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Experimental study of resistivity of metallic materials with dynamic disorder

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Abstract. As a result of strong electron-phonon interaction, the enhancement of scattering with increasing temperature may decrease the mean free path l in crystals down to interatomic distances: $l \approx a$. This means that with respect to the electron wave the degree of the atomic disorder in these crystals is approximately the same as in amorphous metal. Because of a high electron velocity the dynamic character of the disorder seems to be unimportant. At the same time, the degree of disorder can be easily changed by varying the temperature. This makes it possible to simulate and study the transport properties of the disordered media on high-quality crystals with strong phonon scattering. The sign that indicates the fitness of a crystalline metallic material for such studies is the saturation of its resistivity ρ that ceases to grow as the temperature is increased.

The saturation of resistivity was investigated experimentally on (i) Cu-Zr alloys in the crystalline state, (ii) single crystals of WO_2, which is a metal with well-defined Fermi surface.

The samples of Cu-Zr were produced by the recrystallization of amorphous ribbon. Some of these samples reveal resistivity saturation. With further increase of T a maximum in the $\rho(T)$ dependence was observed at those compositions which slightly decreased their ρ value under recrystallization. This unusual dependence can be explained in terms of the two-band model assuming that the d-electrons reach the minimal free path, $l \approx a$, while the s-electrons do not.

The WO_2 crystals were used to study the anisotropy of (T). In the directions, where ρ is high, there is a tendency to saturation. Where ρ is low, no tendency to saturation is observed. The quantitative analysis of the curves has shown that not only the absolute value but also the relative value of the deviation from the Boltzmann law $\rho \sim T$ decreases down as the resistivity decreases.

Keywords. Resistivity; dynamic disorder.

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