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Short Communication

HUMIDITY DETECTORS BASED ON CHALCOGENIDE SEMICONDUCTORS

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Chalcogenide based detectors (sensors) have been prepared as thin amorphous films. The sensitivity of the detectors depends on the chalcogenide composition.

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The search for new materials is important for semiconductor electronics. The gas and humidity sensors are well known, and used in applications [1,2]. One of classes of materials on the basis of which new sorts of detectors can be created, and also improves the parameters already known, are chalcogenide glassy semiconductors (ChGS) [3].

As shown earlier, physical properties of chalcogenide glassy semiconductors change at adsorption of water, in particular there is a change of bulk conductivity [4]. This property has allowed to develop the humidity detectors working on the basis of dependence of bulk conductivity on humidity of the surrounding gas environment. Humidity detectors which work on the basis of change of bulk conductivity from humidity are known [5]. It is obvious, that the detectors working on bulk conductivity, should possess high speed of response.

In this work results of research of thin-film resistive humidity detectors working on bulk conductivity are presented. A film of $As_2(Se_{0.9}Te_{0.1})_3$ or As_2Se_3 was used as a sensitive to humidity layer (Fig. 1).

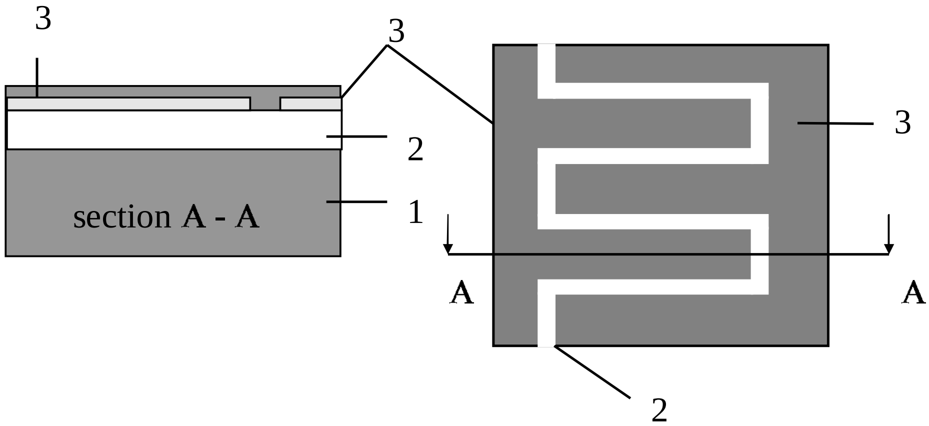

Fig. 1. Structure of resistive thin-film humidity detector: 1 - glassy substrate, 2 - humidity-sensitive layer, 3 - aluminium electrode.

The detectors were prepared on a glassy substrate by vacuum evaporation. The order of layer deposition was as follows: thin film of chalcogenide glassy semiconductor, aluminium.

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For humidity detectors based on ChGS time, amplitude, frequency and functional characteristics have been investigated.

Fig. 2 shows dependences of signal size of the resistive humidity detector on time after placing the detector in a dish above distilled water or above the saturated solution of natrium chloride. One can see from figure, that a stationary value of the signal is established during the order of 6 minutes. Nevertheless, the action of the detector is much rapid, and time of signal regulation should be essentially less than 6 minutes. The time of a stationary signal regulation is determined by a process of regulation of thermodynamic balance in a closed dish in which the detector is placed. The confirmation can be observed in Fig. 3 where comparative dependences of temperature change in thermostat and the signal of the detector as a function of time are presented. As seen from the figure, time of stationary temperature regulation in system after switch on is about the same, as the time of stationary value regulation of a signal.

The time constant of the detector was taken for the environment with relative humidity of 100 %. In this case the signal of the detector is obtained with the stationary value during the order 10 s. Thus, the time constant of resistive humidity detector based on ChGS is about several seconds.

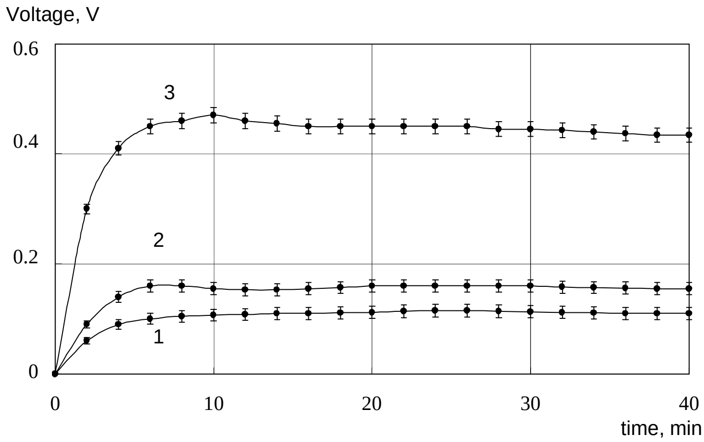

Fig. 2. Dependence of a signal of the resistive humidity detector based on ChGS on time at relative humidity: 1 - 75 %; 2 - 85 %; 3 - 100 %.

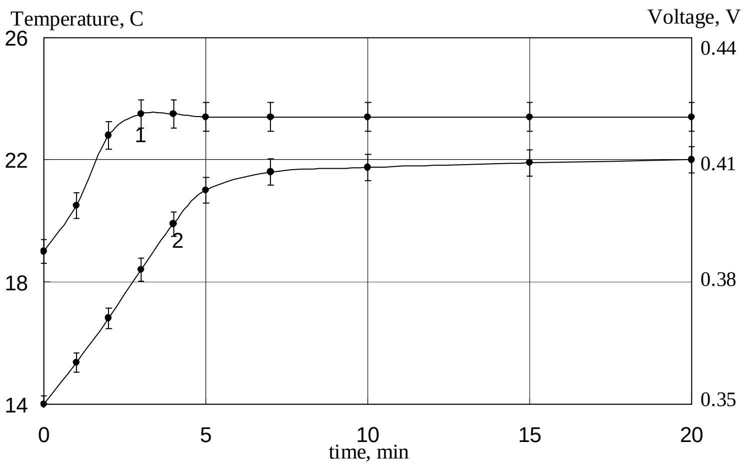

Fig. 3. Comparative dependences of temperature in thermostat (1) and signal of the resistive humidity detector (2) on time.

In Fig. 4 amplitude characteristics for detectors based on $As_2(Se_{0.9}Te_{0.1})_3$ and As_2Se_3 for a signal in the sinusoid form are presented. Amplitude characteristics for all samples are linear in the voltage range from 0.5 to 15 V and not linear in the range from 0 to 0.5 V. Similar dependence is observed for a signal in the meander form. From the received results it is possible to draw the conclusion, that the investigated detectors can be maintained at voltage up to 15 V. Therefore the working voltage for the detectors has been chosen equal 15 V. It allows to receive the maximal signal, working thus in linear area.

Frequency characteristics for a signal in the form of a sinusoid are shown in Fig. 5. The characteristics have a similar shape in case of a signal as a meander. From figure it is visible, that the type of dependence of a signal on frequency is different for the detectors based on ChGS of different structures. For detectors based on $As_2(Se_{0.9}Te_{0.1})_3$, the characteristic shows a maximum at the frequency approximately equal to 300 Hz. For detectors based on As_2Se_3 the characteristic has no maximum. The signal shows saturation at frequency 1.5 - 2.0 kHz. The working frequency for detectors is 300 Hz and 2 kHz.

The functional characteristics of resistive humidity detectors based on As_2Se_3 and $As_2(Se_{0.9}Te_{0.1})_3$ for a signal with the shape of a sinusoid are shown in Fig. 6. For a signal in the form of a meander the sensitivity of detectors is a little bit lower, however, the type of dependence remains the same. Apparently, from Fig. 5, functional characteristics of detectors based on As_2Se_3 are linear, and for detectors based on $As_2(Se_{0.9}Te_{0.1})_3$ - nonlinear. For detectors based on As_2Se_3 alongside with linearity of the functional characteristic it is necessary to note, that they are sensitive to change of relative humidity, starting from the value of 35 % while detectors based on $As_2(Se_{0.9}Te_{0.1})_3$ in the range of relative humidity from 35 to 75 % are not sensitive, and starting from the value of 75 %, their sensitivity increases following a nonlinear law.

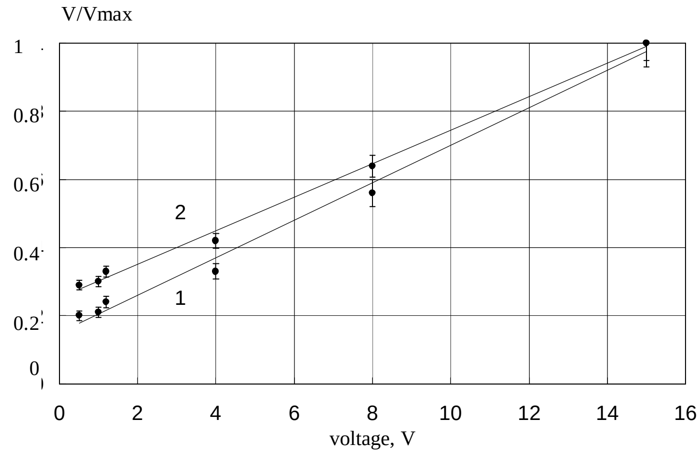

Fig. 4. Amplitude characteristics of resistive humidity detectors: 1 - based on $As_2(Te_{0.9}Se_{0.1})_3$; 2 - based on As_2Se_3.

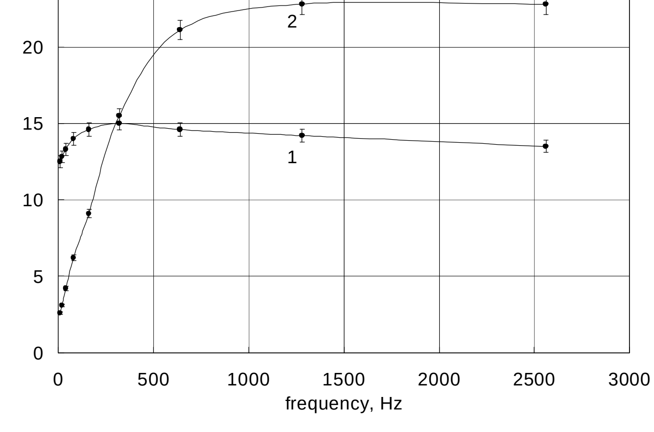

Fig. 5. Frequency characteristics of resistive humidity detectors: 1 – based on $As_2(Te_{0.9}Se_{0.1})_3$; 2 – based on As_2Se_3.

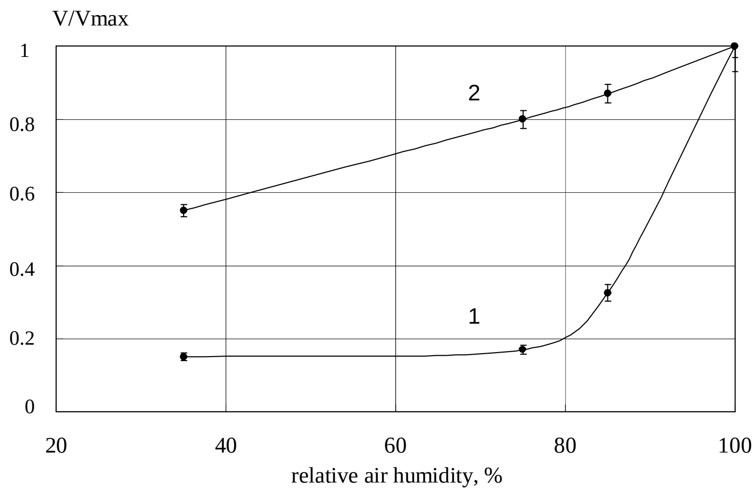

Fig. 6. Functional characteristics of resistive humidity detectors: 1 – based on $As_2(Te_{0.9}Se_{0.1})_3$; 2 – based on As_2Se_3.

However, it is necessary to note, that at relative humidity of 100 % the sensitivity of detectors based on As_2Se_3 is lower on the average of 1.5 times than the sensitivity of detectors of the second type. Thus, the detectors based on $As_2(Se_{0.9}Te_{0.1})_3$ can be used for the measurement of humidity above 75 %, and, owing to the nonlinearity of the functional characteristic, individual graduation is necessary for each detector. The detectors for measurement of humidity based on As_2Se_3, despite their lower sensitivity, have the advantage that they can be applied for measurement of humidity in the wider range, and their functional characteristic is linear.

References

[1] S. Capone, A. Forelo, L. Francioso et al., J. Optoelectron. Adv. Mater. **5**(5), 1335 (2005).
[2] A. Tomescu, R. Roescu, J. Optoelectron. Adv. Mater. **7**(3), 1529 (2005).
[3] Electronic phenomena in chalcogenide glassy semiconductors. S.Peterburg, Nauka, 1996, 486 p.
[4] B. T. Kolomiets, K. P. Kornev, A. S. Kochemirovsky, L. V. Pivovarova, T. N. Mamontova, Influence of surface loading on physical properties of glassy arsenic selenide. Zhurnal technicheskoy fiziki, **52**(2), 2424 (1982).
[5] Detector of gas humidity A.s.1222034 USSR/ A. M. Andriesh, V. I.Verlan, I. G. Grinko, M. S. Iovu, E. L.Romanjuk, M. R.Cherny. № 3766921/24-25 declared 05.07.84