FORMATION OF $TlGaSe_2$ AMORPHOUS FILMS UNDER THE EFFECT OF Ge ATOMS

E.Sh. ALEKPEROV, G.B. IBRAGIMOV, A.M. NAZAROV, A.M. NARIMANZADE
[1]Baku State University, Baku, Azerbaijan, alekperoveldar@mail.ru
[2]Institute of Physics named after G.M.Abdullayev. Baku, Azerbaijan

There has been investigated $TlGa_{1-x}Ge_xSe_2$ (x=0.02:0.08) compound amorphous films of 35 pm in thickness by high–energy electron diffraction method (HEED). It is established that by interacting with triple compound atoms with Ge interstitial ones as an impurity the distance between atoms in films increases from 3% up to 7%. According to the mentioned increase the distance between atoms, there has been observed of coordinate maximum areas and also with the temperature range of amorphous film formation. In this case it is possible to control precisely amorphous thin film parameters.

Keywords: semiconductor, electron diffraction analysis, doping, structure, amorphous film.
DOI:10.70784/azip.3.2024CE50

INTRODUCTION

It is known that semiconductive compound of $A^3B^3C_2^6$ group are widely used in instrument-making, optoelectronics [1-5]. Taking into consideration the demands for semiconductors with novel properties we investigate $TlGaSe_2$ half-valance amorphous films with Ge interstitial atoms in small concentrations. $TlGaSe_2$ compound as one of the mentioned group involves two different structural units as tetrahedron with Ga^{3+} ions and octahedron with Tl^+ ions, this it has specific structure of crystal lattice [6]. Investigation of thin film atomic structure is carried out preferably by electron diffraction methods Bogarde and Gilson [7].

EXPERIMENTAL PART

In this paper by method of high-energy electron diffraction there have been investigated $TlGa_{1-x}Ge_xSe_2$ amorphous films (x=0.01÷0.08) of 35 nm in thickness obtained by simultaneous evaporation of synthesized single crystal $TlGaSe_2$ and Ge at room temperature from two different tungsten furnaces in vacuum ~$4x10^{-5}$ Pa in installation VUP-5 [8, 9]. Given films are covered by carbon film ~3 nm in thickness top and bottom. Freshly spalled single crystals NaCl, KJ and celluloid on the grid are served as a substrate. The rate of molecular vapor deposition in vacuum is 3 nm/sec. Film thickness is read on spectrometer “Spekord 210 plus” and film composition is read on atomic absorption spectrophotometer “Shimadzu AA-6300”. Electrometric system of the installation EMR-102 for recording diffraction reflection intensities improves significantly the structure determination accuracy. Incoherent background metering and experimental intensity curve normalization are made by Nabitovich method [10].

RESULTS AND THEIR DISCUSSION

Electron diffraction patterns of $TlGa_{0.96}Ge_{0.04}Se_2$ amorphous films (Fig.1) taken on the installation EMR-102 have diffusion rings with the values $S = 4\pi\sin\theta/\lambda$ = 21.52, 34.46, 44. 83 nm^{-1}. Diffusion maxima become distinct and are exceptional in electron diffraction patterns with ageing films in vacuum within 5-6 hours at room temperature.

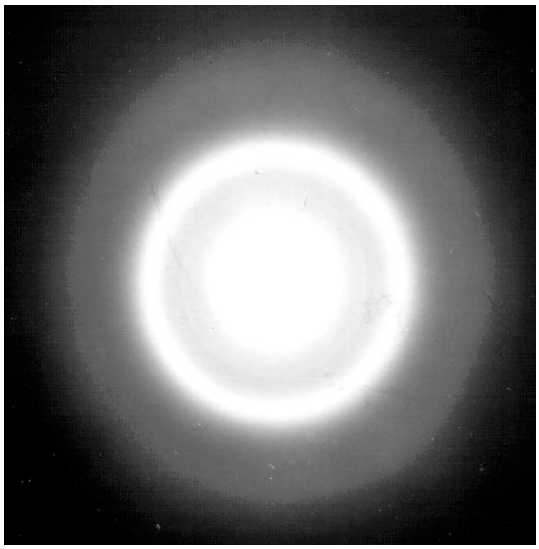

Fig. 1. Electron diffraction patterns of $TlGa_{0.96}Ge_{0.04}Se_2$ amorphous film.

By electron diffraction pattern interpretation based on data of recording unit interference function ($I_x(S)\int m^2(S)$ and $I_o(S)\int f^2(S)$) that is characteristic of short-range atomic order in $TlGa_{0.96}Ge_{0.04}Se_2$ amorphous films, the radial atom distribution curve (RADC) has been obtained (Fig.3).

When interpreting the electron diffraction patterns, taking into account the data from the recording unit for intensities (Fig. 2) and using the interference function ($I_e(s)/\sum_m f_m^2(s)$ and $I_c(s)/\sum_m f_m^2(s)$, which characterizes the short-range atomic order in $TlGa_{0.96}Ge_{0.04}Se_2$ amorphous films, the radial atom distribution curve (RADC) has been obtained (Fig. 3). RADC calculations were performed using the RADIADIAS program on a computer.

131, H.Javid ave, AZ-1073, Baku
Institute of Physics
E-mail: jophphysics@gmail.com

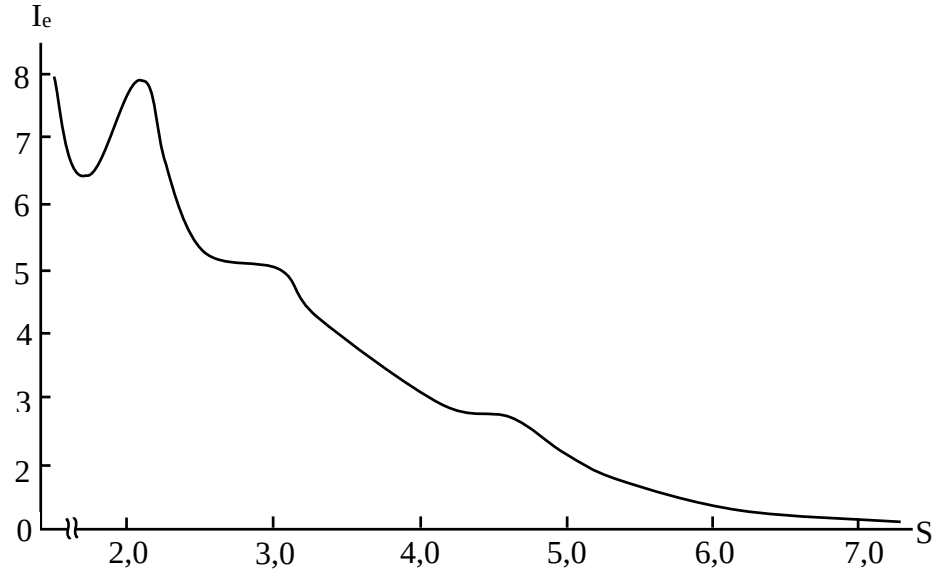

Fig. 2. Experimental intensity curve of $TlGa_{0.96}Ge_{0.04}Se_2$ amorphous compound.

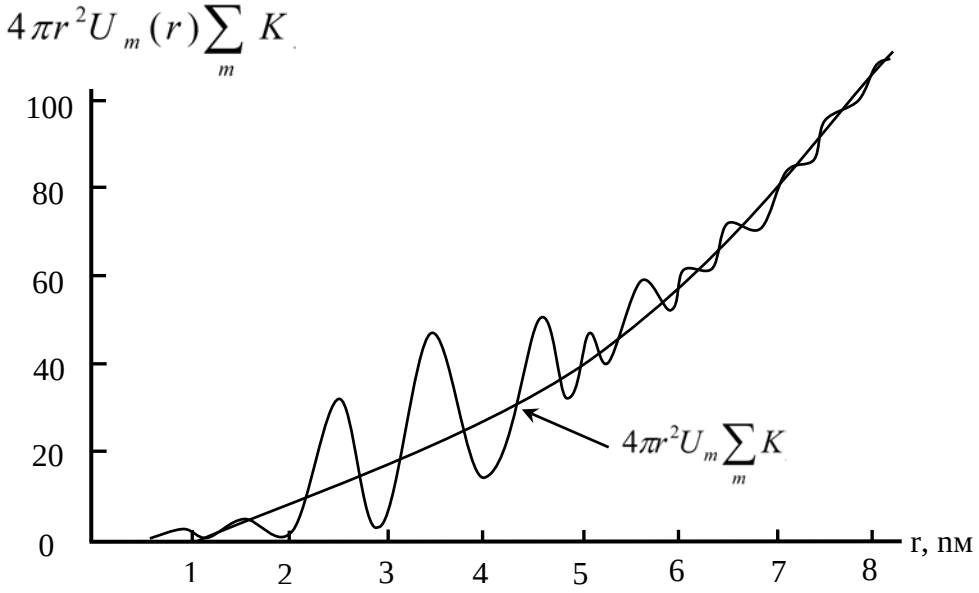

Fig. 3. Radial distribution curve of $TlGa_{0.96}Ge_{0.04}Se_2$ atoms.

By analyzing RADC of $TlGa_{0.96}Ge_{0.04}Se_2$ amorphous compound there have been revealed three maxima corresponding to the first coordinate group at $r_1 = 0.239$ nm, the second coordinate one at $r_2 = 0.340$ nm and the third coordinate one at $r_3 = 0.460$ nm. There have been determined areas beneath the first, second, and third coordinate maxima which are found to be equal $\Delta_1 = 8.6$, $\Delta_2 = 24.6$, and $\Delta_3 = 33.8$, respectively.

The radius of RADC first coordinate group is very close to the mean value of distances between Ga-Se atoms in crystal lattice. The radius of the second coordinate group is in agreement with the distance between Tl and Se atoms, also the third maximum is in agreement with the distance between similar atoms

CONCLUSION

When forming amorphous structures of numerous compositions in thin layers, the presence of Ge as an impurity affects the behavior of Tl-Se and Ga-Se system atom interaction. It is experimentally established that $TlGaSe_2$ films have non-trivial peculiarities that are controlled as by formation conditions as by measured doping them with Ge chemical element atoms. Coordination numbers calculated from the areas beneath the first, second, and third coordinate maxima have the following values: $n_1 \approx 4$, $n_2 \approx n_3 \approx 6$. That is to say about covalent behavior of bond between atoms in $TlGa_{1-x}Ge_xSe_2$ amorphous film which is characteristic of crystal phase. Apparently, Ge atom implantation in $TlGaSe_2$ film brings about the formation of substitutional solid solutions.

[1] *J.S. Sanghera, I.D. Aggarwal, L.B. Shaw, C.M. Florea* et. al. // J. Optoelektroniks and Advanced materials. 2006, V.8, P.2148.

[2] *Malagapov* Ach. U. Review of literature of $A^2B^6C^{21}$ TIB^2C^{21} typed semiconductive compounds. Nalchik: ЭЛФА, 2007, p. 692.

[3] *V. Kovanda, Vicek Mir, H. Jain.* J. Non-Cryst. Solids. 2003, V. 326, P.88.

[4] *A.M. Pashayev, T.D. Dzhafarov.* Physical principles of nanoelectronics. Baku: 2019, p. 88.

[5] *E.M. Kerimova, S.N. Murtafayeva, S.D. Mamedbeyli* and etc. Roentgen conduction of $TlGaSe_2$ single crystals. Fizika, 2001, vol. 7, № 2, pp. 61-64.

[6] *Q.D. Huseynov, F.M. Seidov, Kh.Y. Khalilov, M.Z. Ismayilov* et al. Pseudobinary system TlSe-GaSe crystals. Journal of Phys. Chemistry, 1974, vol. 16, № 3, pp. 803-804.

[7] *G.P. Ignatenko, D.N. Terpii.* XIX Russian conference on electron microscope (IPTM). Thesis of reports, May 28-31, 2002, Chernogolovka, 2002, p. 35.

[8] *A.S. Avilov.* Precious electron diffraction analysis. Thesis of Doctor of physic-mathematical sciences, 01.04.18, Moscow, 1999, p. 274.

[9] *F.F. Volkenstein.* Electron processes on semiconductor surface at chemisorption. M. Nauka, 1987, p. 431.

[10] *I.D. Nabivovitch, Ya.D. Stetsiv, Ya.V. Voloshchuk.* Determination of coherent intensity and background intensity on experimental curve of electron scattering. Crystallography, 1967, vol. 12, № 4, pp. 584-590.