width nearly twice the face height if it is to deliver a beam of light of square or circular cross-section. To do the same, an economical prism requires faces that are square, or nearly so, and this reduces the difficulty of achieving a good optical figure on the faces. On the other hand, all three faces of the economical prism must have a good figure instead of only two. When the economical prism system is used, the prism is placed symmetrically on the axis of the collimator and the camera is much nearer to this axis than in the normal prism spectrograph. This leads to a less-inconvenient shape for the instrument and to greater compactness.

An economical prism system similar to that of Fig. 1 is in use in a spectrograph at the Dominion Physical Laboratory's Auroral Station at Lauder, Central Otago. It replaces an unsatisfactory diffraction grating which had a poor blaze and which was too small to fill the aperture of the camera with light. Exposure times for infra-red plates have been reduced by a factor of four. The prism is a liquid one filled with cinnamic aldehyde, chosen for its exceptionally high dispersion but having a high temperature coefficient of refractive index which demands control to ± 0·2° C. in our case.

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METALLURGY

Point Defects in Niobium, Molybdenum and Tantalum

Experiments in which the thermal recovery of neutron irradiated and plastically deformed molybdenum[1–3] and tungsten[1,4–6] has been followed by measuring changes in electrical resistivity have revealed that in both metals one species of point defect, probably the lattice vacancy, becomes mobile above room temperature. The purpose of this communication is to give a preliminary account of similar experiments on neutron-irradiated niobium and molybdenum and plastically deformed niobium and tantalum.

Recrystallized niobium and molybdenum wires were irradiated for periods of 3, 6, 9 and 12 months at 40° C. in the reactor *BEPO* at the Atomic Energy Research Establishment, Harwell. The irradiations were carried out in a vertical hole in the reactor where the epithermal neutron flux was about $1{\cdot}2 \times 10^{12}$ n./cm.^{2}/sec.[1] and where about 1 epithermal neutron in 10 had an energy > 1 MeV. Isochronal and isothermal recovery curves were obtained for each metal and neutron dose. These revealed one recovery peak for each metal. That for niobium occurred at 120° C. and had an associated activation energy of 1·22 ± 0·02 eV. while that for molybdenum was at 160° C. and had an associated activation energy of 1·25 ± 0·08 eV. For both metals the magnitude of the recovery, $\Delta\rho$, passed through a maximum with increasing neutron dose. The temperature of the peak and the activation energy found for molybdenum agree closely with those reported earlier[1].

Recrystallized niobium and tantalum wires were deformed in tension at room temperature at a strain-rate of about $1{\cdot}3 \times 10^{-5}$ sec.$^{-1}$. Isochronal and isothermal recovery curves were obtained for specimens given elongations of up to 12 per cent for niobium and 16 per cent for tantalum. The niobium gave a recovery stage and an activation energy similar to those found for irradiated material. The relationship between the resistivity recovery, $\Delta\rho$, and the fractional tensile strain, ε, was found to be:

$$\Delta\rho = 0{\cdot}77\,\varepsilon^{1{\cdot}46}\ \mu\Omega\ .\ \text{cm.} \qquad (1)$$

Specimens with a higher initial dislocation density produced by annealing cold-drawn wire at 700° C., a temperature insufficient to cause recrystallization, behaved rather differently. The peak temperature and activation energy were the same but the relationship between $\Delta\rho$ and ε was found to be :

$$\rho\Delta = 0{\cdot}45\,\varepsilon^{0{\cdot}66}\ \mu\Omega\ .\ \text{cm.} \qquad (2)$$

In the case of tantalum a recovery peak was found at 120° C. with an associated activation of 1·25 ± 0·02 eV. The relationship between $\Delta\rho$ and ε was found to be:

$$\Delta\rho = 2{\cdot}01\,\varepsilon^{1{\cdot}41}\ \mu\Omega\ .\ \text{cm.} \qquad (3)$$

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Aggregate Structure in Thin Nickel Films

It is recognized that in the initial stages of metal film growth by vacuum deposition the incident atoms may possess sufficient mobility on the substrate to form aggregates (clusters of crystallites)[1,2]. The degree of aggregation is chiefly a function of the substrate temperature and rate of deposition, and is conveniently thought of as a film thickness above which the films have a continuous structure. Various investigators have obtained electron microscopic evidence of the aggregated structure in thin films of a number of metals prepared under various conditions[3–6]. In addition, precise density measurements have indicated that aggregation in the initial portion of the film formation may result in a decrease in the observed density[7]. Severe aggregation may also be detected by electrical resistivity measurements. In contrast to the foregoing procedures, a simple chemical etching technique has been successfully used to observe metallographically the aggregate structure in thin nickel films. Despite the difference in magnification, such photomicrographs bear a striking resemblance to the published electron micrographs indicating aggregated structures in thin metal films.

The films used in this work were deposited on to glass substrates (40°–60° C.) in a vacuum of 2·8–10·0 × 10^{-6} torr at a rate of 8–14 Å./sec. The source consisted of nickel wire wound around three-braid tungsten wire filaments at a distance of 6–8 in. from the substrate, and arranged so that the vapour beam was at normal incidence to the substrate. Spectrographic analysis indicated a film purity of 99·9 per