Letters

An observation of slip lines in partially-twinned Fe–26.4 wt % Ni–0.24 wt % C alloy martensites

In spite of recent theories [1, 2] on the existence of more than one lattice invariant shear in martensite structures, apart from a few reports [3–5], there have not been enough observations to clarify the mechanism and number of additional inhomogeneities in ferrous alloys. Observations of fine etch traces in Fe–Ni alloy martensites by Fearon [6] shows that the internal structure of martensite is often more complex than was earlier assumed in the standard theory [7, 8]. However it has also been difficult to describe the nature of the additional shears which can possibly be slip or other twinning modes in addition to the well-known {1 1 2} transformation twins in ferrous alloys. Although double-shear theories were introduced to explain {2 2 5} transformations, it was shown by Dunne and Wayman [9] that they are not completely successful, and more work is needed to give satisfactory explanations with the consideration of all possible shear components in conjunction with more detailed structural observations.

In the present work the effect of plastic deformation on the substructure of Fe–26.4 wt % Ni–0.24 wt % C martensite formed from retained austenite or previously-formed plates was investigated and slip lines were observed in the untwinned outer parts of some partially-twinned martensite plates.

The alloy which had a sub-zero transformation temperature ($M_s \approx 35^\circ$ C) was supplied by the United Steel Co. Ltd., UK. Specimens were cut to dimensions of 1 cm × 1 cm × 0.5 cm and annealed in evacuated silica tubes for 12 h at 1200° C. After the annealing process the structures were completely austenitic. These samples were then immersed in a liquid nitrogen–methanol bath to produce martensite. Martensite structure was observed in a Cambridge Stereoscan MK 1 scanning electron microscope equipped with a tilting stage. The same instrument was also used to obtain selected-area channelling patterns of small martensitic regions.

Figure 1 Scanning electron micrograph of the martensite region in a Fe–26.4% Ni–0.24% C alloy showing observed slip lines.

Fig. 1 shows the observed surface relief in the outer parts of a partially-twinned Fe–26.4% Ni–0.24% C martensite plate. The crystallography of surface relief was examined by a selected-area channelling patterns technique in numerous samples. A scanning electron micrograph of the observed markings and corresponding selected-area channelling pattern of the same area is shown in Fig. 2. Indexing of several channelling patterns in conjunction with the scanning electron microscope pictures revealed that these markings are formed on {1 1 0} ⟨1 1 1⟩ systems of the martensite structure. Since {1 1 0} is one of the possible slip planes in Fe–Ni–C martensites [5, 6] and no

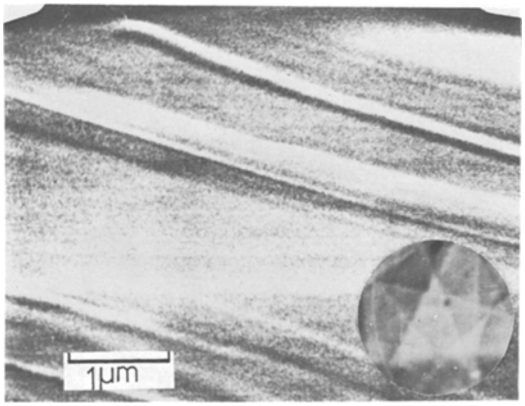

Figure 2 Scanning electron micrograph of slip lines, with inset showing corresponding selected-area channelling pattern.

external stress was involved during or after the transformation, it was concluded that surface relief represents slip lines caused by the constraints of the surroundings. This indicates the existence of another lattice-invariant shear in the outer parts of partially-twinned Fe–26.4% Ni–0.24% C alloy martensites in addition to the well-known transformation twins localized around the midrib.

Present results also support the two-stage process of the partially-twinned martensite formation in Fe alloys which was first suggested by Patterson and Wayman [10].

References

1. N. D. H. ROSS and A. G. CROCKER, *Acta Met.* 18 (1970) 405.
2. A. F. ACTON and M. BEVIS, *Mater Sci. Eng.* 5 (1969/70) 19.
3. G. THOMAS, *Met. Trans.* 2 (1971) 2373.
4. R. P. REED, *Acta Met.* 15 (1967) 1287.
5. T. N. DURLU, D. Phil. Thesis, Oxford University (1974)
6. E. O. FEARON, D. Phil. Thesis, Liverpool University (1972)
7. M. A. WECHSLER, D. S. LIEBERMAN and T. A. READ, *Trans. AIME* 197 (1953) 1503.
8. J. S. BOWLES and J. K. MACKENZIE, *Acta Met.* 2 (1954) 129.
9. D. P. DUNNE and C. M. WAYMAN, *Met. Trans.* 2 (1971) 2327.
10. P. L. PATTERSON and C. M. WAYMAN, *Acta Met.* 14 (1966) 347.

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Lamellar reorientations in low density polyethylene

One of the main deformation mechanisms in oriented polymers at room temperature is chain slip. This is true, for example, in polypropylene and high density polyethylene [1, 2] and in low density polyethylene [3]. Also, in polypropylene and high density polyethylene deformed in tenation, the reorientation of the lamella surface has been found to be close to that expected when shearing of the material occurs as the result of chain slip [1].

In doubly-oriented low density polyethylene (LDPE) deformed in tension along the original draw axis chain slip and lamella separation occurred [3], the latter being attributed to straining of the interlamellar layers. This note provides further data on such an experiment and shows that the changes in the small-angle X-ray pattern are different from what may be expected if the lamellae are sheared by chain slip. It is shown that stretching of the interlamellar layers can account for the reorientation of the lamella surface.

Doubly-textured LDPE was prepared by drawing and rolling at room temperature and then annealing at 95.0° C. Test pieces were cut parallel to the draw (y) axis and strained in tension at 20 ± 3° C. X-rays showed that θ (angle between

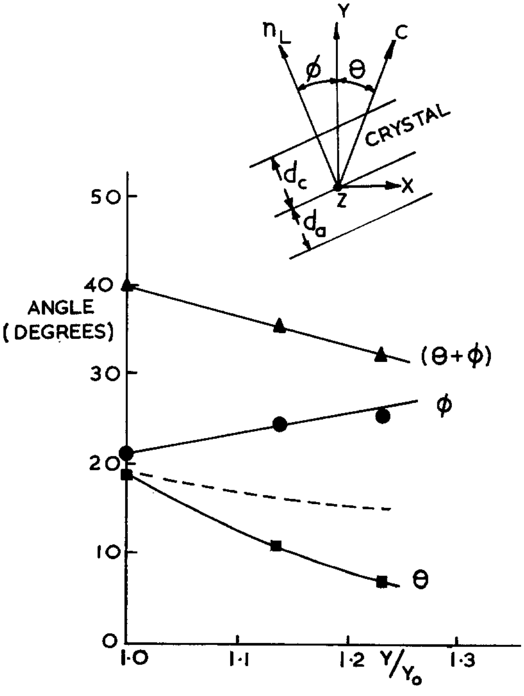

Figure 1 Angles θ, ϕ, and $\theta + \phi$ plotted against y/y_0 for doubly oriented LDPE at 20° C. θ and ϕ are defined in the schematic diagram in which n_L is the lamella normal, y is the tensile axis, and c is the chain axis. x is perpendicular to the rolling plane. The broken curve shows the variation of θ predicted by the equation $y/y_0 = \sin\theta_0/\sin\theta$ (see text).