ABOUT UNUSUAL ANGLE DEPENDENCE OF HALL'S COEFFICIENT IN GaSb – V_2Ga_5 EUTECTIC COMPOSITION FROM THE ZADEH'S "FUZZINESS" POINT OF VIEW

E.A. ISAYEVA[1]*, G.I. ISAKOV [1], M.H. KAZIMOV [2]*****

[1]*Institute of Physics Azerbaijan National Academy of Sciences H. Javid av.33, Baku, Az -1143*
[2]*Nakhchivan Branch of ANAS AZ7000, Nakhchivan city, Haydar Aliyev prospect, 76*
*e-mail: * eaisaeva@mail.ru, **gudrat.isakov@gmail.com, ***mahbub.60@mail.ru*

In the different cases of directions of current I, magnetic field H and metal inclusions X, $J \parallel X \perp H$, $J \perp X \parallel H$, $J \perp X \perp H$, the Hall's effect in InSb - NiSb and GaSb – V_2Ga_5 eutectic compositions has been investigated. It has been shown in the case $J \perp X \perp H$ the maximum of Hall's electromotive force ε is being observed when the direction of magnetic field and the straight line passing through the contacts coincide. This is due to the strong anisotropy of GaSb – V_2Ga_5 material.

Keywords: eutectic composition, Hall's effect, anisotropy
PACS: 72.20.My, 81.30.-t .

INTRODUCTION

The eutectic compositions InSb-NiSb and GaSb-V_2Ga_5 come out when NiSb is 1,8% in InSb-NiSb alloy and GaSb is 4,4 % in GaSb-V_2Ga_5 alloy. The samples are crystallized by the Bridgman method with velocity v = 6sm / hour.

The metallographic investigations of these samples by *MIM-8I* microscopy have shown metal phase NiSb is as short needles but V_2Ga_5 is as long shaft (fig.1 and 2).

In this our paper we have investigated the dependence of Hall's coefficient on angle φ between direction of magnetic field H and axis Z passing through the contacts of InSb-NiSb and GaSb-V_2Ga_5 samples.

EXPERIMENTAL AND DISCUSSION OF THE RESULTS

It is well known the Hall's effect is the transverse effect. The maximum of Holl's electromotive force ε is observed when $\varphi=90°$. When $\varphi=0°$, the $\varepsilon=0$.

Our investigations have shown in the InSb-NiSb eutectic in all cases $J \parallel X \perp H$, $J \perp X \parallel H$, $J \perp X \perp H$ it was carried out (fig.2), i.e the normal behavior of Hall's coefficient.

But in GaSb-V_2Ga_5 eutectic in case $J \perp X \perp H$ we have observed opposite phenomenon, i. e. when $\varphi=90°$, the $\varepsilon=0$ (fig.3). Let's explain this anomaly.

At preparing samples, during their longitudinal and transverse cutting and grinding it is possible non depending from us the mistakes $\delta=1\text{-}5°$. Therefore, the cases $J \parallel X \perp H$, $J \perp X \parallel H$, $J \perp X \perp H$ take places with an error δ.

The dependence $R(\varphi) = R_{max} \sin\varphi$ shows the Hall's effect, because when $\varphi=90°$, the coefficient $R(\varphi) = R_{max}$, when φ= $0°$, the $R(\varphi)$= 0.
Considering the δ it can be written:

$$R(\varphi) = R_{max} = R_{max} \sin\varphi cos\delta \pm R_{max} \sin\delta cos\varphi \; .$$

The $R(\varphi)$ is decomposed into 2 members which differently depend on angle φ.

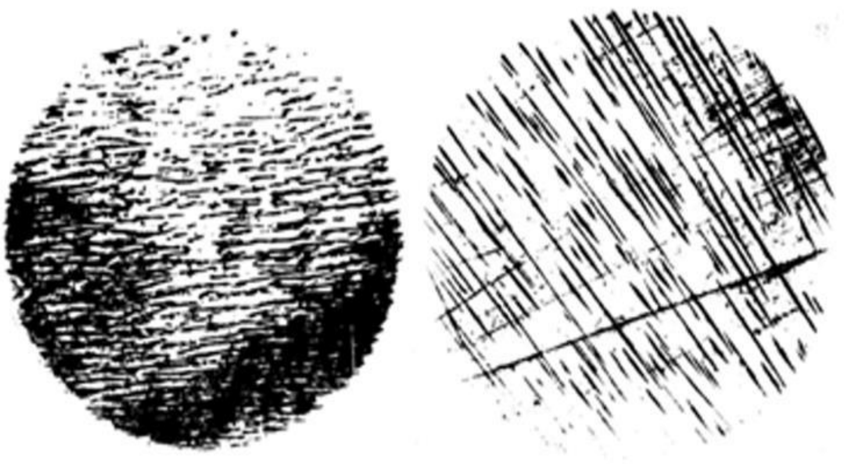

Fig.1. The sort needles in InSb-NiSb and long wires in GaSb-V_2Ga_5 eutectic compositions.

131, H.Javid ave, AZ-1143, Baku
ANAS, Institute of Physics
E-mail: jophphysics@gmail.com

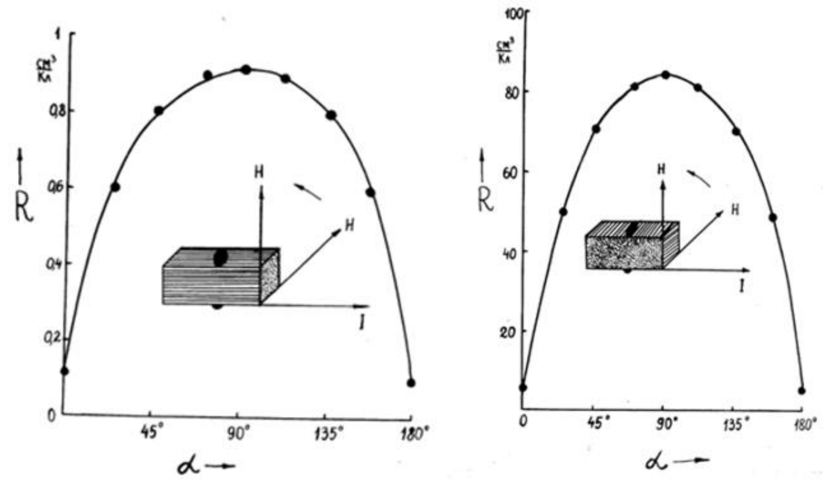

Fig. 2. Normal dependence of the Hall's coefficient on angle in the cases $J \parallel X \perp H$ and $J \perp X \parallel H$.

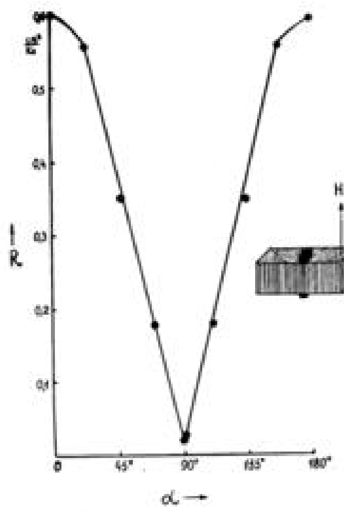

Fig.3. In the GaSb-V_2Ga_5 eutectic the unusual dependence of the Hall's coefficient on angle in the case $J \perp X \perp H$

The member $R_{max} \sin\varphi\, cos\delta$ grows with growth φ. When φ=90° it equals to $R_{max} \cos\delta$. When φ = 0° it equals to 0, i.e., its behavior is the usual. Let's call it the usual Hall's coefficient *A*.

$$A = R_{max} \sin\varphi\, cos\delta .$$

The second member $R_{max} \sin\delta cos\varphi$, opposite, decreases with growth angle φ. When $\varphi=90°$ it equals to 0. When φ = 0° it equals to $R_{max} \sin\delta$, i.e., its behavior $B = R_{max}\, cos\varphi\, sin\,\delta$.

Thus, the coefficient of Hall $R(\varphi)$ is the sum of usual and closing coefficients.

$$R(\varphi) = A + B \qquad (1)$$

When $\delta=0$, $R(\varphi) = A$, i.e., the usual Hall's coefficient. It takes place in the isotropic materials because there is no conception of the error δ. Here we would like to see the conception of the error δ and connect it with fuzziness of Lutfi Zadeh [4]. The error δ is little and it can be saying the δ is the least. We even can say that $\delta=0$. Then sin 0=0 and B=0. In this case we say that we have deal with homogeny material where there no a conception of δ. But we have been investigating the anisotropic materials InSb-NiSb and GaSb-V2Ga5 and therefore $\delta \neq 0°$. Here we have deal with the "fuzziness" medium inside our samples which can be by Zadeh's fuzzy logic and fuzzy sets [5].

At first, let's consider δ on the plane I and Z, i.e., $J \parallel X$, $J \perp X$ (fig.4).

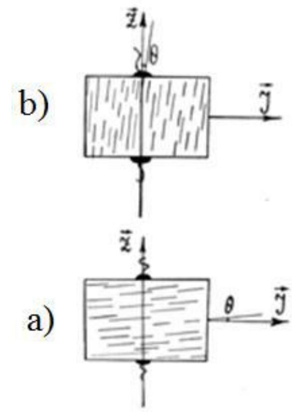

Fig. 4. The angle δ on the (J, Z) plane.

Magnetic field is not considered by us now. It is perpendicular to the plane (I, Z). Let's choose the current I as the direction of indication of δ in these two cases. In the case $J \parallel X$, $\delta = \delta$, but in the case $J \perp X$, $\delta = \delta + 90°$.

Thus, in the case $J \parallel X$, $B = R_{max}\, cos\,\varphi\, sin\,\delta$, in the case $J \perp X$, $B = R_{max}\, cos\,\varphi\, sin(\delta + 90) = R_{max}\, cos\varphi\, cos\delta$.

As we see, in the closing Hall's coefficient B the $R_{max}\, cos\varphi$ in the case $J \parallel X$ multiplies on $sin\,\delta$, but the case $J \perp X$ multiplies on $cos\,\delta$. We note δ = 1 - 5°. Therefore, $sin\,\delta \to 0$ and B=0 in the case $J \parallel X$, but $cos\,\delta \to 1$ and B=$R_{max}\, cos\varphi$ in case $\perp X$.

Let's substitute this value in formula (1).

B=0, $R(\varphi) = A + B = A = R_{max} \sin\varphi$, in the case $J \parallel X$ and B = $R_{max}\, cos\varphi$, $R(\varphi) = A + B = R_{max}\sin\varphi \pm R_{max}\, cos\varphi$ in the case $J \perp X$.

Thus, in the case $J \parallel X$, $R(\varphi) = A$ – the usual dependence.

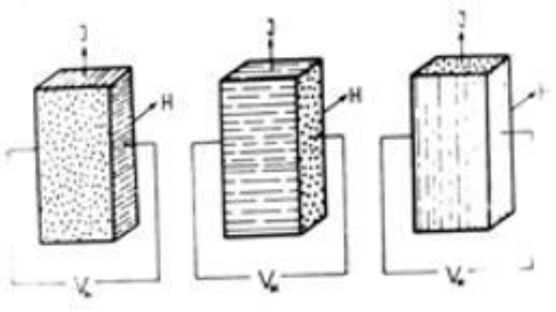

Fig. 5. All cases $J \parallel X \perp H,\ J \perp X \parallel H,\ J \perp X \perp H$

But in the case $J \perp X$, $R(\varphi) \neq A$ – the unusual dependence.

The case $J \perp X$ are realized in two cases $J \perp X \parallel H$ and $J \perp X \perp H$. Let's consider the angle δ on the plane of magnetic field and axis Z. Jn the fig. 4 we exchange I on H. All our conclusions are true for this case too.

B=0, $R(\varphi) = A + B = A = R_{max} \sin\varphi$, in the case $H \parallel X$ - the usual dependence and B = $R_{max}\, cos\varphi$, $R(\varphi) = A + B = R_{max}\sin\varphi \pm R_{max}\, cos\varphi$ in the case $H \parallel X$ - the unusual dependence.

Uniting both consideration on the planes (I, Z) and (H, Z) we cross over into the space (*I, Z, H*) (fig.5).

We have seen in the case $J \perp X \perp H$ there is unusual dependence of the Hall's coefficient on angle, i.e., $R(\varphi) = R\sin\varphi \pm R\, cos\varphi$. But why it is observed only in the GaSb-V_2Ga_5 eutectic compositions because of the metallic inclusions V_2Ga_5 are as long "wires" which close Hall's voltage on contacts, $V_x=0$ when φ=90°. But in NiSb-GaSb the inclusions NiSb are short needles which cannot close Hall's voltage.

CONCLUSION

Is the Hall's effect wrong law of nature? It is not true. The Hall's effect is absolute truth showing physical law in nature in any situation. The observed by us unusual behavior of Hall's effect due to the geometry of the directions of current, magnetic field and matal inclusins. It is "geometric" effect. We could understand it due to the conception of "fuzziness" of Lutfi Zadeh too.

[1] *Muller, M. Wilhelm.* Die binaren Eutektika GaSb-GaV_3Sb_5 and GaSb-V_2Ga_5. J.Physics and Chem.Solids, 1967, V.28, pp. 219-224.

[2] *H. Weiss, M. Wilhelm.* Indiumantimonid mit gerichtet eingebauten electrisch gut leitenden einschlussen: System InSb-NiSb. Zeitschrift für Physics, 1963, v.176, pp. 399-410.

[3] *A.R. Yavari, P.J. Desre, T. Benameur.* Mechanically driven alloying of immiscible elements. Phys.Rev.Lett., 1992, V.68, №14, pp.2235-2238.

[4] *L.A. Zadeh.* Fuzzy Sets as a Basis for a Theory of Possibility. Fuzzy Sets and Systems, 1978, v.1, pp. 3-28.

[5] *R. Hodge* Key Terms in Fuzzy Logic: Deep Roots and New Understandings. Fuzzy Sets and Systems, 2001, v.2, pp.76-84.

E.A. İsayeva, G.İ. İsakov, M.H. Kazımov

ZADƏNİN "QEYRİ-SƏLİS" NÖQTEYİ-NƏZƏRİNDƏN GaSb – V_2Ga_5 EVTEKTİKASINDA HALL ƏMSALININ QEYRİ-ADİ BUCAQ ASILILIĞI

I cərəyanının istiqamətlərinin, H maqnit sahəsinin və X, metal daxilolmalarının müxtəlif J‖X⊥H, J⊥X‖H, J⊥X⊥H hallarda InSb-NiSb и GaSb - V_2Ga_5 evtektik kompozisiyalarında Hall effekti tədqiq edilmişdir. J⊥X⊥H halda, maqnit sahəsinin istiqaməti və kontaktlardan keçən düz xətt üst-üstə düşdükdə Hall elektrhərəkət qüvvəsinin ε maksimumu müşahidə edilir. Bu, GaSb – V_2Ga_5 materialının güclü anizotropiyası ilə bağlıdır.

Э.А. Исаева, Г.И. Исаков, М.Г. Казымов

О НЕОБЫЧНОЙ УГЛОВОЙ ЗАВИСИМОСТИ КОЭФФИЦИЕНТА ХОЛЛА В ЭВТЕКТИКЕ GaSb – V_2Ga_5 С ТОЧКИ ЗРЕНИЯ «НЕЧОТКОСТИ» ЗАДЕ

В различных случаях направлений тока I, магнитного поля H и металлических включений X, J‖X⊥H, J⊥X‖H, J⊥X⊥H исследован эффект Холла в эвтектических композициях InSb-NiSb и GaSb - V_2Ga_5. Показано, что в случае J⊥X⊥H максимум электродвижущей силы Холла ε наблюдается при совпадении направления магнитного поля и прямой, проходящей через контакты. Это связано с сильной анизотропией материала GaSb – V_2Ga_5.