ON THE TEMPERATURE DEPENDENCE OF ELECTRONIC ABSORPTION OF RAYLEIGH SOUND WAVES

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The problem of absorption of Rayleigh sound waves as a result of their interaction with conduction electrons,was considered in the literature for some special cases in the absence of constant magnetic field /I,2/.It is the purpose of this paper to investigate the temperature dependence of the coefficient of absorption in a large interval of frequencies assuming that the only sensitive parameter to the temperature,is the free path of the electrons l .

In crystal solids the stress tensor is related with the elastic moduli λ_{ikem} through

$$\sigma_{ik} = \lambda_{ikem} U_{em} \quad , \quad U_{em} = \frac{1}{2}\left(\frac{\partial U_e}{\partial x_m} + \frac{\partial U_m}{\partial x_e} \right) \qquad /I/$$

where U_i are the components of the vector of elastic deformations $\vec{U}$ .Because of the boundery conditions which σ_{ik} has to satisfy on the free surface of the metal,the Rayleigh sound waves are linear combination of longitudinal and transverse sound waves.In isotropic case it gives /3/

$$(\kappa^2+\varkappa_{to}^2)\left[S_e^2(\varkappa_{eo}^2-\kappa^2)+2S_t^2\kappa^2\right] = 4S_t^2\varkappa_{to}\varkappa_{eo}\kappa^2 \qquad /2/$$

where κ is the wave vector, $S_{e,t}$ are the velocities of longitudinal and transverse waves,and $\varkappa_{eo,to}$ are defined as

$$\varkappa_{eo} = \kappa^2 - \frac{\omega_o^2}{S_e^2} \quad , \quad \varkappa_{to}^2 = \kappa^2 - \frac{\omega_o^2}{S_t^2} \qquad /3/$$

The equation /2/ is satisfied for ω_o

$$\omega_o = S_t \kappa \zeta \qquad /4/$$

where ζ is the solution of

$$\zeta^6 - 8\zeta^4 + 8\zeta^2\left(3-2\frac{S_t^2}{S_e^2}\right) - 16\left(1-\frac{S_t^2}{S_e^2}\right) = 0 \qquad /5/$$

The interaction of the Rayleigh sound waves with the conduction electrons results in renormalization of the elasticity moduli of the medium.Both,equilibrium and nonequilibrium electrons are responsible for this.The relation /I/ is applicable for the renormalized tensors $\tilde{\sigma}_{ik}$

and $\tilde{\lambda}_{iklm}$,which includes all the volume changes.As a result of this interaction,the equation /2/ is changed for two reasons.Firstly,the functions $\varkappa_{\ell o}$ and $\varkappa_{t o}$ will be changed because of the renormalization of the elastic moduli and secondly,in equation /2/ terms which result from the scattering of the electrons from the surface are absent.

However,in the absorption of Rayleigh sound waves the surface is without significance.When the effective mean free path of the electrons $\tilde{\ell}$ /$\tilde{\ell} = \frac{\ell}{1+i\omega\tau}$, $\nu \equiv \frac{1}{\tau}$ is the frequency of relaxation of the electrons, ω -frequency of the sound waves/,is much smaller then the depth of damping of the Rayleigh sound wave / $|\varkappa\tilde{\ell}| \ll 1$ /,the effects due to the surface are unnoticeable /in comparison with the effects of the bulk of the sample/.In the other extreme case / $|\varkappa\tilde{\ell}| \gg 1$/,the situation is analogous to the case of anomalous skin-effect in electrodynamics:effective are those electrons whose velocity is parallel to the surface.Consequently in order to calculate the coefficient of absorption we shell use equation /2/,where $\varkappa_{\ell o}$ and $\varkappa_{t o}$ are changed with $\varkappa_{\ell}$ and $\varkappa_{t}$,functions which have to be determined.To do so we have to solve the system of the equation of the theory of elasticity,the Maxwell equation and the kinetic equation for the electrons /4/. Explicit results can be obtained only if the formof the deformation potential Λ_{ik} is assumed.We use the following

$$\Lambda_{ik} = \tilde{m} \left(V_i V_k - \frac{1}{3} V^2 \delta_{ik} \right) \qquad /6/$$

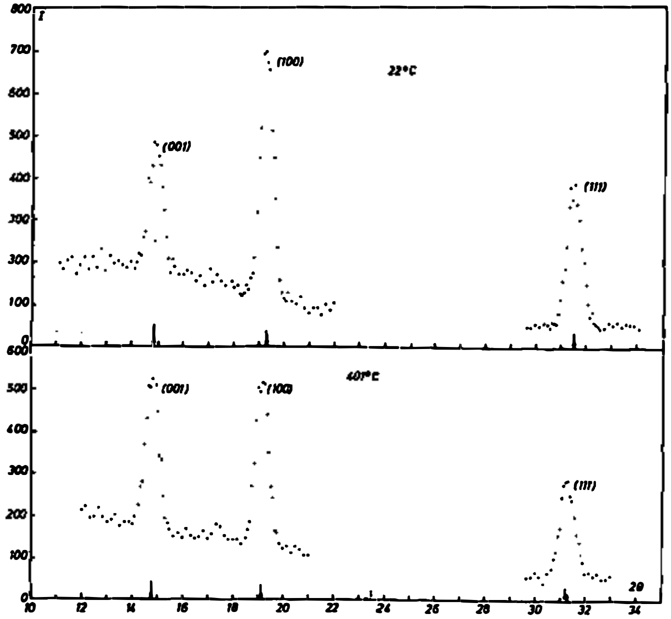
where $\tilde{m} \sim m$ and it characterizes the interaction betweean the electrons and the sound waves.The final expressions for the coefficient of absorption are given below

$$\gamma = \frac{\tilde{m}\,\omega_{pe}^2 V_F \ell \omega_o^2}{\rho S_t^2 e^2} R_1 \quad , \quad |\varkappa\tilde{\ell}| \ll 1 \qquad /7/$$

When $|\varkappa\tilde{\ell}| \gg 1$

$$\gamma = \frac{\tilde{m}\,\omega_{pe}^2 \omega_o}{\rho e^2 S_t} R_2 \quad , \quad \omega \ll \frac{S}{\delta_o} \left(\frac{S}{V_F} \right)^{1/2} \qquad /8/$$

maxima (001), (100) and (111) at 22 and 401 C are shown in the figure. In order to obtain the degree



of order and the magnetic intensities (100) and (111) at a particular temperature point it was necessary to put the observed intensities on an absolute scale. It was done by measuring the intensities of the diffraction maxima of nickel powder.

Our results show the following: (1) the intensity of (001) reflection increases with temperature, what means that the degree of order of this alloy is higher at higher temperatures in the temperature range from 22 to 425 C; (2) the Curie temperature of this material is about 400 C.

Braun, P. B. and Goedkoop, J. A., Acta Cryst. 16 (1963) 737.