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INVESTIGATION OF GALVANOMAGNETIC PROPERTIES OF HYDROGENATED PALLADIUM SINGLE CRYSTALS

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A study was made of the galvanomagnetic properties and the Hall emf of high-purity hydrogenated single crystals of palladium, for which $\rho(T = 300°K)/\rho(T = 4.2°K) \approx 3000$ between the limits 0–20 at.% hydrogen. It was established that, within these limits, the nature of the resistivity anisotropy remained constant, the value of the resistivity anisotropy in effective fields did not change, and the Hall coefficient was not affected by low concentrations of hydrogen (0–3 at.%). From the data obtained we could conclude that the open regions of the Fermi surface did not change at low hydrogen concentrations.

IN an earlier investigation[1] dealing with the galvanomagnetic properties of single-crystal samples of pure palladium, we have established that palladium is a compensated metal whose Fermi surface consists of two parts of equal volume, one of them (hole) open and the other (electron) closed. Since we expected that the solution of hydrogen in single-crystal palladium would change the dimensions of the various parts of the Fermi surface,[2] we measured the galvanomagnetic properties and the Hall emf of palladium samples in which hydrogen concentration ranged from 0 to 20%.

The original single-crystal samples of palladium with their axes oriented along [001] and [011] were of sufficiently high purity: $\alpha = \rho(T = 300°K)/\rho(T = 4.2°K) \approx 3000$. For some samples, used to determine the parameters of the open cylinders of the Fermi surface, we had $\alpha = 5100$. The rapid change in the value of α with an increase in the percentage content of hydrogen in palladium forced us to estimate the Fermi-surface parameters only for samples with low hydrogen concentrations (from 0 to 3 at.%). The degree of saturation with hydrogen was checked by measuring the value of α, which varied from 3000 to 2.0 with the concentration of hydrogen. We could reinstate the original value of α by placing hydrated samples in an oxygen atmosphere. To calibrate the dependence of the change in the resistivity on the hydrogen concentration, we determined the amount of hydrogen in samples with sufficiently high concentrations of this gas, using mass spectroscopy.

We investigated the angular dependences of the resistivity $(\Delta\rho/\rho)_{H = \text{const}} = f(\varphi)$, the change of

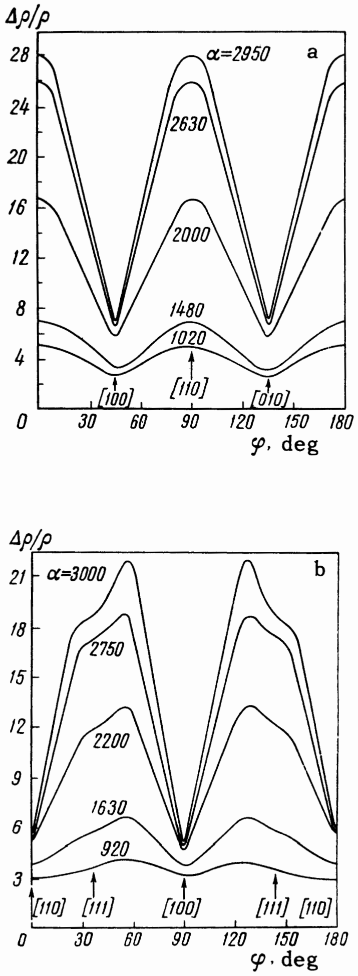

FIG. 1. Dependence of the relative change in the resistivity on the angle between the magnetic field direction and the crystal axes for samples containing various concentrations of hydrogen ($T = 4.2°K$, $H = 26$ kOe): a) sample with the orientation [001]; b) sample with the orientation [011].

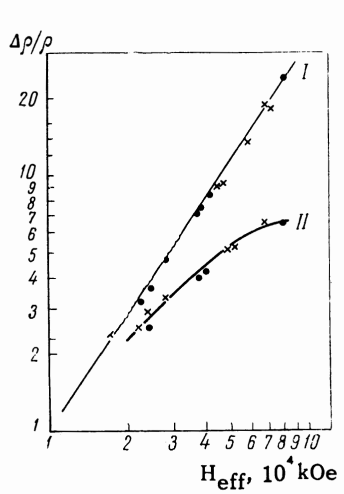

FIG. 2. Dependence of the relative change in the sample resistivity on the effective magnetic field. Curve I: ● – J || [100], H || [110], × – J || [110], H || [111]; Curve II: ● – J || [100], H || [010], × – J || [110], H || [011].

the resistivity in a transverse magnetic field $(\Delta\rho/\rho)_{\varphi=\text{const}} = F(H)$ and the Hall emf. The measurements were carried out in constant fields up to 26 kOe and in pulsed fields up to 150 kOe.

Figure 1 shows the angular dependences of $\Delta\rho/\rho$ when the orientation of the field was varied in planes perpendicular to the [001] and [011] axes in samples having various concentrations of hydrogen. It is clear from the curves in this figure that the nature of the angular dependences is not affected within the limits of the investigated hydrogen concentrations. The dependence of $\Delta\rho/\rho$ on H_{eff} for φ = const (Fig. 2), plotted on logarithmic scale for the maxima and minima of the angular dependence of $\Delta\rho/\rho$, shows that the magnitude of the resistivity anisotropy in effective fields remains constant for samples having various concentrations of hydrogen.

The measurements of the value of the Hall coefficient were carried out using a sample whose axis coincided with a fourfold axis, for H || [001]. In this case, as is known from [3], the diameter, d, of the open cylinders can be determined from the value of the Hall coefficient.

Figure 3 shows the dependence of the Hall coefficient on the sample purity, for different concentrations of hydrogen. It is evident from this figure that the value of the Hall coefficient remains constant, within the limits of the experimental error, in the range of low concentrations where the galvanomagnetic properties are governed by the topology of the Fermi surface. The variation of R in the region where c > 3 at. % is probably governed by the influence of the scattering processes, since in this range there is practically no magnetoresistance anisotropy.

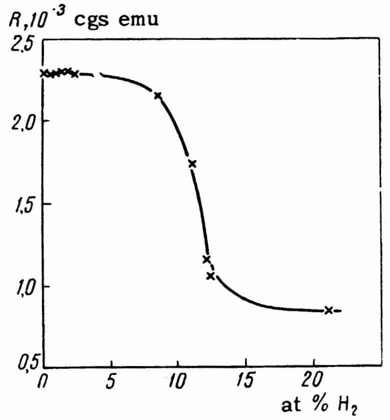

FIG. 3. Dependence of the value of the Hall coefficient of a palladium sample (α = 3200, J || [001], H || [100]) on the percentage content of hydrogen dissolved in it.

Our estimate of the dependence of d on the hydrogen concentration shows that the diameters of the open cylinders remain constant. Thus, from data obtained for hydrogenated single crystals of palladium, we may conclude that the open parts of the hole component of the Fermi surface do not change within the limits of the investigated hydrogen concentrations.

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