ABSORPTION SPECTERS OF NARROW GAP SEMIMAGNETIC SEMICONDUCTORS WITH COMPARED WITH NONMAGNETIC SEMICONDUCTORS

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Abstract. In present work were studied the main laws of components repartition on the epitaxial coats geometry of $Hg_{1-x}Mn_xTe$, $Hg_{1-x}Cd_xTe$ and $Hg_{1-x-y}Cd_xMn_yTe$ using two methods: the micro-X-ray-structural method and the optic methods. A curve of standardization was constructed, having from the experiment the energy band width to determine the concentration of cadmium and manganese. Analyzing the absorption specters structure it was determined that in the absence of external magnetic field the energy specters of the charge carriers of the semimagnetic materials $Hg_{1-x}Mn_xTe$, $Hg_{1-x-y}Cd_xMn_yTe$ and of nonmagnetic materials $Hg_{1-x}Cd_xTe$ with the same energy gap width have the same form. The theoretical calculations of absorption specters were realized within the Kane model with its non-parabolic perturbations specific for indium antimonid as the narrow-gap semiconductor.

Keywords: semimagnetic materials, absorption specters.

1. INTRODUCTION.

The detailed study in works [1,2] of semimagnetic materials of $Hg_{1-x}Mn_xTe$, $Hg_{1-x}Mn_xSe$ type with narrow-gap traced out a set of unusual features of energy specter with free charge carriers as: the increase of irradiation intensity within the magnetic field, a more major stability of physic features in relation with $Hg_{1-x}Cd_xTe$ etc. The unusual behavior of semimagnetic semiconductors of $Hg_{1-x}Mn_xTe$ type is determined by the influence of the change interaction of charge carriers with localized magnetic moments of manganese ions' electrons from $3d^5$ states [3].

Semimagnetics of the $Hg_{1-x}Mn_xTe$ type can, in perspective, be used in designing some receivers of infrared radiation (λ=10,6μm) with a greater working temperature in relation with the receivers that function on the basis of optic transitions of the "impure localized level – conduction band" type. It is obvious that the influence of change integrals on magnetic field restoring depends on the content of Mn in respective alloy, for instance, in $Hg_{1-x}Mn_xTe$, but the greatest part of manganese content in the $Hg_{1-x}Mn_xTe$ contributes also to the increase of energy gap, which, in a way, complicates the emphasizing of change integrals contribution. In such a state of things, better opportunities are offered by the quaternary $Hg_{1-x-y}Cd_xMn_yTe$ alloy properties study. According to the physic conception of this alloy we can obtain semimagnetic materials with the same energy band, but with different manganese content. This experimental situation can be created though altering in certain limits the manganese and cadmium concentration. The realized technologic process allows solving this problem. [4]. This work aims at analyzing the optic features of semimagnetic materials $Hg_{1-x}Mn_xTe$, $Hg_{1-x-y}Cd_xMn_yTe$, and non-magnetic materials $Hg_{1-x}Cd_xTe$ with the same structure of the energy bands and possible modifications in relation with manganese and cadmium concentration.

2. THE EXPERIMENTAL RESULTS AND THEIR ANALYSIS

The work studied optic specters of semimagnetic semiconductors $Hg_{1-x}Mn_xTe$, $Hg_{1-x-y}Cd_xMn_yTe$ epitaxial coats and non-magnetic materials $Hg_{1-x}Cd_xTe$ coats with the same structure of energy bands for the temperatures pitch (4,2÷300k) and spectral pitch (2-50μm).

Samples $Hg_{1-x}Mn_xTe$, $Hg_{1-x-y}Cd_xMn_yTe$, and $Hg_{1-x}Cd_xTe$ with different manganese and cadmium concentration, studied in this work, were obtained through the method of phase epitaxy in thermodynamic systems closed by oriented sublevels of cadmium telluride <111> in absolute accordance with state diagram. The obtaining technology of epitaxial coats is described in the following work [5]. The technological process realized in this work also allows, resulting from the experiment needs, the doping of the coats. The concentration of unidentified impurities was determined out of galvanic-magnetic measurements and varied within ($2\div5\cdot10^{14}cm^{-3}$) and ($3\div6\cdot10^{15}cm^{-3}$) limits. The composition and homogeneity of the epitaxial coats was checked up with the help of the micro-X-ray spectral analyzer.

In fig.1 is presented the diagram of the components (Mn, Hg, and Te) distribution within the epitaxial coats according to the thickness for the $Hg_{1-x}Mn_xTe$ alloy. From these results we can emphasize that from the coat surface on a thickness of 80μm we practically have a constant distribution of the components. These results confirm the high degree of studied coats homogeneity. A similar situation is valid for the quaternary $Hg_{1-x-y}Cd_xMn_yTe$ alloy. For this alloy, as the experiment confirms it, we have a high degree of coat's homogeneity on a thickness of 20μm.

The stability of physic characteristics in time of semimagnetic $Hg_{1-x}Mn_xTe$, $Hg_{1-x-y}Cd_xMn_yTe$ materials coats in relation with $Hg_{1-x}Cd_xTe$ was also checked up, measuring the galvanic-magnetic features in different time intervals, namely, 6 months after the end of the technological process.

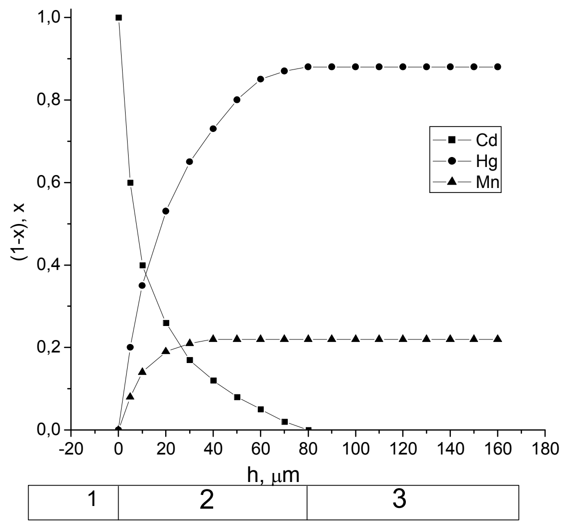

Fig.1 The diagram of components distribution in $Hg_{1-x}Mn_xTe$ epitaxial coat according to the width.
1. The substratum oriented to CdTe.
2. Transition layer.
3. $Hg_{1-x}Mn_xTe$ coat with the determined composition.

The obtained experimental data confirm a 20% more major stability than the physic characteristics stability of $Hg_{1-x}Cd_xTe$. It is a conclusion that corresponds with author's physic conceptions [6].

The transparency specters raised to different temperatures from the (4,2÷300K) pitch in the absence of magnetic field. The results of the optic effects study, the photoconduction of the materials with energy band semiconductors properties calculated within the well-known model Kane demonstrates that $\lambda_{1/2}$ in photoconduction specters correlate with the absorption coefficient of 500cm^{-1} value. This experimental affirmation convinces us that it is possible to determine out of absorption specters the fundamental absorption border at this level of absorption coefficient for the studied alloys with the thickness ≤ 150μm. So, from these experiments we calculated the energy band width in relation with the temperature and the components concentration. The experiment confirms an, actually, linear dependence on the temperature and a more complicated dependence on the alloy composition. Nowadays in reference literature are known, for instance, for $Hg_{1-x}Cd_xTe$ 9 analytic forms for $E_g=E_g(x,T)$. Using the standardization curves constructed for $Hg_{1-x}Cd_xTe$, we determined the alloy composition. More exact data were obtained for the temperature of 300K. As concerning with the errors of this experiment, we resulted from the fact that the linear dispersion of the used specter constitutes 0,18 μ/mm (for λ=10μm) and the spectrometer diaphragm (≤1mm) allowed us to determine the fundamental border position with a 0,2μm exactness which corresponds to the exactness of cadmium concentration determination in the alloy at 300K an is of ±0,005 order. An argument for this exactness constitutes the high absorption specters from the coat surface with the help of a diagram with the sizes (100÷200μm).

In fig.2 are presented segments from absorption specters that express optic transitions of "energy band of holes – conduction band" type of $Hg_{1-x-y}Cd_xMn_yTe$ coats raised to the temperature of 300K in relation with different content of cadmium and manganese in absence of magnetic field.

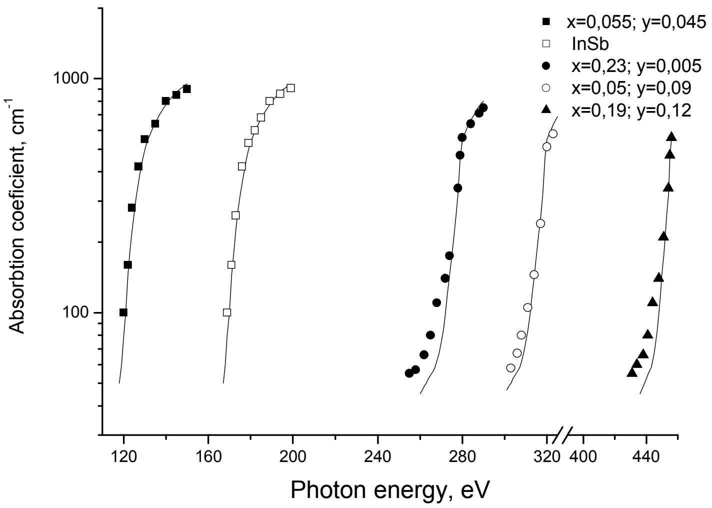

Fig 2. Absorption specters of $Hg_{1-x-y}Cd_xMn_yTe$ epitaxial coats raised to the temperature of 300K. In comparison with different content of cadmium and manganese; magnetic field induction B=0.

At the absorption coefficient level α=500cm^{-1} the energy gap width was determined. The obtained results for a set of alloys are presented in table 1 for $E_g=E_g$ (x,y,T) in relation with the manganese and cadmium concentration determined by the micro-X-ray analyzer.

Using the above stated procedure we calculated $E_g=E_g(x,T)$. Absorption specters were also obtained for $Hg_{1-x}Mn_xTe$. Comparing the experimental results and calculated date the following can be emphasized: continuous lines in specters are theoretic calculations realized in Kane's concepts of the energy bands model formulated for the semiconductors with narrow gaps.

Components structure of $Hg_{1-x-y}Cd_xMn_yTe$ coats and the energy gap (T=300K). Table 1:

Sample	Type Conduct.	x (Cd)	y (Mn)	E_g, eV experiment	E_g, eV theoretic
KMPT-4	p	0,200	0,042	0,310	0,360
KMPT-36	p	0,074	0,088	0,270	0,250
KMPT-46	p	0,230	0,050	0,270	0,240
KMPT-56	p	0,190	0,120	0,440	0,420
KMPT-13	n	0,050	0,055	0,140	0,130
KMPT-41	n	0,050	0,090	0,300	0,310
KMPT-18	n	0,110	0,085	0,250	0,260
KMPT-8	n	0,055	0,045	0,124	0,078
MB-156	p	0,220	0,040	0,320	0,340

We can emphasize a sufficient accordance between experimental data and theoretical calculations for the effective weights from the pith in relation with the alloys components concentration and the concentration of charge carriers: for the electrons – m^*_e~ (0,005÷0,106m_e), for heave hole – m^*_{hh}~ (0,441÷0,50m_e), for light hole – m^*_{lh}~ (0,0115÷0,018 m_e) and ε_∞=16. The form of rather abrupt absorption fundamental border and the coincidence of the theoretic and experimental absorption specters confirm that the studied $Hg_{1-x}Cd_xTe$, $Hg_{1-x}Mn_xTe$, $Hg_{1-x-y}Cd_xMn_yTe$ coats have a major degree of homogeneity and a satisfactory technical-scientific level of the technological process used in this work. For comparison the absorption specters of the InSb calculated within the limits of the same theoretical conceptions; the absorption specters of semimagnetic materials $Hg_{1-x-y}Cd_xMn_yTe$, $Hg_{1-x}Mn_xTe$ and non-magnetic materials $Hg_{1-x}Cd_xTe$ at the temperature of 300K have the same form.

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