additive alloying selection of samarium rare earth element due to the fact, that which lead to the modification of structure and communication with all elements. On the other hand, in the form of a positively charged ions are atoms of the substances according to the model intrinsic charged defect model [6-7,8] D $^+$ и D⁻centers, mainly by changing the concentration of the substance allows you to manage electronic properties.This type of low-frequency Raman studies [30] shows that the influences differently by doping samarium in these materials. As chemically active element doping by samarium of As$_{33.3}$Se$_{33.3}$S$_{33.4}$creates with all elements communication and forms new structural elements. These elements form nano-scale areas in amorphous matrix. The average order on the chaotic orientation increases in the composition of the disorder. They increase disorder in scale the average order with the chaotic orientation.It is assumed that, hydroxyl groups completely deviates from sensor layer after thermal processing, which as a result decreases 2-4 times inertia in sandwich structureAl- As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx -Te.

CONCLUSION

In article have been studied the influence of moisture in sandwich structure Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$-Te, Al-As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx-Te (x=1 at%). It is clear from the analysis of schedules, after thermal annealing time characteristics is improved for the sample doped by Sm .It is assumed that, hydroxyl groups completely deviates from sensor layer after thermal processing, which as a result decreases 2-4 times inertia in sandwich structureAl- As$_{33.3}$Se$_{33.3}$S$_{33.4}$:Smx -Te.

ACKNOWLEDGEMENTS

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