SELF-ORGANIZED STRUCTURES AND NANOSIZED LEVELS OF THEIR FORMATION IN THE NON-CRYSTALLINE MATERIALS As(Ge)-S(Se) SYSTEM INDUCED BY WHITE NOISE

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INTRODUCTION

At the present stage of development information technology, along with crystalline materials, amorphous substances are widely used. A significant advantage of amorphous materials over crystalline ones is their manufacturability (relative simplicity and lower energy consumption of the technological process), the ability to change the composition and properties [1-3]. Non-crystalline materials provide the ability to design devices that are easily microminiaturized; they are also easily integrated with crystals in one device [2]. An important stimulus for the development of research on non-crystalline and intelligent materials is also the development of intelligent nanoenvironments, which requires the development and creation of devices for operation in the functioning of artificial intelligence [3,4]. To obtain reproducible results of experimental studies of the structure of amorphous films, it is important to control the basic parameters of their production. Therefore, in the process of carrying out the relevant technological processes should take into account the most important characteristics of the stochastic variability of the obtaining conditions.

The study of self-organization processes in non-crystalline systems that are in fluctuating non-equilibrium environments determines the reappraisal of the views on the influence of randomness [2,4]. In the theory of self-organization, randomness plays an important constructive role, and the question of the influence of external noise on open systems is the subject of constant attention [5,6]. This is primarily due to the fact that the parameters of the macroscopic system (including the bifurcation parameters) are values that are guided externally and also subject to fluctuations. Such fluctuations are perceived by the system as external noise. In the study of the influence of external noise exerted, for example, on the velocity of cooling, the irradiation power, the bioactive external fields, there may be the impression that the effect of external noise on the non-crystalline solids is averaged and we obtain an integral effect, while the macroscopic system "adjusts" its state to the averaged conditions in the environment. Indeed, the stochastic variability of obtaining conditions in the technological environments leads to the blurring of the system states approaching some averaged value [2-4].

The above-mentioned approaches are presented in this article. A significant emphasis is placed on the study of self-organization processes of non-crystalline materials in the presence of external white noise. The use of object-oriented modelling, which is de facto built on the principles of synergetics, is essential in the implementation of this approach.

THE CONCEPTS AND INVESTIGATION METHODS

The following basic aspects can be distinguished in the simulation of the problem of the influence of an external random field on the behavior of macro- and microscopic parameters of non-crystalline materials. The influence of the external environment on the non-equilibrium system is described at the level of the phenomenological equation with the help of an external parameter q_t, which is a random variable. These values, like random stationary processes, can be given as:

$$q_t = q + \sigma_\xi \xi_t , \qquad (1)$$

where q is an average value of the cooling velocity (corresponds to the deterministic case), ξ_t is a random external fluctuating field, σ_ξ is an intensity of the external noise ($\sigma_\xi^{\ 2} = \langle \xi_t \cdot \xi_{t'} \rangle$, $\langle \dots \rangle$ is the averaging by random field). Stochastic differential equation (SDE) and the stochastic differential with the consideration of external noise acquire the following form [2,3] :

$$\frac{d\eta_\sigma(r,t)}{dt} = f_{q_t}(\eta_\sigma(r,t)), \quad d\eta_\sigma = f_{q_t}(\eta_\sigma)\cdot dt + G_q \cdot dW_t .$$

Here $\eta_\sigma(r,t)$ is an ordering parameter of the non-crystalline system, $f_{q_t}(\eta_\sigma(r,t)) = h(\eta_\sigma) + q_t \cdot g(\eta_\sigma)$ is a nonlinear function that describes the local evolution of components $\eta_\sigma(r,t)$ in space r and time t, $h(\eta_\sigma)$ та $g(\eta_\sigma)$ are functions from $\eta_\sigma(r,t)$, W_t is the temperature field of the environment (thermostat), G_q is the source of random noise. As a parameter of the order a system, the relative change in the temperature of the dynamic instability of the non-crystalline solids can be used

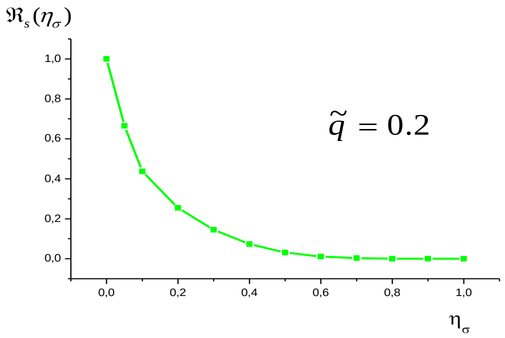
$$\eta_\sigma = \left(T_m - T_{sg}\right)/T_m , \qquad \tilde{q} = (q - q_c)/q_c \geq 0 , \qquad (2)$$

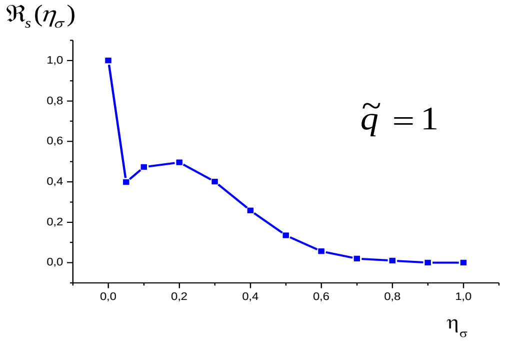
which is directly determined experimentally and conjugate to the proportion of atoms in soft atomic configurations [6]. For the crystal $T_{sg} = T_m$ and accordingly $\eta_\sigma = 0$; for the non-crystalline solids $T_{sg} = T_{sg}(q) \leq T_m$, decreases with growth q [5, 6].

Thus, the interval of change of values for η_σ is as follows $0 \le \eta_\sigma \le 1$.

SELF-ORGANIZED STRUCTURES IN THE NON-CRYSTALLINE SOLIDS

On Fig.1 shown the dependence of probability density $\Re_s(\eta_\sigma)$ at various reduced cooling rates $\tilde{q}$ and the intensity of the external noise. The qualitative state of the system is determined the number and position of extremums $\Re(\eta_\sigma)$ in the stochastic case and synergetic potential $V_{q_t}(\eta_\sigma)$ in the deterministic case.





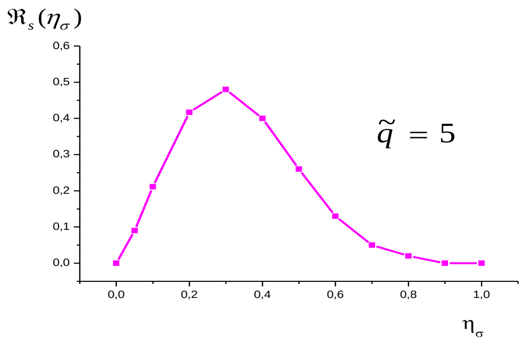


Fig. 1. Dependence of the stationary density of the distribution function $\Re_s(\eta_\sigma)$ at different cooling velocity $\tilde{q}$ ($\sigma_\xi = 1 \cdot 10^{-2} (K/s)$))

The representation that the role of fluctuations is ultimately secondary is based on the linear type of connection between the system and the surrounding environment. However, the carried out theoretical and experimental studies of cooling the melt in a fluctuating medium with noise indicate the opposite: the random nature of the medium along with the disorganizing effect can initiate the formation of qualitatively new self-organized structures in non-crystalline solids [3]. The class of structures thus obtained is qualitatively more varied in comparison with the possible spectrum under the corresponding deterministic conditions. Therefore, increasing the stochastic variability of the obtaining enviroment can determine the possibility of controlled structuring of non-crystalline materials depending on the intensity of noise levels, nanoscale formation systems of self-organized structures. This can be extremely relevant in particular when developing of intelligent non-crystalline materials [3,4].

CONCLUSIONS

Complex researches of the processes of self-organization and the formation of self-organized structures by the presence of white noise in the non-crystalline materials *As (Ge)-S (Se)* systems have been carried out, the results of which get the following conclusions:

- Investigation of the influence of cooling velocity fluctuations in the approach of white noise on the formation of self-organized structures of non-crystalline materials makes it possible to determine the threshold values of the intensity noise $\sigma_\xi < \sigma_{\xi c}$ at which the structural characteristics of non-crystalline materials are insensitive to changing conditions of their obtaining. To predict also the formation of self-organized structures at noise determined by the noise intensities $\sigma_\xi \ge \sigma_{\xi c}$.

- The presence of transition induced by noise is also established, which is related to the displacement of the deterministic bifurcation diagram. Qualitative change in the behavior of the system, which is described by the distribution function $\Re(\eta_\sigma)$, is observed at intensities greater than the threshold value, and the state of the system is determined by the number and position of extremums of probability density $\Re(\eta_\sigma)$.

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