L.129 TUNNEL EFFECTS CAUSED BY STANDING WAVES IN METALS.

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A study has been carried out on the influence of hydrostatic pressures up to IO kbar and of magnetic fields up to 70 kOe at oscillation in tunnel conductivity of aluminium-insulator-lead junctions caused by standing waves in lead films.

Oscillating parts of conductivity had maximums at certain bias U, U=Uq which is accounted for by coordination[I] of standing wave energy levels in different crystallites of the film at energies Eq,Eq-Ef=Uq(e=I, Ek - Fermi energy).

The realization of this effect is complicated with some difficulties since electron wave length in a metal is comparable with the lattice spacing and since perfect single crystals of small dimensions are necessary for standing waves to exist.However,we managed to observe this phenomenon in many samples of the tunnel conductivity derivative I"(U) at the hydrostatic compression (P).

The experiments have been performed at 4.2 K. The lead films had texture [III] and thickness ~ 250Å.Through the shift under pressure of the zero I"(U) corresponding to the greatest maximum of the oscillating part of conductivity,magnitude $\eta$ is determined as below:

$$\eta = dUq/dp = d(E(Kq)-E_f)/dp,$$
$$Kq=K(I/2,\ I/2,\ I/2\ ).$$

Momentum K values are given in terms of $\pi$/a, a - lead lattice constant.The obtained value of $\eta$=4 ± 0.2 meV/kbar is in satisfactory agreement with calculations of the band structure parameters of lead,done nonrelativistically,which proves a connection between the observed phenomenon and the metal band structure.(Value $dE_f/dp$ is taken from Ref.[2])

It is well known that to interpret the change in Fermi surface of metals with pressure, the main difficulty occurs while determining $E_f$ at different pressures. Any theoretical model of band structure allows to calculate the electron energy at point Kq in the symmetrical direction of the Brillouim band much more accurately and thousands times quicker than that of $E_f$. Therefore the shift measurement with a high accuracy under pressure of the oscillating picture permits, within the limits of a theoretical model, to determine dependence $E_f = E_f(p)$ which provides an unambiguous interpretation of experiments on pressure influence upon Fermi surface of metals. Nonlinearities in dependence $\varrho = \varrho(p)$ may signal the presence of phase transisions.

The samples being covered with a coat of SiO with the thickness of I500 ÷ 2000 Å resulted in the shift of oscillations up to 2o meV which can be connected with a change of the boundary potential[I,3].

Unfortunately we have not observed the predicted in Ref.[I] oscillation corresponding to Kq(2/3, 2/3, 2/3). It is very probable that this fact may be explained by the increase of standing wave damping for the energies much lower than the Fermi level.

For many junctions complicated oscillations (Fig.I) have been observed which can be interpreted as interference of oscillation I"(U) from the film where it is textured in various crystallographic directions. By curves like those in Fig.I band energy values of Pb films at three points of the Brillouin band (in respect to the Fermi level) are determined as follows: E(I/2, I/2, I/2)=800 ÷ 820 meV,

E(I, I, 0)=540 ÷ 580 meV,

E(I, 0, 0)=880 ÷ 920 meV.

The pressure up to 6 kbar being applied resulted in the shift of the interference pictures (Fig.2).

For a number of samples there was found the influence upon the observed picture of oscillations of the 60–70 kOe magnetic field parallel to the film plane (Fig.3). This effect may be explained by the damping increase of electron standing waves with small radii of orbits ($r_h$) where imperfections are found between film crystallites[3]. For example, the condition of coordination between quantum levels of film grains textured in direction [210] is satisfied at point W of the Brillouin band. Assuming that it is these electrons in the vicinity of this point that are responsible for the observed effect, we shall obtain $Ew'_2=700\pm20$ meV. It is also possible to relate the effect with point X(direction [100]); however, in this case a worse agreement of the experiment and band structure calculations[4] is observed. Thus, large magnetic fields allow to select directions of considerably varying $r_h$.

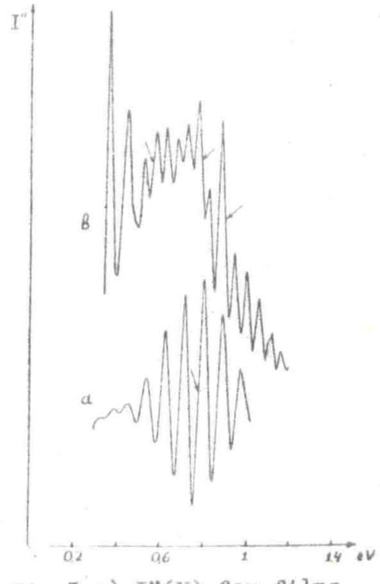


Fig.I.a) I"(U) for films textured in direction [III]
b) Interference I"(U) from film grains textured in directions [III],[IIO],[IOO].

Vivid oscillations have been also observed for alloys of the substitution type $Pb_{98}Tl_2$, $Pb_{100-x}Bi_x$, $x\leq5$. It has been noticed that as electron concentration grows, oscillations shift to big energies and vice versa. These experiments show that the damping of standing waves, in the main, is caused by scattering at the film boundaries. Therefore oscillations to be observed in alloys with a greater concentration of Bi and Tl are also possible. The experiments of this kind performed on the films textured in different crystallographic directions enable to obtain the electron energy value in alloys for a number of Brillouin band points, i.e. to acquire the information otherwise unobtainable.

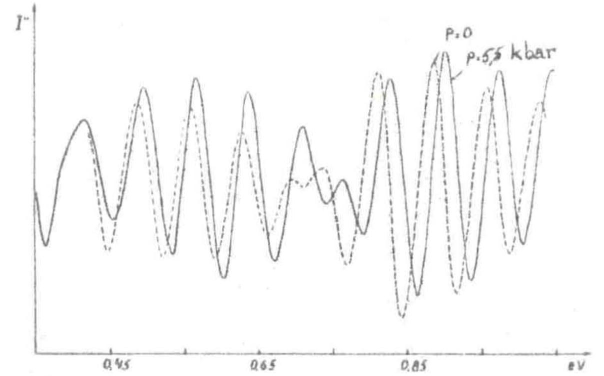


Fig.2. Influence of pressure on interference picture.

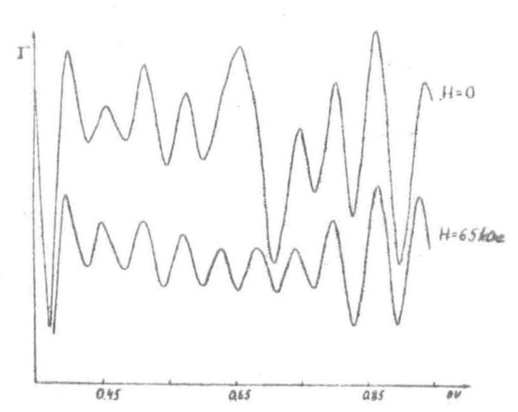


Fig.3. Influence of magnetic field on I"(U).

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