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IN A Co-Fe ALLOY***

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EFFECT OF ELECTRON IRRADIATION ON THE 3C-4H TRANSFORMATION IN A Co-Fe ALLOY

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In general, irradiation of materials by high energy electrons, protons or neutrons has been shown to stabilize the existing microstructure against subsequent martensitic transformation. Alloys which have been studied include the binary intermediate phases NiTi [2, 3] and $\text{Ni}_{63}\text{Al}_{37}$ [4] and ternary phases between $\text{Cu}_{37.5}\text{Al}_{62.5}$ and $\text{Cu}_{63.6}\text{Al}_{36.4}$ [5, 6] as well as the intermetallic $\text{Cu}_{69.01}\text{Al}_{17.92}\text{Zn}_{12.17}$ [7, 8, 9]. In these materials, the martensitic transformations are known to be sensitive to small changes in chemical composition and to the degree of long range order. In addition, one should expect the kinetics of martensitic transformations to be sensitive to other forms of structural damage introduced during irradiation also. This spectrum of irradiation-induced phenomena renders the interpretation of results in studies of such concentrated binary and ternary phases rather complicated, therefore.

We present here the preliminary results of a study of the effect of electron irradiation on the character of the martensitic transformation in a relatively dilute terminal solid solution of Co+5.75 wt pct Fe, similar in composition to that employed for studies of the transformation mechanism itself [10]. The effect of the solute Fe is to depress the equilibrium Co-transformation temperature and to modify the transformation, which in Co is fcc-hcp, to one of the type fcc-dhcp; that is, the transformation is between the three-layer stacking sequence of the cubic structure (ABC), known as 3C, and the four-layer stacking sequence of the di-hexagonal structure (ABAC), known as 4H. The transformation involves only the glide of groups of Shockley-like partial dislocations [10, 11, 12] and is one of the family of simple martensitic transformations often called shear transformations. While electron irradiation may modify to some extent the degree of short range order in such an alloy, its predominant effect is surely the formation of faulted Frank-type dislocation loops, which may be expected to impede the shear transformations (that is, to stabilize the existing structure) by acting as barriers to the glide of the necessary transformation dislocations. The effect of the presence of Frank loops on nucleation of such a transformation is perhaps less predictable. The loops enclose intrinsic or extrinsic stacking faults, the introduction of which is the structural essence of the transformation. However, the irradiation-induced loops themselves are sessile; that is, the transformation cannot propagate by glide of the loops in the fault plane; only by climb. The transformation occurring in this manner would not be martensitic.

The subject alloy was prepared by arc melting and hot rolling by the Materials Preparation Center of Ames Laboratory. 3 mm disks were cut by EDM, lapped to about 200 mm thickness, annealed for 2 h at 915°C in an evacuated Vicor tube and air cooled to room temperature, resulting in predominantly 3C material. Some of the specimens were subsequently quenched in LN₂ to produce a significant volume fraction the 4H structure within 3C. Thin foils were prepared by jet thinning at -15°C in a perchloric acid-alcohol electrolyte.

Preliminary experiments were performed at the Research Center for Ultra-High Voltage Electron Microscopy at Osaka University. The threshold of electron energy to produce displacement damage in this alloy is estimated to be between 400 and 500 kV. At an electron energy of 2 MeV, the displacement cross-section for electron damage in this material is approximately 75 barns ($1 \text{ barn} = 10^{-24} \text{ cm}^2$). Heating of one of the quenched specimens (large volume fraction of 4H) in an Hitachi H-800B operated at 200 kV (well below threshold for displacement damage) revealed that the 4H-3C transformation occurred over the range 120-400°C in the electron transparent areas of the specimen. A similar specimen was subjected to 2 MeV electron irradiation (well above threshold for displacement damage) in the Hitachi H-3000 at room temperature for more than 1 h with the electron beam substantially defocussed over the entire electron transparent region. The specimen was subsequently heated but failed to observably transform until about 600°C. A specimen which was initially predominantly 3C was irradiated in a similar manner also at room temperature, followed by cooling in an Oxford helium-cooled double tilt holder. No transformation to the 4H structure was observed in this specimen even on cooling to an indicated temperature of 16 K. Both experiments seem to demonstrate qualitatively the profound effect that the damage structure produced by electron irradiation can have on these simple martensitic transformations. In the interpretation of results of related earlier studies involving intermetallics, the

contribution of irradiation-induced structural defects (not associated with disordering) to the stabilization phenomenon was totally ignored, which, in view of the qualitative results presented here, seems to be thoroughly unjustified.

A more thorough study of this phenomenon is being pursued which attempts to quantify the transformation retardation effect. The major problem in doing so stems from the well known fact that such martensitic transformations are significantly retarded due to surface relaxation and possibly surface contamination effects in thin regions of foil specimens.

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