THE INVESTIGATION OF COMPOSITE FILMS CONTAINING GaAs AND GaAs<Te> BY ROENTGENODIFFRACTOMETRIC METHOD

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The initial films HDPE and composite films on the base of high-density polyethylene and semiconductor fillers HDPE+GaAs and HDPE+GAS<Te> at room temperature are investigated by the method of roentgenodiffractometric analysis. The crystallinity (C) degree values of these samples are calculated. It is revealed that crystallinity degree value of composite films increases in 1,3 and 1,4 times (17-20%) correspondingly in the result of implantation of GaAs and GaAs<Te> micro-particles in polymer matrix. The obtained results are explained within framework of three-phase models and change of polymer permolecular structure at implantation of filler micro-particles (d-50μm) playing the role of additional centers of nucleus of crystallization.

Keywords: roentgenodiffractometry, HDPE, GaAs, GaAs<Te>, composite, permolecular structure, crystallinity degree.
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INTRODUCTION

The obtaining of polymer compositions with interesting properties significantly depends on filler nature, particle dimension and its distribution character and degree of interaction between components. Usually, the new fillers lead to change of polymer matrix morphology. The composition materials obtained on the base of new fillers acquire the unique properties [1-2]. In this aspect the composites on the base of high-density polyethylene (HDPE) with semiconductor compounds GaAS and GaAs<Te> is of the special interest. This is caused by the facts that given semiconductors have the peculiar crystal and band structures and are perspective materials in microelectronics and optoelectronics [2-3]. HDPE-GaAs composite films are widely used in the capacity of neutron detector [4-5]. HDPE ($C_{2n}H_{2n+2}$) choice as polymer matrix is caused by well study of the given material [6-8]. Note that the information on composite study of HDPE-GaAs and HDPE-GaAs<Te> is practically absent in scientific literature. The similar investigations are firstly carried out by us; their results are presented in [9-10]. As these investigations show the change of optical-spectrometric and heat parameters are interconnected with the change of supramolecular structure (SMS) of polymeric matrix [9-10].

The present paper is the cycle continuation of these investigations and is dedicated to study of composite films HDPE-GaAs and HDPE-GaAs<Te> (filler content is 1-10 mass%), obtained by roentgenodiffractometric spectroscopy method. The given method allows us to see the structural changes caused by implantation of microparticles in polymer matrix composition and reveal the regularities connected with these changes [11-12].

EXPERIMENT TECHNIQUE

The homogeneous mixture is prepared from HDPE powders and GaAs and GaAs<Te> semiconductors (with particle dimensions ~50μm) by the way of mechanical mixing. Further, the homogeneous mixture is subjected to hot pressing at temperature T=413K with soaking during 15 minutes and is cooled up to room temperature during 30 minutes. The given method allows us to obtain HDPE films with uniform distribution of microparticles in polymer volume that is the necessary factor for optical and spectral investigations.

The distribution uniformity of microparticles in HDPE films is controlled by Fourier-IR absorption spectrum background. The thicknesses *d* of initial and composite films are equal to 50-100 μm. The content of introduced quantity of GaAs and GaAs<Te> microparticles is varied from 1 up to 10 mass%. The diffractograms of initial and composite samples are obtained on powder roentgen diffractometer D2 Phaser (Bruker). CuKα is the source and Ni filter is used. The values of crystallinity degree of investigated samples are calculated.

THE RESULTS AND THEIR DISCUSSION

The diffractograms of initial films HDPE (a), composite films HDPE +2%GaAs (b) and HDPE +GaAs<Te> (c) are given on fig.1. As it is seen from fig.1(a) PE initial films are characterized by the presence of series of reflexes: $2\theta=22^o$ and 24^o. The given lines are character lines of PE crystallinity (a).

The implantation of gallium arsenide 2 mass% into matrix composition leads to appearance of new strong lines 27^o and 45^o, comparatively weak lines $53{,}5^o$ and $72{,}5^o$ and also series of weak ones.

The new observable lines are related to GaAs(b). The same diffraction lines (reflexes) as in HDPE +GaAs composite the intensities of which are redistributed at doping of gallium arsenide in matrix content doped by tellurium 2mass% (c). The redistribution of diffraction lines (fig.2a,b) takes place with increase of implanted microparticle concentrations in polymer matrix composition from 2 up to 6 mass% and positions of these lines don't change. The strongest lines are: $2\theta=27;45$ and $53{,}5^o$.

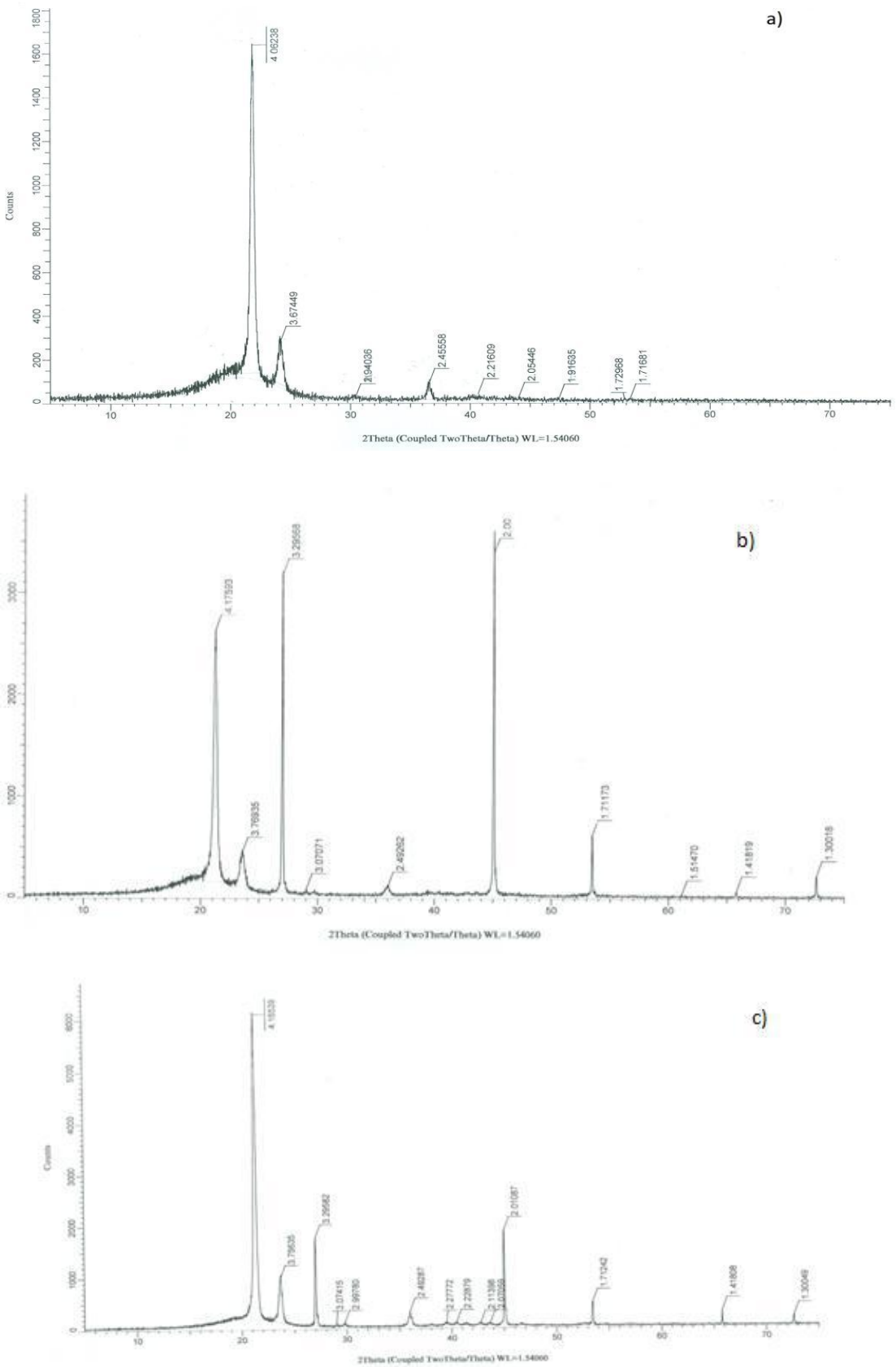

Fig.1. The diffractograms of PEHD (a), PEHD +2mass%GaAs (b) and PEHD +2mass%GaAs<Te> (c).

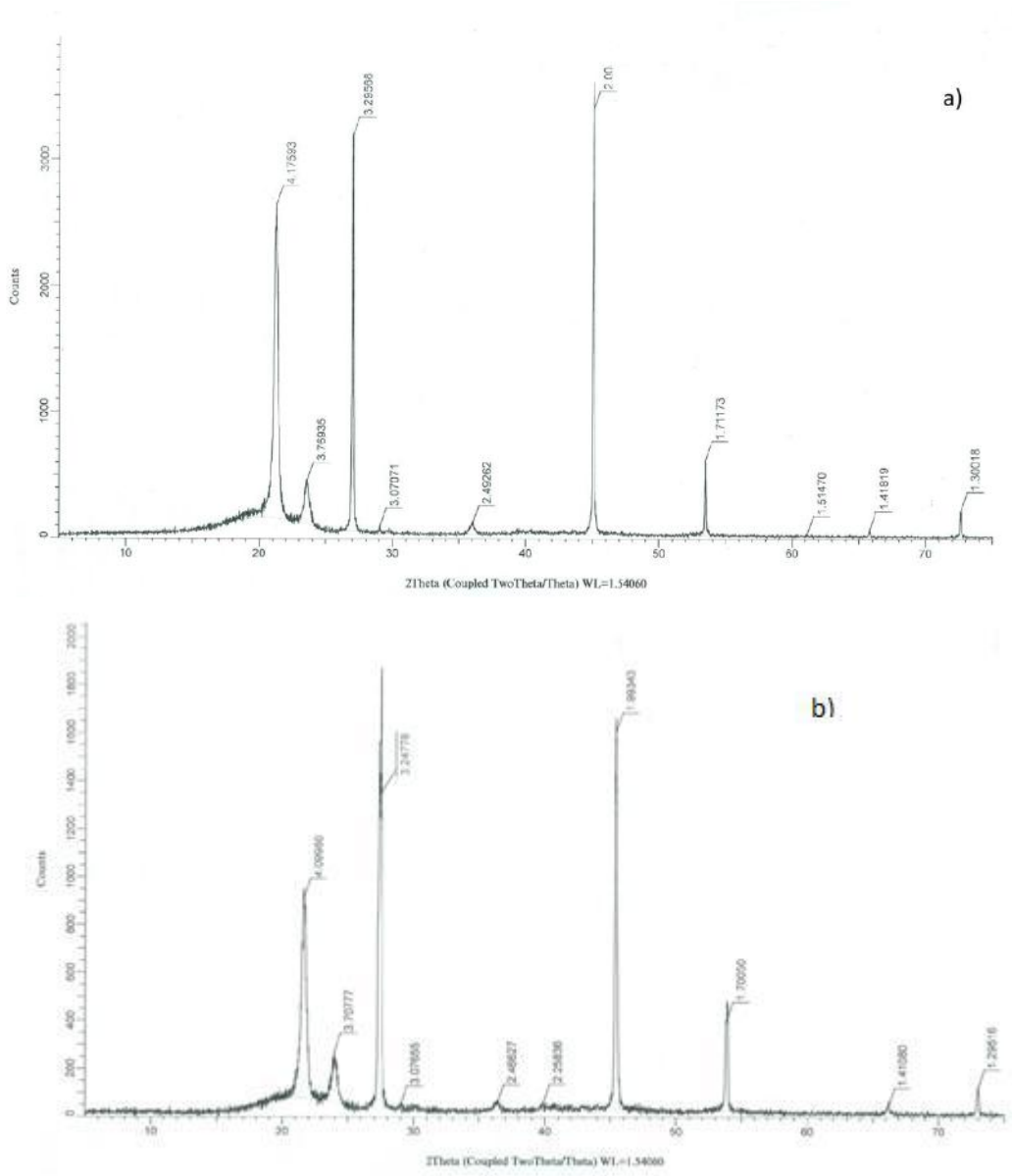

*Fig.2.*The comparative diffractograms of HDPE +GaAs 2 mass% (a) and HDPE +GaAs 6 mass% (b).

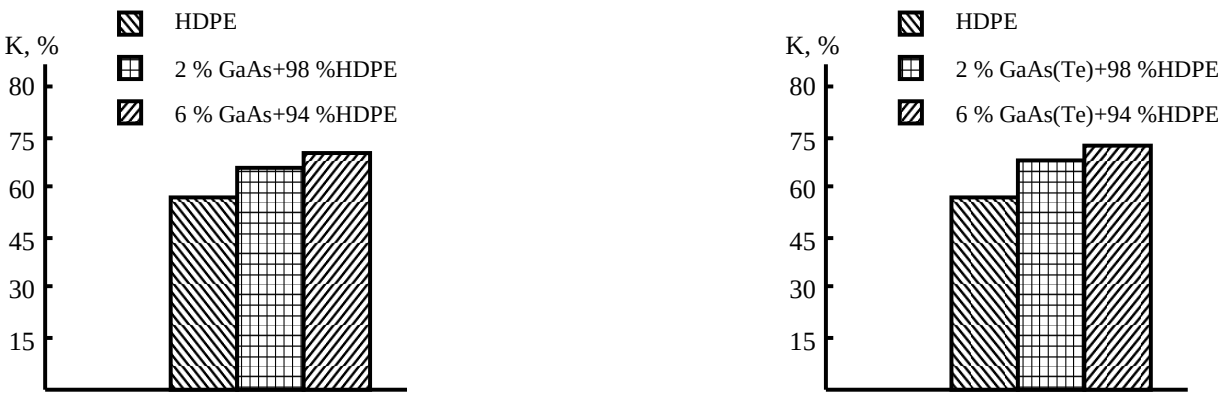

Fig.3. The histograms of crystallinity degree change HDPE +GaAs and HDPE +GaAs<Te> on addition concentrations.

The intensity change of HDPE crystal phase lines is significantly seen. The crystallinity degrees of HDPE initial films, HDPE +GaAs composite films (b) and HDPE +GaAs<Te> (c) are calculated on the base of given data by known program. It is established that the crystallinity degree of composite materials HDPE +GaAs relatively initial films maximally increases in 1,3 times (from 54 up to 71,4%) and for HDPE +GaAs<Te> composites increases in 1,4 times (from 54 up to 73,9%) with increase of concentration of additions. The observable changes are well agreed with data followed from Fourier-IR spectroscopic investigations [9]. The histograms of crystallinity degree redistribution on mass content of implanted microparticles of additions are shown on fig.3.

Thus, on the base of comparative roentgeno-diffractometric analysis it is established that crystallinity degree of composite films in comparison with crystallinity degree of initial films increases on value K =17-20%. The observable effects are probably connected with change of supramolecular structure (SMS) and polymer crystallinity degree (C) as GaAs и GaAs<Te> fillers with dispersivity 50μm in compositions with polyethylene play role of structure generators(these microparticles are nuclear crystallization centers) in crystallinity degree increase and in change of polymer supramolecular structure. Indeed, the well correlation is observed between Fourier-IR spectroscopic values and crystallinity degree ones. The crystallinity increase can take place because of formation of third transient phase according to three-phase model of supramolecular structure (SMS) of amorphous-crystalline polymer consisting of mainly straightened chains (SC) proposed in [12]. According to roentgen data SC can have the three-dimensional structure with periodicity λ=50-60нм [13]. SC are inherent part of high-oriented PE. The value λ for PE fibers corresponds to length of trance-sequences in lamel crystalline regions. Probably, GaAs 2-6 and GaAs<Te> 2-8 mass % microparticle concentrations in PE content lead to SC increase quantity in PE transversal crystalline layer. This can be caused by the fact that GaAs и GaAs<Te> microparticles are centers of additional crystallization at these concentrations. At increase of filler microparticle concentrations in PE content bigger than 6 mass% the cluster dimensions for GaAs and GaAs<Te> begin strongly to exceed the SC periodicity value that is revealed in decrease of relative degree of periodicity.

Probably, the microparticle dimension increase prevents the chain straightening and crystallization process. The filler concentration increase leads to cluster-formation, decrease of surface energy and stabilization up to completion of polymer crystallization processes.

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