Letters to the Editor

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Influence of an Elastic Strain on the Self-Diffusion of Copper at Low Temperatures

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IN all diffusion processes, the influence of elastic strains seems to be considerable. However, measurement of the effect is difficult. Self-diffusion is generally measured at temperatures directly below the melting point. In this region, the material is very weak. So it is difficult to give a large elastic deformation and at the same time prevent plastic deformation. One has to load the material in compression. This experiment was carried out on sodium and phosphorus by Nachtrieb *et al.*[1,2] The effect measured by these authors is due to two different effects. Firstly, the concentration of the vacancies is altered by the elastic strains. Secondly, the mobility of the vacancies is modified. The first effect is related to the creep which occurs by diffusion.[3] We will call the second effect strain-activated diffusion.

Since the jump probability of a vacancy is very sensitive to a change of the activation energy, it is likely that such a change will be the main reason for an effect. If this is valid, the diffusion coefficient is multiplicated by a factor $e^{-\Delta Q/KT}$ (where ΔQ denotes the change of the activation energy).

In case one wishes to measure only the strain-activated diffusion, it is necessary to work with "injected" vacancies (vacancies which are not in thermal equilibrium). Injected vacancies can be formed by irradiation[4] or by cold working.[5] Measurements on injected vacancies have the advantage that it is possible work at low temperatures. At such temperatures, the material is much stronger, especially when it is cold worked. It is thus possible to load the material in simple extension. Also at low temperatures $|\Delta Q/KT|$ is larger.

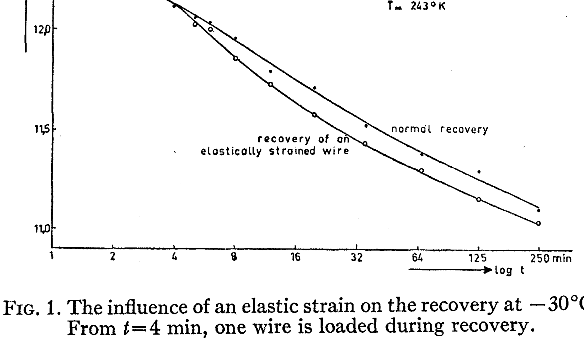

Fig. 1. The influence of an elastic strain on the recovery at −30°C. From $t=4$ min, one wire is loaded during recovery.

The experiment was quite simple. Two copper wires were stretched 20% in liquid nitrogen. After the stretching, the recovery of the electrical resistivity was measured at −30°C as a function of time. During the first four minutes, the curves coincide for both wires. After four minutes, one wire was loaded with 17 kg/mm². The recovery of the resistivity of this wire then speeded up. In Fig. 1, both curves are given.

In case this recovery of the resistivity is due to the diffusion of vacancies, this recovery is a function of $D\times t$ (where D is the diffusion coefficient of the vacancies). When the wire is strained the diffusion coefficient is anisotropic; let D' be the average diffusion coefficient for this case. From our measurements, we calculate $D'/D=1.7$. Calculations of this effect will be published in the near future.

With these calculations, one is able to account for the influence of internal stresses on the recovery of the electrical resistivity after cold working.

[1] N. H. Nachtrieb *et al.*, J. Chem. Phys. **20**, 1189 (1952).
[2] N. H. Nachtrieb and A. W. Lawson, J. Chem. Phys. **23**, 1193 (1955).
[3] C. Herring, J. Appl. Phys. **21**, 437 (1950).
[4] J. W. Glen, Advances in Phys. **4**, 381 (1955).
[5] J. A. Manintveld, Nature **169**, 623 (1952).

Effective Electron Mass in Indium Arsenide and Indium Antimonide

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MEASUREMENTS have been made of Hall coefficient and thermoelectric power for indium arsenide and indium antimonide at room temperature and above. The specimens were prepared from highly purified elements and contained 5×10^{16}/cc extrinsic electrons in the indium arsenide and 7×10^{15}/cc extrinsic holes in the indium antimonide. The values of thermoelectric power indicated that both materials were slightly degenerate at all temperatures within the range considered. Assuming covalent scattering and taking account of the degeneracy present, the effective electron mass ratio has been calculated and is plotted in Fig. 1 as a function of kT which represents the approximate mean energy of the electrons in the conduction band. For energies greater than 0.04 ev above the bottom of