HIGH-PLASTIC TRANSITION IN THERMOELEMENTS ON GeTe-Co_2Ce EUTECTIC BASE

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The level of mechanical stresses developing in thermoelements (TE) at heating and cooling is significantly decreased at the use of semiconductor-metal eutectics as intermediate between GeTe and Co because of eutectics transition into plastic state at comparatively low temperature (T=600K). The weakening of physical bond inside crystals of each phase, highly-stressed state of eutectic satiety by its vacancies and dislocations causes the high atomic diffusion mobility and is the reason of superlasticity effect.

Keywords: thermoelements, semiconductor-metal eutectics, plastic state, phase change materials
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INTRODUCTION

Last years the big successes in formation of thermoelectricity physical bases have been achieved, the high-effective crystals on the base of nano-structuring and intercalation have been obtained [1-5]. The transformers for electro-generation and solid-state cooling developed on this base are widely used in science and technology. As it is known, $A^{IV}B^{VI}$ compounds are used as materials for medium-temperature thermoelements (TE); $A_2{}^{V}B_3{}^{VI}$ and their solid solutions are used for low-temperature ones [3-6].

It is required to form the reliable coupling, i.e. it is necessary to supply the chemical, mechanical and electric compatibility of contact and work materials for improvement of TE characteristics and approximation of their parameters to calculated ones [7-8]. The metals from transition group Ni, Co and Fe having the big melting temperature and high values of electric and heat conductions are used at TE coupling by conducting materials.

EXPERIMENT AND DISCUSSION

The difference of thermal expansion coefficient and big fragility of materials consisting in TE cause the strong revealing of inverse elastic aftereffect indirectly after both their formation and in work process at hot junction temperatures 700-900K that leads to its body cracking and complete destruction.

In connection with above mentioned the possibility use of GeTe - Co_2Ge system eutectic alloy in the capacity of layer coupling in TE is shown by us. The complex investigations in wide temperature interval on study of thermoelectric, mechanical and thermal properties of eutectics, their adhesion ability in relation to semiconductor and metal are necessary to carry out.

GeTe and Sb_2Te_3 belong to class of pseudo-binary alloys $(GeTe)_{\mathbf{m}}$ - $(Sb_2Te_3)_{\mathbf{n}}$ which are called phase change materials (PCM) because of ability to transit from crystal state into amorphous one.

.Nowadays PCM are used for preparation of different types of optical rewritable random. The potential possibilities of energy-dependent electron random formation on PCM base are highly estimated [8].

Let's consider the role of nano0structuring in TE transit layers. The limits of increase of Z quality factor parameter and W power of thermoelectric materials (TEM) at nano-structuring are defined in [9]. It is shown that Z and W parameters of nano-structures (NS) change because of $\lambda_{ph} \rightarrow \alpha$ and $\lambda_e \rightarrow \alpha$ transitions in TEM (α is interatomic spacing, λ_{ph} and λ_e are average length of free path of phonons and electrons in samples).

It is revealed that $\lambda_e \rightarrow \alpha$ transition in $l \sim \lambda_{ph} / \alpha < \lambda_e / \alpha < 2 - 3$ interval can be used for simultaneous increase of Z and W of thermoelectric materials. It is established that nano-structuring thermoelectric materials can effectively work in maximum power mode in force thermoelectric energy transformations [9]. The mismatch of Z and W parameters in TEM by optimal concentration of current carriers, increase of electric and thermal resistances of contacts, also the development of diffusion instability leads to undesirable processes and add the diffusion phenomena in metal-semiconductor transitions [7].

The formation of high-plastic transition for TE branches (TEB) on base of GeTe-eutectic GeTe - Co_2Ge satisfying to physical-chemical bases of TE coupling is the aim of the work. The reasons of plasticity rapid increase in eutectic melts and other similar systems are very multiform ones and are mainly connected with change of atom electron structure near interphase.

If the values of strength and yield point take the intermediate position between components consisting in it, then this is no observed for plasticity. The plasticity with temperature increase strongly increases and already at T>600K transforms into superplastic state (Fig.1).

The thermoelectric properties of GeTe - Co_2Ge system eutectic composition Co = 1,39 at%, Ge = 49,81 at%, Te = 48,8 at% (GeTe=98,67 height%, Co_2Ge =1,33height%) and T_{mel} =1000K are considered for further analysis. The thermo-e.m.f., electric conduction, heat conduction and their temperature dependences are studied; the measurements are carried out on controlled oriented samples.

As the samples are two-phase ones then generalized "σ" electric conduction, "**α**" thermo-e.m.f. and "**æ**" heat conduction are measured (see fig.2, fig.3). Having σ and $Z = 0.6 * 10^{-3}$ grad $^{-1}$ values at temperatures 600-950K GeTe - Co_2Ge alloy eutectic makes the significant contribution in TE efficiency. Thermo-e.m.f. sign for GeTe - Co_2Ge eutectic is positive one.

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This is very important as this eutectic is used for TE coupling. GeTe - Co_2Ge eutectic saves its high value of electric conduction in whole temperature interval (600-900K) and its thermo-e.m.f. practically doesn't change. The striving of eutectic atom components in interface to interaction is accompanied by coalescence of different phase crystal lattices on more profitable crystallographic planes.

This causes the oriented and dimensional correspondence in different phase atom disposition in near-boundary layer, high regularity and fineness of eutectic structure, mechanical strength and high-temperature strength of interface.

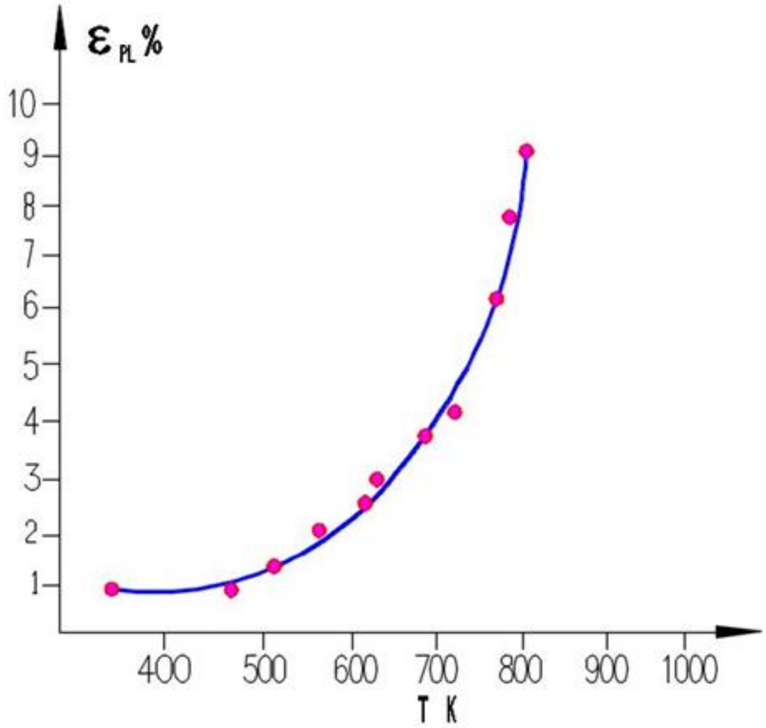

Fig.1. Temperature dependence of plasticity **ε_{PL}%** of GeTe - Co_2Ge eutectic.

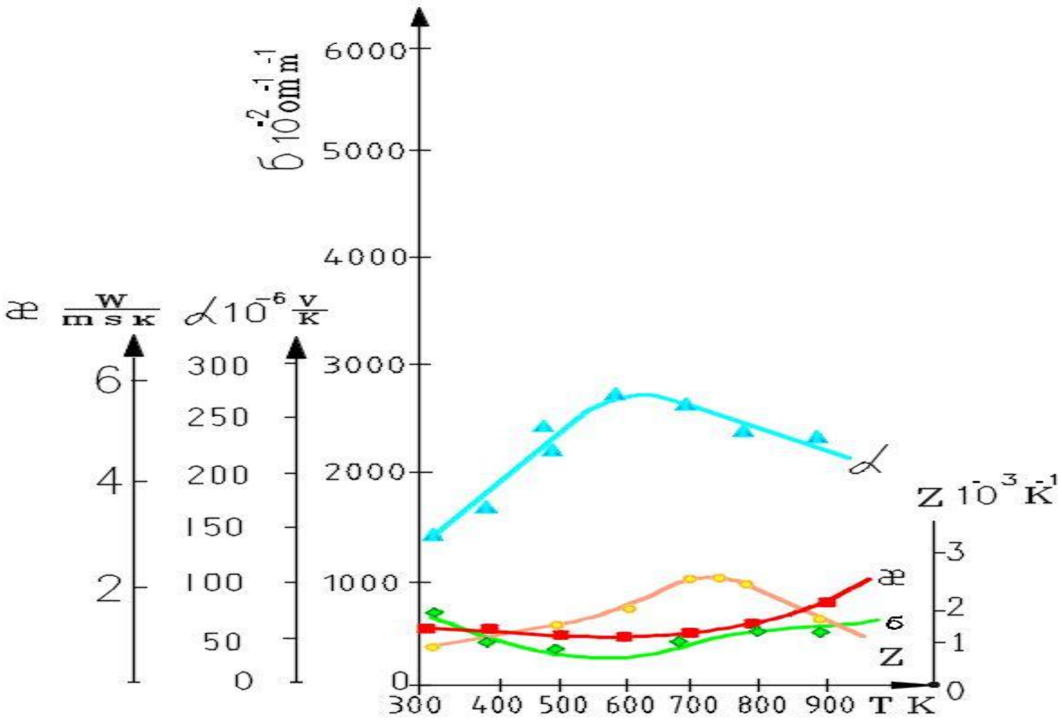

Fig.2. Temperature dependence of thermoelectric properties of TE positive branch on GeTe base.

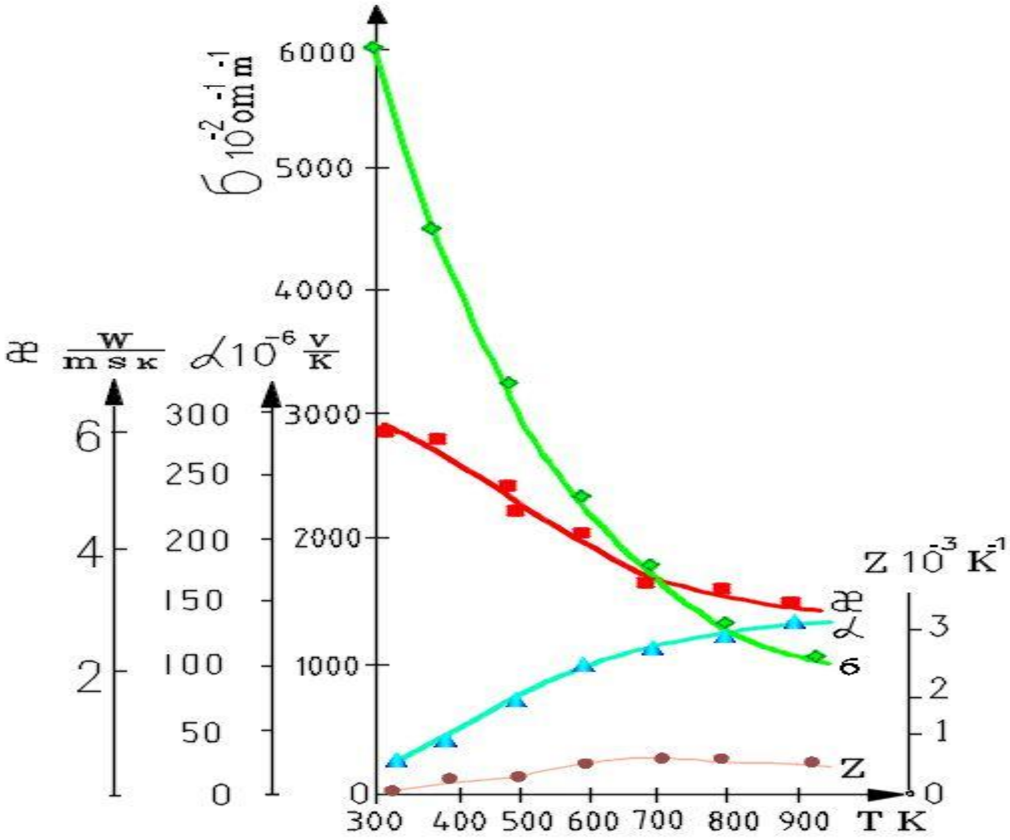

Fig.3. Temperature dependence of thermoelectric properties of GeTe - Co_2Ge eutectic.

The semicoherence of interface boundary caused by mismatch of crystal lattices causes the high-stressed state of eutectic alloy and its saturation by vacancies and dislocations that in collection with decrease of valence electron bond energy inside each phase is the reason of revealing of superplasticity effect in eutectic.

The principle of thermoelement branch coupling consisting in use their eutectic intermediate interlayer between semiconductor and mechanic current distributor that allows us to exclude the chemical interaction in thermoelement near-contact region, supply the strength contact with small thermal and electric losses, decrease the mechanical stresses appearing in thermoelement in process of its work at T_B = 900K is supposed on the base of complex investigation of electron structure, physicochemical, thermoelectric, heat and mechanical properties of eutectic alloys of Co- Ge-Te system. This causes the oriented and dimensional correspondence in atom disposition of different phases in near-boundary layer, high regularity and fineness of eutectic structure, mechanical strength and high-temperature strength of interface.

CONCLUSION

Analyzing the experimental data one can make the following conclusion:

1. the linear dependence saving in temperature interval 300-800K is observed in diagram two-phase part of composition-property dependence for strength, hardness, yield point at compression, thermal expansion coefficient and thermoelectric parameters;

2. it is experimentally observed that ε_{PL}**%** strong increase is observed in eutectic of GeTe - Co_2Ge system at temperature increase higher 650K. The eutectic transforms into superplastic state at higher temperatures;

3. the striving of eutectic atom components to chemical interaction is accompanied by coalescence of different phase crystal lattices on more profitable crystallographic directions. This is the reason of high regular and fine-dispersed eutectic structure and also high mechanical strength of interface.

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