S. M. Klotsman. *Role of defects in the formation of the properties of metals.* The basic paths of research on the types, properties, and interactions of point, linear, and two-dimensional defects in metals, conducted at the Institute of the Physics of Metals at the Ural Scientific Center of the USSR Academy of Sciences, are described in the report. Progress in the technique and technology of diffusion experiments has opened up the possibility of obtaining physical information on defects from studies of diffusion phenomena: temperature dependences of self- and heterodiffusion, isotopic effect accompanying diffusion, diffusion in the gradients of external fields, etc.

In univalent noble metals (copper, silver, gold) the energy of activation of volume diffusion decreases linearly as the excess charge of the impurities increases[1–3] (Fig. 1). This dependence is produced by the vacancy mechanism of diffusion and the Coulomb interaction of the screened charges of point defects, responsible for mass transport in the crystal. In nickel (a 3d transition metal) the same behavior is observed if the excess charge of an impurity is correctly determined using that part of the collectivized electrons, which fill the 3d band of the matrix and change the magnetization of the corresponding solid solution.[4] The coincidence of the activation energies of diffusion of cobalt and nickel in nickel (zero excess charge of cobalt) is the qualitative result of such a determination of the excess charges.[5] An even more marked decrease in the activation energy with the growth of the positive excess charge of the diffusing impurity was established in tungsten.[6]

In the presence of self- and heterodiffusion in an exter-

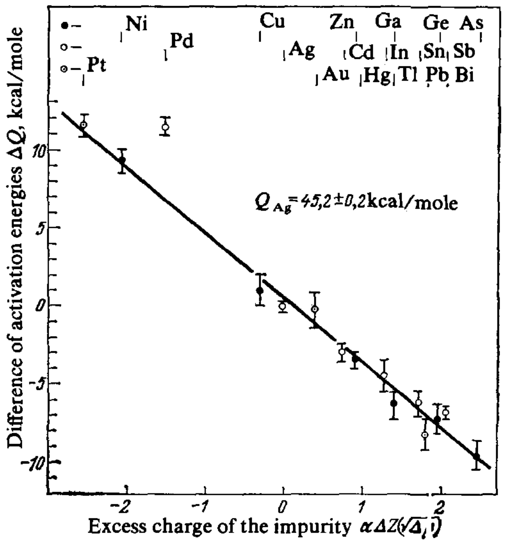

FIG. 1.

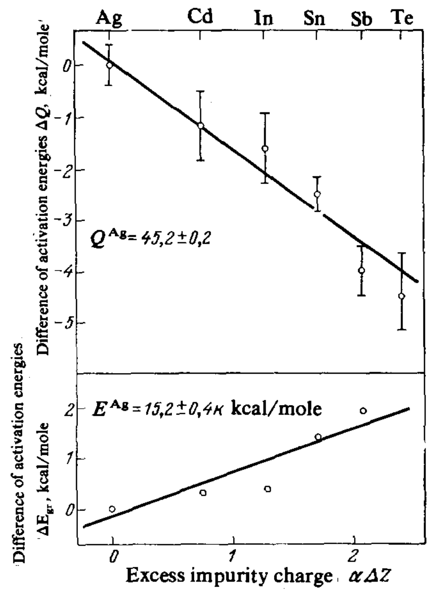

FIG. 2.

nal electric field (electric transport) the direction of ion drift is determined by the entrainment of ions by the main group of current carriers in the metal,[7] while the effective charge is determined by the scattering cross section of the impurity-vacancy complex and the correlation effects, characteristic of the vacancy mechanism of diffusion.

The characteristics of the volume diffusion and electric transport have become the foundation for the analysis of the properties and interactions of defects at grain boundaries in metals. The activation energy of intercrystallite diffusion of impurities does not decrease but rather increases with the positive excess charge of the impurities (Fig. 2).[2] The direction of electric transport at the grain boundaries in copper, silver, and gold is opposite to the volume transfer, which together with the high magnitude of the effective charge of the intercrystallite electric transfer indicates the hole entrainment of ions at grain boundaries in group I noble metals.[8] The discovery of these two effects gave experimental support for the idea that the electronic spectrum changes in the core of structural defects in the form of dislocations and grain boundaries in metals and that the point defects responsible for the high diffusion permeability of these linear and two-dimensional defects predominate.[9]

Another type of point defect, responsible for many radiation-stimulated phenomena, are the diplons (mixed dumbbells), discovered in the study of anomalously fast volume diffusion of impurities in lead,[10] and the intrinsic interstitial defects,[11] discovered in the study of radiation defects in metals. At sufficiently high temperatures the radiation defects (vacancies and intrinsic interstitial defects) can escape from the crystal by diffusing to sinks: dislocations, grain boundaries, outer surface, etc. The appearance of flows of point defects toward sinks gives rise to stationary separation by composition of the volume of crystals and sinks of radiation defects. The radiation-stimulated segregation creates high concentrations of impurities and components at the sinks and leads to the appearance of embrittling phases at the sinks. Thus, the concentration of sulfur on the surface of a nickel single crystal containing $2\cdot10^{-5}$ atomic fractions of sulfur increases by a factor of 1000 after electron irradiation at 400°C. The plasticity of commercial-grade nickel drops by a factor of two below that of a control sample after irradiation by electrons.[12] The improvement of the properties of existing materials and the development of new materials are limited by the knowledge of the parameters of the interactions of point defects with one another and with other defects.

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