INFLUENCE OF RADIATION ON THE KINETIC PARAMETERS OF BRANCH MATERIALS OF THERMOELECTRICAL COOLER

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ABSTRACT

The influence of neutron, electron and γ-radiation impact on the temperature dependence of kinetic parameters of monocrystal of solid solutions n-$Bi_2Te_{3-x}Se_x$ between 77-300 K temperature is investigated.

INTRODUCTION

The last 10-15 years thermoelectrical cooling is widely used all over. The little (miniature) dimensions, the practical unlimited resources of works, the absence in cooling systems of working liquids and gases consequently, the absence in danger polution of environment of space, high reliability defination by use thermoelectrical refrigerators for provision necessary temperature regime in many branches of modern techniques.

The main problem, which necessary must solve by creation of modern efficient thermoelectrical cooler problem increases efficiency of thermoelectrical materials.

Now a lot quantities of thermoelectrical materials of perspective for practical using are researched as by its thermoelectrical efficiency, so and by works interval temperature. But quantity for practical purpose is less important. These alloys of solid solutions on the basis of Bi_2Te_3 and Bi-Sb are the principal.

Thermoelectrical materials on the basis of bismuth and antimony chalcogenids are widely applied at the temperature intervals close to the room in different cooling devices. However the works, dedicated for studying the influence of radiation on the kinetic properties of monocrystal of solid solutions, is lack in literature.

The given work is devoted to the experimental investigation of neutron, electron and γ-radiation impact on the temperature dependence of kinetic parameters (thermo.-e.m.f.-α, electrical conductivity - σ, common heat conductivity - H_c and Hall - R_H) of monocrystal of solid solutions n- $Bi_2Te_{3-x}Se_x$ between 77-300K temperature.

Experimental results and their discussions

For the synthesis used material Bi-BI-0000, Te-TV4 and Se brand of S.VC. For investigations of kinetic coefficients are used monocrystal, which received from melting by method of Bridjmen and by method of Chokralsky. Monocrystals are received in the direction of $[10\bar{1}0]$, perpendicular central of crystal c axis.

The neutron irradiation is realized by impulses of reactor neutrons in interval of flueses 10^{13}-10^{14} cm^{-2} in the room of temperature. The source ^{60}Co was used as γ-radiation. The samples were exposed by influence of γ-rays at room temperature at 10^6-10^8R dose intervals. Electron irradiations of crystals is realized by electrons with energy 3MEV from linear accelerator at 10^{13}-10^{14} cm^{-2} beam intensity. Irradiation of samples is made in air and in vacuum. The kinetic parameters of samples measuring in the constantly electrical and magnetic fields, by compensation method before and after definite integral dose of irradiation.

Temperature dependence of electrical conductivity, thermal resistance and thermo.-e.m.f. coefficients, typical experimental curve a lot of quality received results for monocrystal n-$Bi_2Te_{3-x}Se_x$ by difference types and doses are shown in fig. 1.

The analysis of received experimental dependence α(T) execution with help well-known correlation for concentration current carriers:

$$n = \frac{4(2\Pi m^x kT)^{3/2}}{\sqrt{\Pi}\, h^3} F_{1/2}(\eta) \qquad (1)$$

where $F_{1/2}(\eta)$ is integral Fermi to type

$$F_{1/2}(\eta) = \int_0^\infty x^s \left[\exp(x-\eta)+1\right]^{-1} \qquad (2)$$

From (2) may define temperature dependence of effective mass of density conduction $m^* \sim T^s$ by n=const. This dependence is conditioned deflexion α(T) from theoretical dependence (by $\Gamma = -0{,}5$ and m=const) in difference solid solutions on the basis of tellurids bismuth [1-2].

By analysis dependence of σ(T) usually, to except the influence of degeneration, consider of value

Fig.1. Temperature dependences of coefficients of electrical conductivity (a), thermal resistance (b) and thermo. e.m.f. (c) from neutron, electron and γ-irradiation.

Δ - non-irradiation sample

∗ - $1 \cdot 10^{13}$ cm^{-2} (neutron irradiation)

• - $1 \cdot 10^{14}$ cm^{-2} (neutron irradiation)

O - $1 \cdot 10^{13}$ cm^{-2} (electron irradiation)

× - $1 \cdot 10^{14}$ cm^{-2} (electron irradiation)

o - $1 \cdot 10^{6}$R (γ-irradiation)

Δ - $5 \cdot 10^{13}$ cm^{-2} (neutron irradiation)

◊ - $1 \cdot 10^{8}$R (γ-irradiation)

- $5 \cdot 10^{13}$ cm^{-2} (electron irradiation)

$$\sigma_0 = \frac{F_{1/2}(\eta, \Gamma)}{F_0(\eta, \Gamma)} \frac{2}{\sqrt{\Pi}} \sigma \qquad (3)$$

where $F_{1/2}(\eta, \Gamma)$ and $F_0(\eta, \Gamma)$ are Fermi integrals by (2) form.

Heat conductivity of crystal lattice calculate as difference total conductivity and electron part. Last part calculate by Wiedemann-Franz law (H_{el}=LσT, where L - quantity of Lorentz, defined by Γ=-0,5).

It is known, that nature of radiation defects and character change of electrical physical properties of crystals by irradiation are defined in principal of types irradiation properties of irradiation materials and condition of it irradiation.

Irradiation of crystals of highly energy particlies create free vacancy and between knot atoms. As between knot atoms, so that vacancy have solely many agility, that allow them transference. Vacancy and between knot atoms are divided by potential barrier, that makes hard their disappearance by meetings. In results the component steams of Frenck are received possibility by effective interaction with different imperfection structures and form complexes defects - according to this thermoelectrical materials on the basis of chalcogenids bismuth are usually used itself by unregulated phases with breach crystals lattice in type border grains, dislocation point electroactively defects in many define electrofisical parameters and they change in processes of exploitation.

That is why, by irradiation monocrystals n-$Bi_2Te_{3-x}Se_x$ in different variety and absorbed doses may expect the formation of complex defects, so that the second defects the variation of intensive irradiation lead in particular modification of concentration bearer charge in zones of consequence which appears change charge of condition react defects, form complex and change of velocity of accumulation by the second defects.

Apparently, of graphs, different varieties are irradiated of influence on property monocrystals

n- $Bi_2Te_{3-x}Se_x$ on difference.

As, by irradiation of neutrons and fast electrons and with increase dose irradiation meaning of coefficients electric conductivity and thermal resistance as compared with non-radiation models increase, by irradiation γ-quantum meaning σ(T) decrease, for α(T) - on the contrary.

As indicated above, by irradiation crystals of highly energy particles are formed free vacancy and between knot atoms. γ-quantum so that fast electrons are evoke advantage origins defects of structure point type. Transmission energy γ-quantum of crystal lattice happens across excitement irradiation of fast electrons. Transmission energy of electrons of atoms lattice are evoke displacement them with formation points of defects.

At this increase the concentration vacancy and steam Frenck leads to decrease period of lattice, and between knot atoms by its increase. In general case change of period lattice depends on the concentration defects.

Increase doze of irradiation leads to increase to breach lattice, that leads to increase meaning thermal resistance of lattice.

Account aforesaid, increase meaning, σ(T) by neutrons and fast electrons, by apparently, connected with increase concentration bearer current, but decrease σ(T) by γ-irradiation with decrease them, witness about the result temperature dependence of coefficient Holla.

At this effective mass density condition with increase the concentration bearer of increase. Agility bearer current with increase temperature in irradiation models of decrease strongly, than in non-radiation models, that conditioned by increase defect crystal of lattice.

Properly note, that influence temperature and intensives irradiation on process defect formation correlation and by corresponding variation them may change concentration bearer of crystals in broad interval temperature, that is govern properties of crystals.

CONCLUSION

The influence of difference types and irradiation doses of solid solutions monocrystals n-$Bi_2Te_{3-x}Se_x$ adduce to marked difference changes of kinetic parameters of materials.

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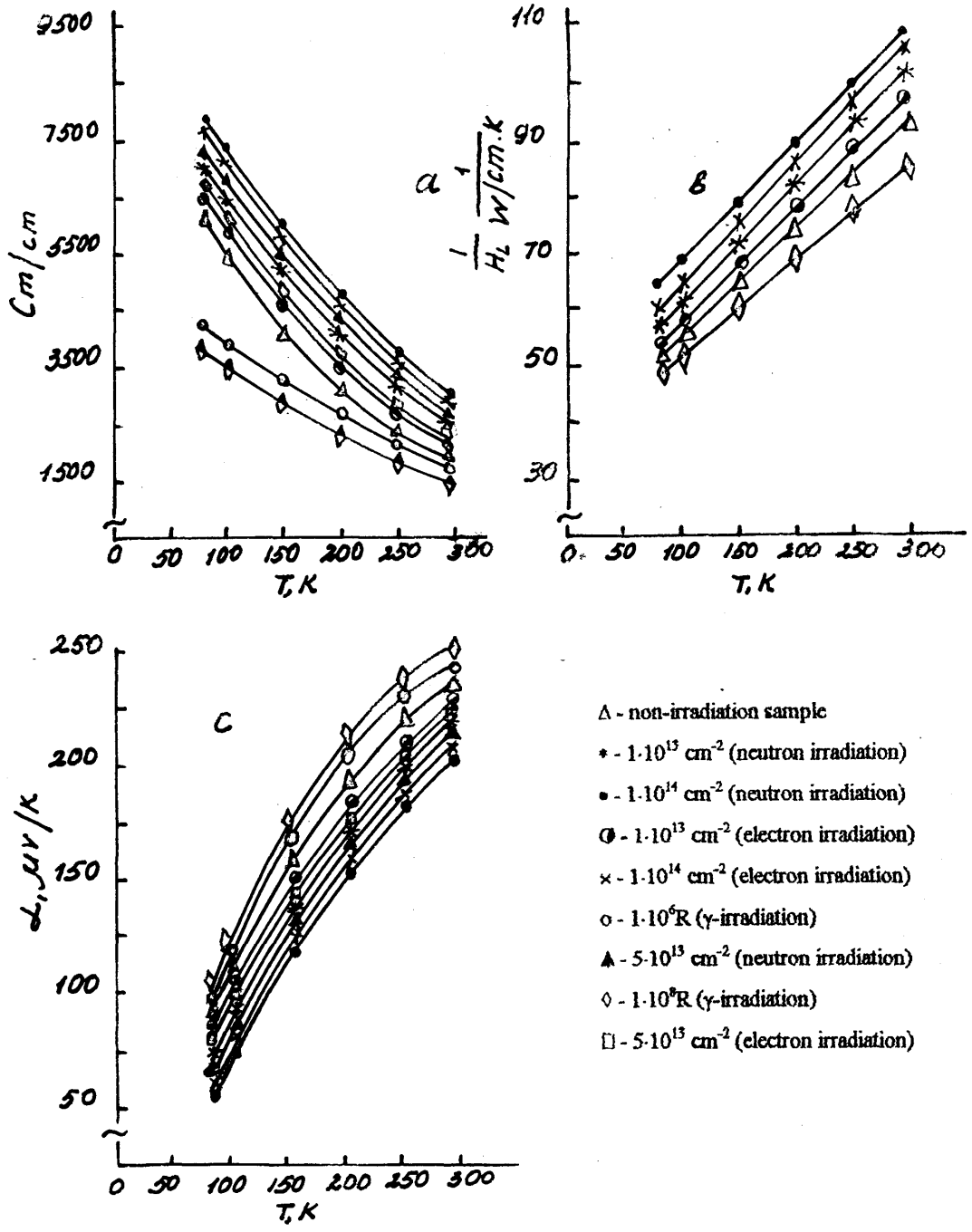


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