

FORMATION OF TlGaSe₂ AMORPHOUS FILMS UNDER THE EFFECT OF Ge ATOMS

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There has been investigated TlGa_{1-x}Ge_xSe₂ (x=0.02:0.08) compound amorphous films of 35 nm 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.

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INTRODUCTION

It is known that semiconductive compound of A³B³C₂⁶ group are widely used in instrument-making, optoelectronics [1-5]. Taking into consideration the demands for semiconductors with novel properties we investigate TlGaSe₂ half-valance amorphous films with Ge interstitial atoms in small concentrations. TlGaSe₂ compound as one of the mentioned group involves two different structural units as tetrahedron with Ga³⁺ 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_xSe₂ amorphous films (x=0.01÷0.08) of 35 nm in thickness obtained by simultaneous evaporation of synthesized single crystal TlGaSe₂ and Ge at room temperature from two different tungsten furnaces in vacuum ~4×10⁻⁵ 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}Se₂ amorphous films (Fig.1) taken on the installation EMR-102 have diffusion rings with the values

$S = 4\pi\sin\theta/\lambda = 21.52, 34.46, 44.83 \text{ nm}^{-1}$. Diffusion maxima become distinct and are exceptional in electron diffraction patterns with ageing films in vacuum within 5-6 hours at room temperature.

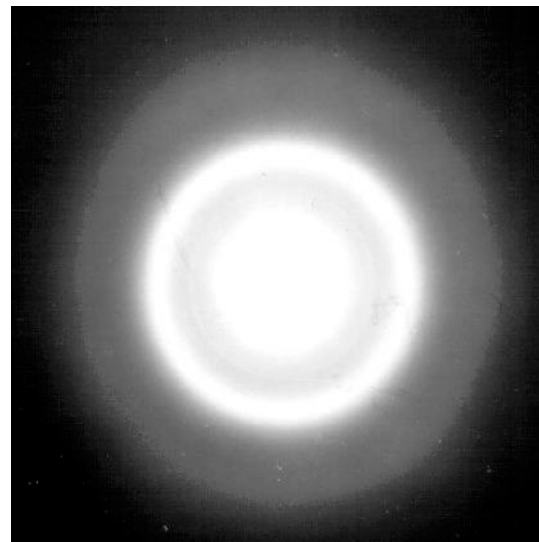


Fig. 1. Electron diffraction patterns of TlGa_{0.96}Ge_{0.04}Se₂ amorphous film.

By electron diffraction pattern interpretation based on data of recording unit interference function ($I_x(S)/m^2(S)$ and $I_o(S)/f^2(S)$) that is characteristic of short-range atomic order in TlGa_{0.96}Ge_{0.04}Se₂ 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}Se₂ amorphous films, the radial atom distribution curve (RADC) has been obtained (Fig. 3). RADC calculations were performed using the RADIADIAS program on a computer.

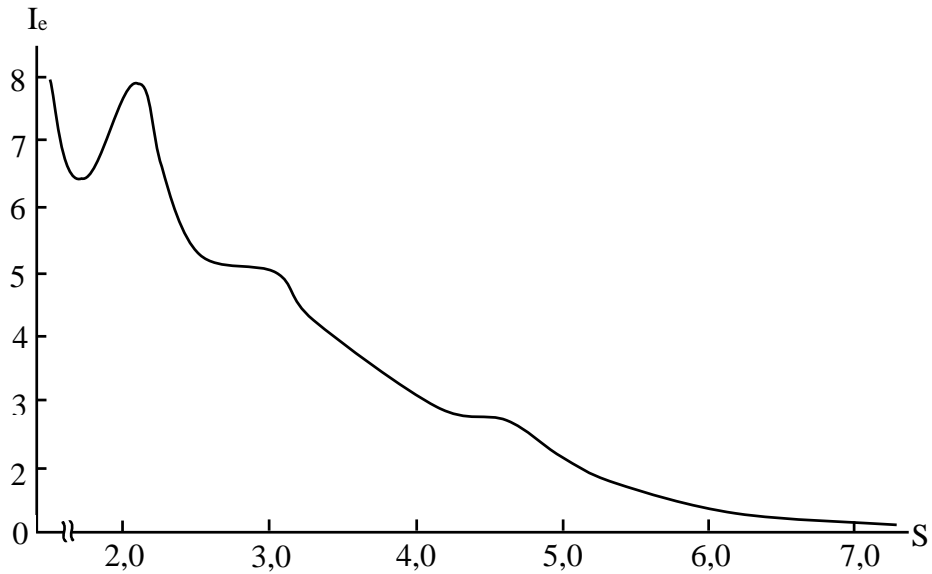


Fig. 2. Experimental intensity curve of TlGa_{0.96}Ge_{0.04}Se₂ amorphous compound.

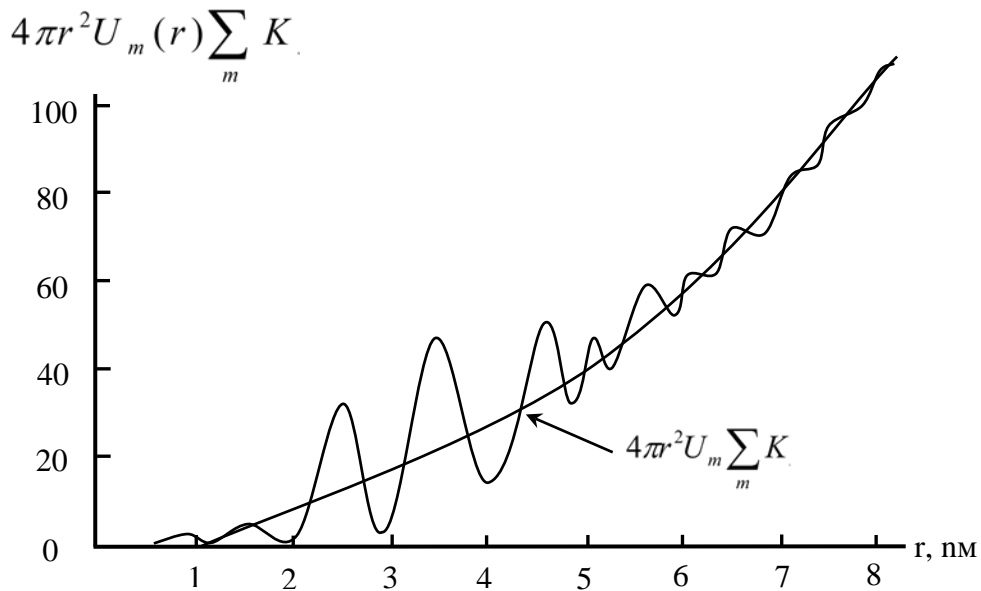


Fig. 3. Radial distribution curve of TlGa_{0.96}Ge_{0.04}Se₂ atoms.

By analyzing RADC of TlGa_{0.96}Ge_{0.04}Se₂ 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 TlGaSe₂ 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_xSe₂ amorphous film which is characteristic of crystal phase. Apparently, Ge atom implantation in TlGaSe₂ film brings about the formation of substitutional solid solutions.

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