THE PROCESS OF OSTWALD MATURATION ON $TlGaTe_2$ CRYSTAL SURFACE

K.G. KHALILOVA[1], N.M. ABDULLAYEV[1], K.Sh. KAGRAMANOV[1]
G.M. Abdullayev Institute of Physics of Azerbaijan NAS
131, H. Javid ave., Baku, AZ 1143

It is shown that nano-island crystallization on TlGaTe2 crystal surface is accompanied by their coalescence with process transition into Ostwald maturation. The analysis of conditions of Ostwald maturation (*OM*) stage beginning is carried out in the work. The growth mechanism on isotropic substrate on principle doesn't differ from the one on crystal substrate. The process of condensate formation is divided on following parts: germ-formation, growth and coalescence of germs, channel formation.

Keywords: coalescence, maturation process, fluctuation, Ostwald maturation
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1. INTRODUCTION

TlGaTe2 semiconductor crystals belong to class of compounds of $A^3B^3C^6_2$ group crystallizing in tetragonal space group D_{4h}^{18} (structural type TlSe). The above-mentioned crystals present themselves Ga - Te chains extended along tetragonal *C* axis of crystal. This is crystal characteristics. It is obvious that the nano-formations of Ostwald maturation are responsible for changes of temperature dependence of its electric conduction [1].

According to [1 -2] the presence of wide homogeneity region of $A^3B^3C^6_2$ group crystals reached up to 6.8mol.% can be the reason of structure defect. The segregation coefficient in homogeneity is less than 1, that's why there is big probability of composition inclination on stoichiometry at single crystal growth. This will be cause to appearance of big amount of layer join defects, vacancies and dislocations.

The revealing of *OM* on $TlGaTe_2$ crystal surface is the aim of this work.

2. EXPERIMENT

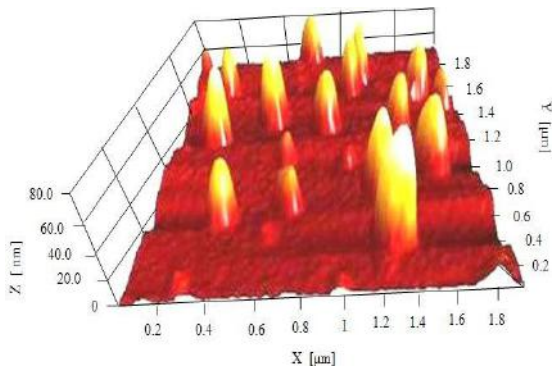

Fig.1. *AFM* – images in 3D-scale of nano-islands *(NI)* $TlGaTe_2$ surface being in mode of Ostwald maturation and reached the maximal height h_{max} = 58 nm; h_{min} = 20 nm.

The real crystals are studied in the work, the surface images obtained in atomic-force microscope (*AFM*) of annealed $TlGaTe_2$ single crystals are considered. As it is seen from the figures (fig. 1 – 6) the obtained results evidence on the fact that the growth of new phase islands is defined by two main processes which are: substance transfer to island, i.e. the diffusion process (fig. 2) and transition of atoms through interface i.e. old phase – new phase.

The many experimental investigations show that the new phase germs comparably rapidly move on substrate surface on initial stages of atom condensation. This process is the important part in phase structure formation [1 – 3]. Such movements take place under the influence of different internal forces: collision with rapid flux particles, temperature gradient, electric and magnetic fields, drugs by movable steps and etc. According to the island migration mechanism, the only two main models describing the island movement are used until now. In first model the particle diffusion takes place only on island surface, moreover the particles fitting to interface stay immovable ones related to it.

In the second model the island is considered as sliding one on substrate surface. The concrete mechanisms of island morphological change and sliding process are suggested enough big amount, however, they are all lead to relative low values of island migration velocities and coefficients of their diffusion in comparison with real observable ones in some cases. In models of 1st type it is connected with low values of adatom self-diffusion which can't supply enough rapid island movement. In models of 2nd type this is caused by big sliding friction forces between island and substrate (i.e. high sliding activation energy) especially at epitaxial growth. Recently the quite another movement model of directly growing islands on alien substrate is suggested in work [2]. In reality, their kinetics of new phase germ-formation and filling of the condensation surface by them are the one of the important tasks of surface phase transitions by 1st order.

Designations are: the approaching *NI* which are able to maturation are shown by circle, the arrows show the nano-particle diffusion direction in the process of formation of Ostwald maturation.

Indeed, the growing islands absorb the adatoms and decrease the satiety on which the island formation velocity depend and velocity of their growth because of coalescence of small *NI* in big ones (fig. 5).

131 H.Javid ave, AZ-1143, Baku
ANAS, G.M.Abdullayev Institute of Physics
E-mail: jophphysics@gmail.com

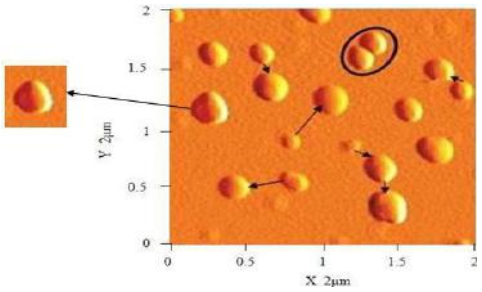

Fig.2. AFM – images in 2D scale *NI* in coalescence process and formation of Ostwald growth mode taking under consideration the fluctuations of particle number in germ.

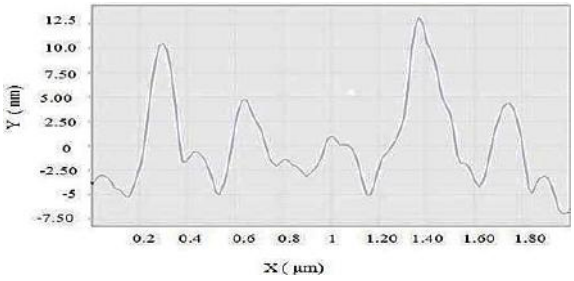

Fig.3. The profilogram of *NI* sizes on $TlGaTe_2$ surface. Designations are: height *NI* oscillates from 5*nm* up to 12.0 *nm*. The growth profilogram of *NI* evidences on their growth.

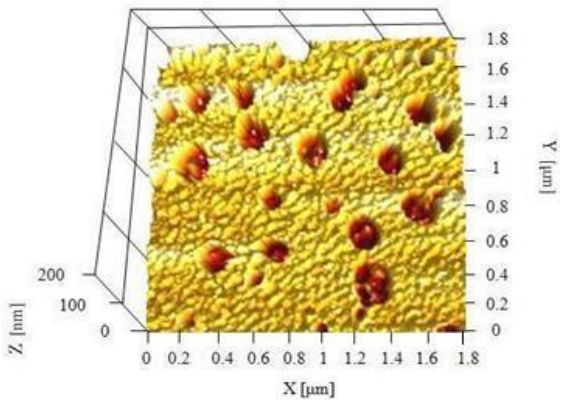

Fig.4. $TlGaTe_2$ coagulation nano-formations obtained in *NI* coalescence process.

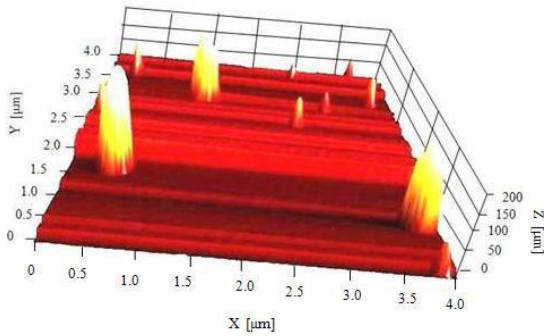

Fig.5. AFM - images *NI* after diffusion processes and coalescence (Ostwald *NI* formation process). As a result the free zone (which is seen in front part of) forms from which the small *NI* diffuse in Ostwald maturation bands of nano-islands.

At study of *OM* islands on grains of different orientation we obtain that the substance from the grains recondenses on other ones the orientation of which is the more profitable from both the thermodynamics and kinetics point of view.

The finiteness of system sizes in which the melt hardening leads to appearance of fluxes of substance and heat. If the melt overcools near boundary in some time moment and the phase transition with formation of nuclear new phase takes place in it, then the melt can be overheated far off it. In layer where the formation takes place *OM* stage begins. However, *OM* band will be in the essentially differ conditions from ones investigated above. These conditions are the result of inhomogeneous distribution of fluxes of heat and substance by the system.

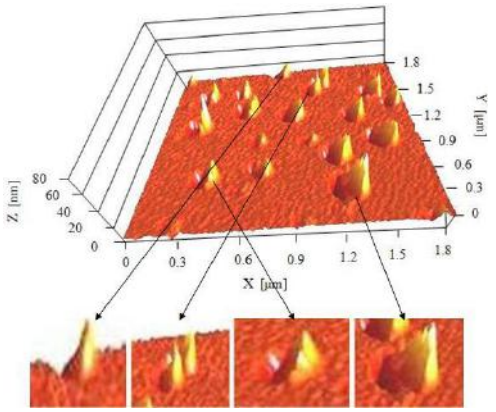

Fig.6. AFM-image of $TlGaTe_2$.

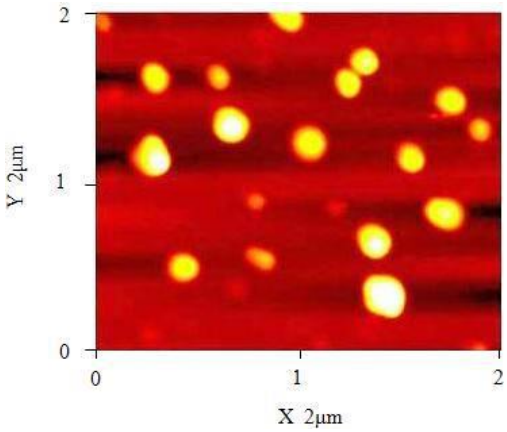

Fig.7. AFM - image in 2D scale on $TlGaTe_2$ basis surface. The process of big particle formation from small ones given on *fig.*1 is shown (process is coalescence).

From the figure it is seen the consequence of diffusion processes leading to formation of complex nano-formations (such nano-formations are beyond the limits of scanning). The all main modern theoretical conceptions and experimental results describing the both the processes of new phase formation, following evolution and *NI* growth processes, aren't given in description. The theory of many-component system formation requires the following development. The construction of the theory

allowing us to calculate the composition of forming films is far from the completion. The theory of steam-liquid-crystal transition taking under the inner symmetry change requires the significant investigation. The explanation of appearance reason of the different structures at the film growth from the melts from melts of eutectic composition presents the essential interest.

The condense theory in open system at power laws of growth rate on particle number and total concentration on time with arbitrary indexes [2 – 3].

3. RESULTS AND THEIR DISCUSSION

The 1st stage is the formation of small crystal germs (by diameter 0.2 – 0.5 nm) is after several seconds after condensation beginning. The germ density is very high (10^{10}-10^{11} cm^{-2}). The coalescence of the germs begins at their collision. The new germs growing up to collision with big formations after that they coalesce with them appear on substrate surface being free because of coalescence (fig. 2).

The coalescence of big islands of condensed phase carries out very hard and slowly. The filling of channels and spaces carry out by both the formation of new germs in them and the way of atom join directly from molecular beam or adsorbed layer (fig. 2).

The coalescence of small and big islands of condensed phase carries out unequally. The germs coalesce even in that case when they don't join each other. The substance transfer in this case is carried out by the way of surface diffusion by substrate. Such germs can also move on substrate and join with each other. The islands bigger than 20nm in diameter coalesce at collision with each other by the means of surface self-diffusion and

mass transfer through contact isthmus. The volume self-diffusion carries out simultaneously. If two islands coalesce with different orientation, then the inner intergranular boundary appears. Such boundary shifts and out from merging formation by the way of volume diffusion (*AFM* - images 1 – 3). As we see the germ-formation stages, stages of separate growth of new phase germs, coalescence and last stage, i.e. Ostwald maturation on which the growth of bigger islands is carried out because of formation of small ones, are usually related to such stages. The given processes have the essentially different scales by time. The stage of formation, later the stage of separate growth and etc rapidly carry out. This time hierarchy means that rapid processes are "adapt" to slow ones.

The final stage *NI* by size 250 nm is obtained on $TlGaTe_2$ crystal surface.

Consequently, the coalescence on $TlGaTe_2$ crystal surface presents itself the merge of several islands and can be accompanied by recrystallization leading to the fact that mutually disoriented islands have the unique orientation at merging that leads to formation of biggest *NI*.

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