THE PECULIARITIES OF ELECTRIC AND GALVANOMAGNETIC PROPERTIES OF $Fe_{1,2}Cr_{1,8}S_4$

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Electric and galvanomagnetic properties of ferrimagnetic compound $Fe_{1,2}Cr_{1,8}S_4$ were investigated. It is revealed, that magnetic resistance is negative with the sharp peak in the range of $T_c \cong 250K$ and it is shown, that the spontaneous Hall coefficient reduces exponentially with the temperature in the region of the magnetic ordering.

$FeCr_2S_4$ has the spinel structure and is the ferrimagnetic semiconductor with the Curie temperature ~180K [1,2]. The chromium ions in the octahedral sublattice are replaced partially by the enelyse ions in order to get magnetic semiconductors with the high Curie temperature and it was shown, that $Fe_{1,2}Cr_{1,8}S_4$ has also spinel structure and is ferrimagnetic with the Curie temperature $T_c \cong 250K$ [3,4]. However the information lack on the electric and in particular galvanomagnetic properties gives no chance to present the full picture of the semiconductive properties and its correlation with the magnetic structure. Therefore the temperature dependences of the electroconductivity, the Hall effect and magnetoresistance of the given content in the wide temperature of the magnetic phase transition, were investigated. The receipts and the samples analysis were conducted by the technology described earlier [4].

The electroconductivity was measured by the compensated method on the constant current, but galvanomagnetic properties in the magnetic field of the strength up to 12K.

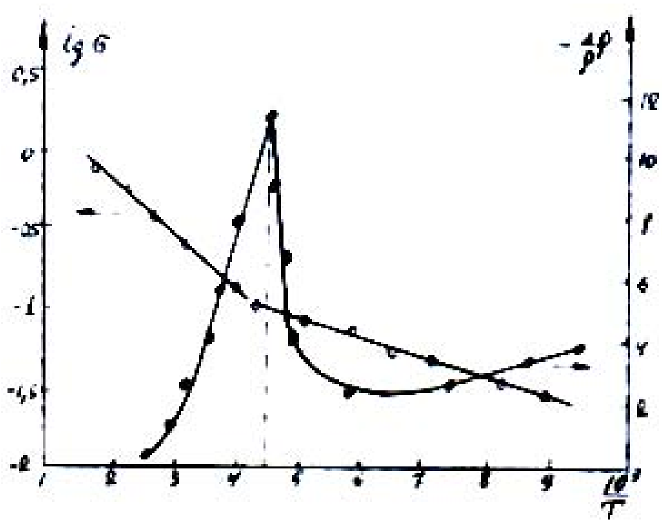

Fig.1. The dependence of $lg\sigma$ and $\frac{\Delta\rho}{\rho}$ on the temperature for $Fe_{1,2}Cr_{1,8}S_4$.

The dependence of $lg\sigma$ and $\frac{\Delta\rho}{\rho}$ on $\frac{10^3}{T}$ for this constant is presented on fig.1. As it is seen from the figure, the content has the semiconductive nature of the conductivity. So that in the range $100 \div 250^0K$ the electroconductivity increases with the temperature growth with the activation energy ~ 0,02eV. The activation energy of the conductivity changes in the range of the magnetic ordering, and it becomes equal to ~0,07eV. Therefore the activation energy of the conductivity reduces by ~0,05eV at the transition in the magnetic ordering state. This result is in agreement with the theory, developed in the paper [5], in which the electroconductivity of the antiferromagnetic semiconductors was examined by means of *S-d* exchange model. It is concluded in these papers, that magnetic sublattice with the opposite orientation of spins, which in consequence of the exchange interaction with the conductivity electrons create the additional periodical potential, having more low symmetry, than that of crystals, occur at the transition into the magnetic-ordered state and the energy bands fission and the reduction of the activation energy, may occur, what we have confirmed experimentally.

The dependences of on $\frac{10^3}{T}$ are also presented on fig.1. It is seen, that the value of $\frac{\Delta\rho}{\rho}$ is negative, moreover it achieves the maximum (12%) in the region of the magnetic phase transition. Such anomalies of the magnetoresistance at the Curie point in the ferromagnetic semiconductors achieve quiet essential values, for example 80% for $FeCr_2S_4$ (T_c=130K) and even 10^4 times for EuSe (T_c=8K) [6].

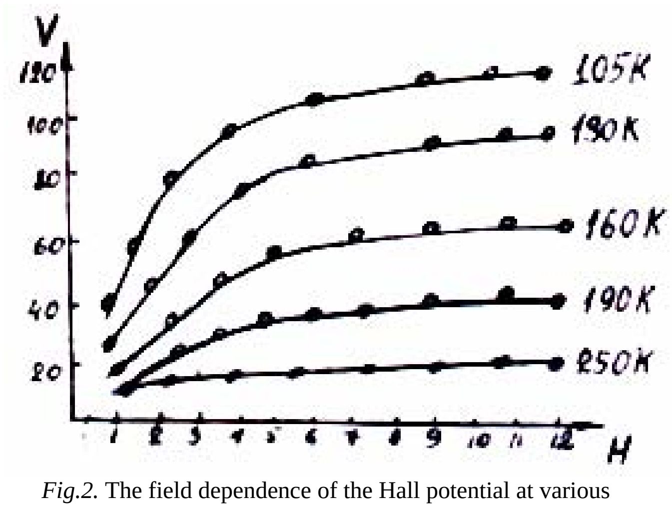

Fig.2. The field dependence of the Hall potential at various temperatures for $Fe_{1,2}Cr_{1,8}S_4$.

Such behavior of the magnetoresistance is connected both with the energy bands splitting and with the current carriers scattering on the disordered spins. Such relatively low value of the jump of $\frac{\Delta\rho}{\rho}$ at the Curie point in $Fe_{1,2}Cr_{1,8}S_4$ in comparison with the ferromagnetic semiconductors with high agility values proves once more, that the jump value of $\frac{\Delta\rho}{\rho}$ is connected obviously with the value of the current carriers agility, what is discussed in the paper [6].

The field (0-12K) and temperature (90÷250K) dependences of Hall potential of $Fe_{1,2}Cr_{1,8}S_4$ are also investigated. The field dependences of the Hall potential at various temperatures of $Fe_{1,2}Cr_{1,8}S_4$ is presented on fig.2.

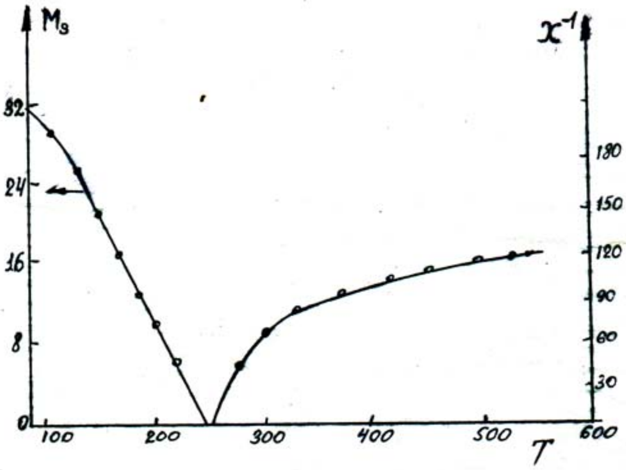

Fig.3. The temperature dependence of the spontaneous magnetization M_s and paramagnetic susceptibility χ_m^{-1} for $Fe_{1,2}Cr_{1,8}S_4$.

The Hall-e.m.f. in the magneto-ordered compounds (ferro and ferrimagnetics) is presented by the sum:

$$V_x = (R_0 H + R_1 M)\frac{J}{d}$$

where $R_0 H\frac{J}{d}$ is classical and $R_1 M\frac{J}{d}$ is anomalous potential, correspondingly. The anomalous Hall potential at $H\to 0$ turns out into the spontaneous Hall potential, which has the form:

$V_{XS} = R_S M_S\frac{J}{d}$, since $R_0 H\frac{J}{d} = 0$, where R_s is the spontaneous Hall coefficient, M_s is the spontaneous magnetization, d is the sample thickness, J is the sample current. V_{xs} and M_s are determined by the extrapolation of $V_x(H)$ and $M(H)$ from the region of the paroprocess on the $H=0$ axis and the coefficient R_s is calculated as a ration:

$$R_s = \frac{V_{xs} d}{M_s J}$$

The magnetization and paramagnetic susceptibility of $Fe_{1+x}Cr_{2-x}S_4$ ($0\le x\le 0.5$) system are investigated by us before [4]. The values of the spontaneous magnetization in the temperature interval 90÷250K and the paramagnetic susceptibility of the compound $Fe_{1,2}Cr_{1,8}S_4$ calculated from these experiments are presented on fig.3.

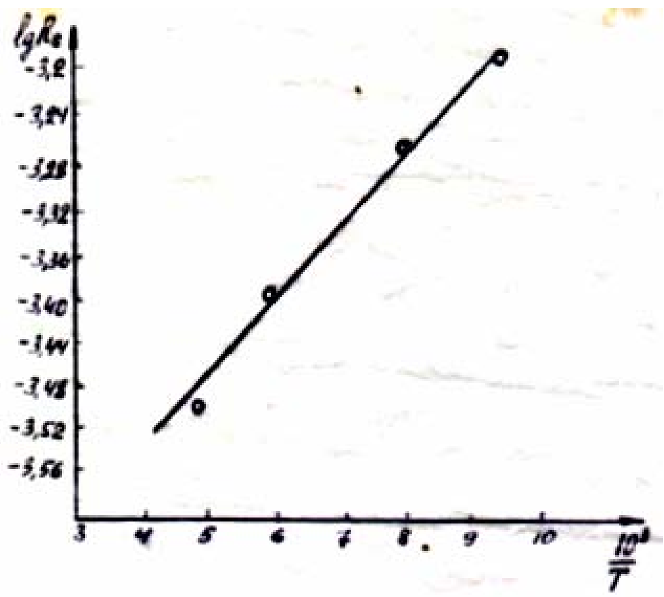

Fig.4. The dependence of the Hall coefficient lgR_s on the temperature for $Fe_{1,2}Cr_{1,8}S_4$.

The value are V_{xs} is calculated from the dependence of V_x~H at various temperatures in the range $T<T_c$, in which values V_{xs} are determined by the value extrapolation V_x for $H\to 0$ in the process region.

The dependence of lgR_s on $\frac{10^3}{T}$ is presented on fig.4. As it is seen from the figure, the spontaneous Hall coefficient reduces exponentially with the temperature increase. Since the spontaneous Hall coefficient is the consequence of the spin-orbital interaction between the current carriers and the localized magnetic moments, it indicates on the fact that the magnetic heterogeneity of the given compound increases with the temperature increase.

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$Fe_{1,2}Cr_{1,8}S_4$-ÜN ELEKTRİK VƏ QALVANOMAQNİT XASSƏLƏRİNİN XÜSUSİYYƏTLƏRİ

$Fe_{1,2}Cr_{1,8}S_4$ birləşməsinin elektrik və qalvanomaqnit xassələri tədqiq edilmişdir. Maqnit müqavimətinin $T_c \approx 250$ K-də kəskin pikə malik olmaqla mənfi qiymət aldığı müşahidə edilmiş və spontan Holl əmsalının maqnit nizamlı oblastda temperaturla eksponensial azaldığı göstərilmişdir.

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ОСОБЕННОСТИ ЭЛЕКТРИЧЕСКИХ И ГАЛЬВАНОМАГНИТНЫХ СВОЙСТВ $Fe_{1,2}Cr_{1,8}S_4$

Исследованы электрические и гальваномагнитные свойства ферримагнитного соединения $Fe_{1,2}Cr_{1,8}S_4$. Обнаружено, что магнитное сопротивление отрицательно с резким пиком в области $T_c \approx 250$К и показано, что в области магнитного упорядочения спонтанный холловский коэффициент экспоненциально уменьшается с температурой.

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