Magnetoresistance of pure metals in solid and liquid phase

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Anomalously large changes of the electrical resistance of liquid metals in a magnetic field have been found. The magnitude of the magnetoresistance $\Delta\rho/\rho_0$ in the liquid phase amounts to 2.6. Typical features, corresponding to structural changes of the melt, are observed on the temperature dependence curves of $\Delta\rho/\rho_0$.

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Unlike other electrical and magnetic properties of molten metals, which have been investigated a great deal in recent years, there is little information about the magnetoresistance of metals in the liquid phase. In the literature known to us there are only data for Hg and Na,[1–3] where the magnitude of the effect is small. Thus, for example, for Hg $\Delta\rho/\rho_0 = 0.02$ for $H = 12$ kOe.[3]

In our work we have measured the tranverse magnetoresistance of some pure metals and semimetals in the temperature interval encompassing both the solid and liquid phases. The measurement of $\Delta\rho/\rho_0$ was made by the four-contact method for $H = 0$, $H = 13.6$ kOe, and $H = 20.0$ kOe. An R348 potentiometer was used as the voltmeter. The $\Delta\rho/\rho_0$ values were estimated from the measured values of the current and magnetic field in the forward and reverse direction. The samples were measured three times both in the direction of increasing and in the direction of decreasing temperature. The repeatability is such that the difference between two successive measurements is 2–3% for $\Delta\rho/\rho_0$ and 0.1–0.2% for ρ. The samples were placed in a specially fabricated cylindrical quartz cell with an inside diameter of 6 mm. The distance between the current probes was 20 mm, and between the potential probes–10 mm. The uniformity of the magnetic field in the operating portion of the sample was 0.05%; the temperature differential was 0.1–0.2° C.

The magnitude and behavior of the $\rho(T)$ dependence of the solid and liquid phases agree with literature data[4] for all the samples in the absence of a magnetic field. The temperature dependence of $\Delta\rho/\rho_0$ of the solid phase of Bi and Sb is shown in Fig. 1 for two values of H. The presence of the magnetoresistance effect is visible, and its magnitude decreases with an increase in temperature. At the same time, measurements of In and Sn, existing in the solid phase, exhibit a complete absence of this effect.

Transition to the liquid phase leads to large magnetoresistance effects for all the metals named, regardless of their behavior in the solid state. The largest values $\Delta\rho/\rho_0 = 2.6$ are exhibited by Bi and In (Figs. 1, 2).

The large $\Delta\rho/\rho_0$ values observed in liquid metals, in contrast to the solid phase, may be caused by a change in sample geometry due to the action of the magnetic field and also by the ionic contribution to conductivity in the melt.

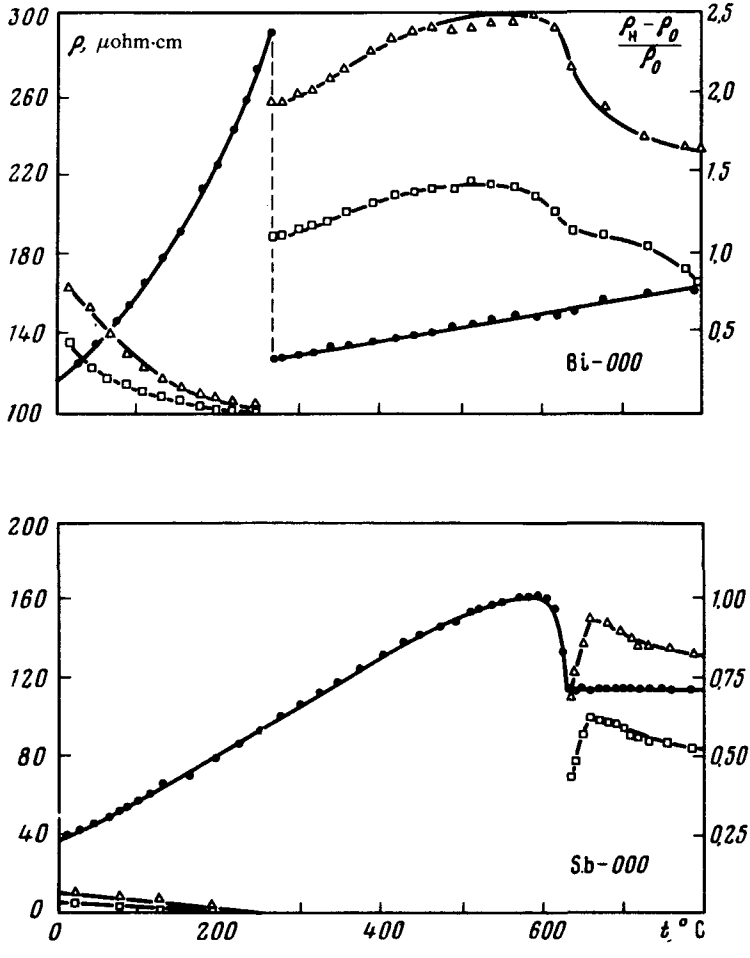

FIG. 1. ●—ρ - resistivity; □, Δ—$\frac{\rho_H - \rho_0}{\rho_0}$ - magnetoresistance for $H = 13.6$ kOe and $H = 20.0$ kOe, respectively.

Characteristic points are observed on the $\Delta\rho/\rho_0 = f(T)$ curves in the melt, the prominence of which is enhanced with an increase in the field. It can be assumed that they correspond to those temperature changes which determine the structural rearrangements. The transition regions between the knees on the curves, in particular the increase in $\Delta\rho/\rho_0$ after melting, are apparently due to a decrease of the structural elements in the melt and the transformation of the liquid into monatomic form.

The possibility of using the magnetoresistance test data to draw conclusions about structural transformations in the melt makes this effect, along with known "direct"

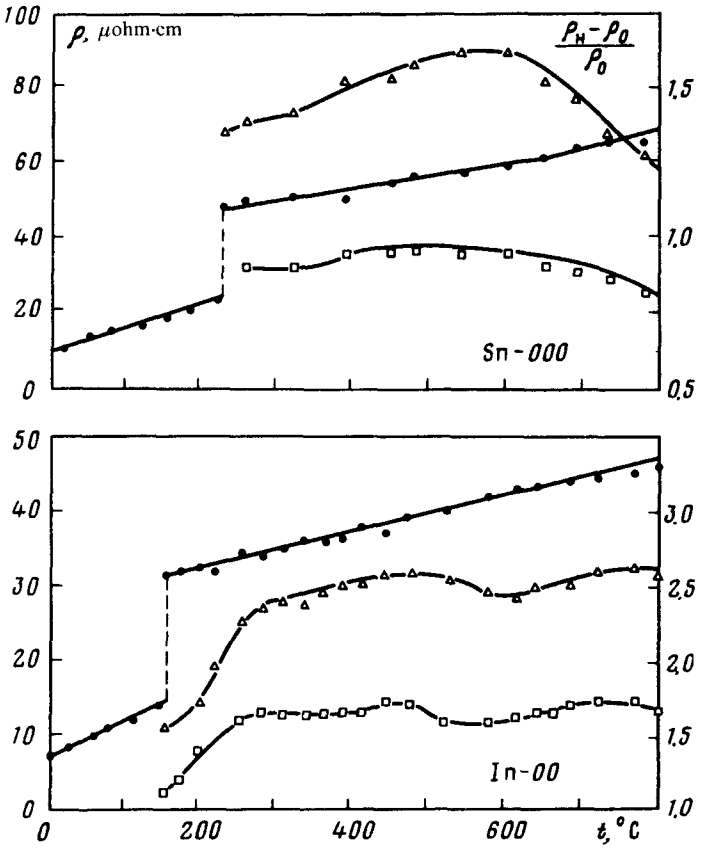

FIG. 2. ●—ρ - resistivity; □, Δ—$\frac{\rho_H - \rho_0}{\rho_0}$ - magnetoresistance for $H = 13.6$ kOe and $H = 20.0$ kOe, respectively.

methods of studying liquid metals (*x*-ray, electron and neutron diffraction), valuable for establishing the melt morphology.

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