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MECHANICAL TWINNING IN NICKEL

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MECHANICAL TWINNING IN NICKEL

We are investigating the structure and mechanical properties of polycrystalline nickel deformed by shock loading at room temperature as well as by tensile and compressive testing at various temperatures. The experiments are being done to try to understand the reasons for the considerable hardening that can occur as a result of shock loading without much change in dimensions or grain structure.[1]

Thin foils were prepared from $\frac{1}{4}$ inch thick polycrystalline deformed materials by spark erosion slicing followed by electropolishing. The transmission electron microscopy results have shown that up to 350 kilobar pressure the structure of explosively deformed nickel is similar to that of statically loaded specimens in that dense tangles of dislocations and cell walls were observed. Cell walls were also observed even after tensile deformation in liquid He. However, during explosive deformation at and above 350 kilobars pressure (equivalent to 5×10^6 psi), nickel deforms by mechanical twinning on (111) planes. This is of interest since Dieter[2] was unable to observe twinning in his experiments using both light microscopy and electron microscopy of replicas. As shown in Fig. 1, the twins are extremely fine ($\sim 0.05\mu$ thick) and cannot be resolved by light metallography. There appears to be a high density of dislocations at the twin-matrix interface (Fig. 2) suggesting that the twins may be incoherent. Figure 3 shows the electron diffraction pattern of Fig. 2. The foil is in the $(5\bar{1}0)$ orientation and the spots marked T_1 and T_2 are the reflections corresponding to the two sets of twins in Fig. 2. T_1 has the orientation $(13\bar{4})$ and T_2, (134). The contrast can be reversed for either set by means of dark field illumination using the

diffraction spots corresponding to that set. The spots in the diffraction pattern not corresponding to any of the three lattices are attributed to double diffraction.

The compression axis in Fig. 2 is designated by the arrow C. This corresponds to the $[15\bar{1}]$ direction. Since this lies in the dodecahedral plane, one might expect conjugate twinning on the $(\bar{1}1\bar{1})$ and (111) planes. However, twinning occurs on the $(\bar{1}1\bar{1})$ and $(1\bar{1}\bar{1})$ planes. Operation of the unexpected $(1\bar{1}\bar{1})$ twin probably occurs because of the complex stress system set up in the polycrystalline sample.

Although Haasen[3] has reported that twins formed in the necked region of single crystal specimens deformed at 20°K and below, so far, we have not observed any twinning after low temperature static deformation up to 20% strain.

It appears from the present state of research on mechanical twinning that the latter is favored by deformation at low temperatures or very high strain rates as well as by lowering stacking fault energy (by alloying).[4]

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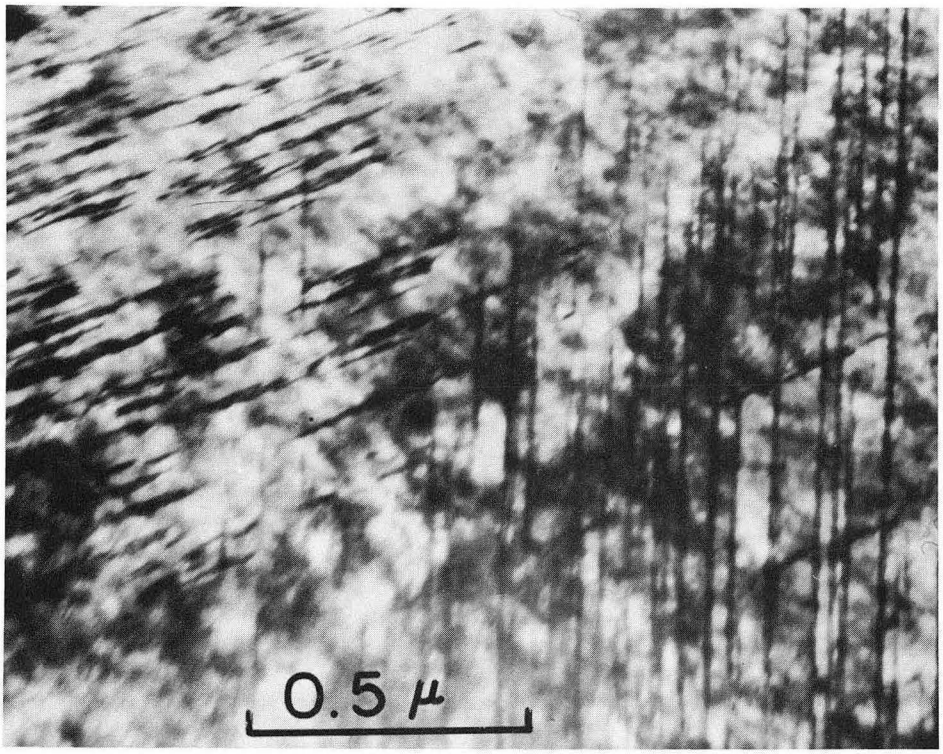
Figure Captions

Fig. 1 Ni explosively deformed at 350Kb showing two sets of twins lying normal to the foil surface (orientation [110]). Foil surface parallel to stress axis.

Fig. 2 As Fig. 1, foil orientation $[5\bar{1}0]$, showing two sets of twins T_1 T_2 (see text). Arrow C shows direction of stress axis.

Fig. 3 Selected area diffraction pattern of Fig. 2 showing twin spots T_1 T_2. Matrix reflections are indexed.



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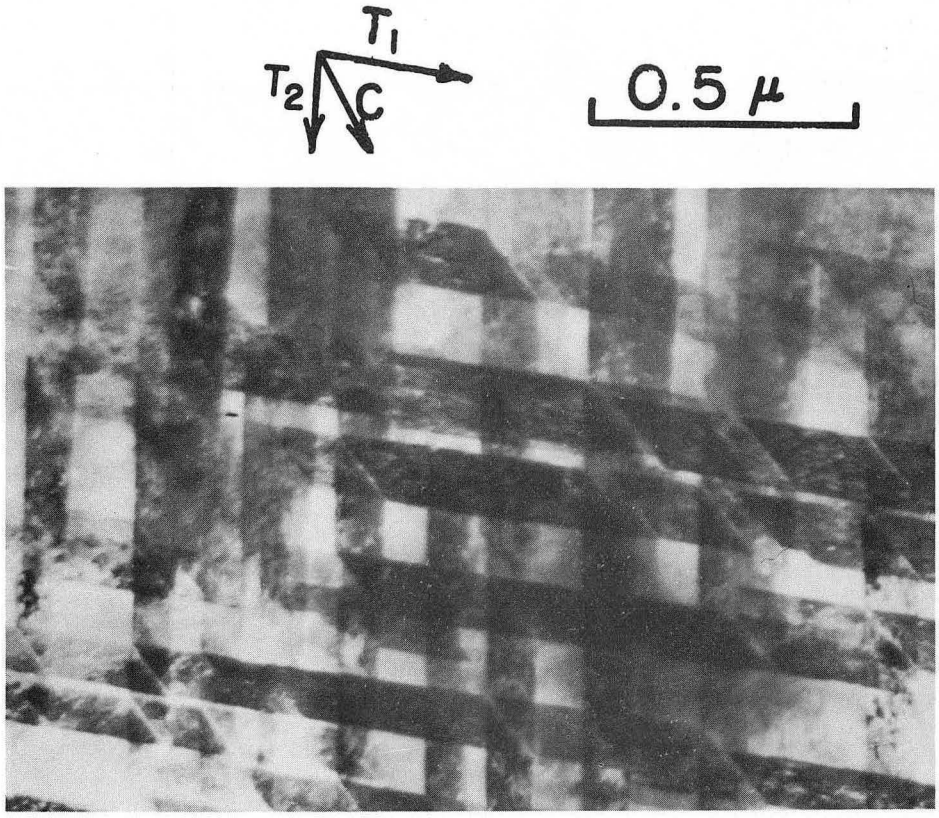

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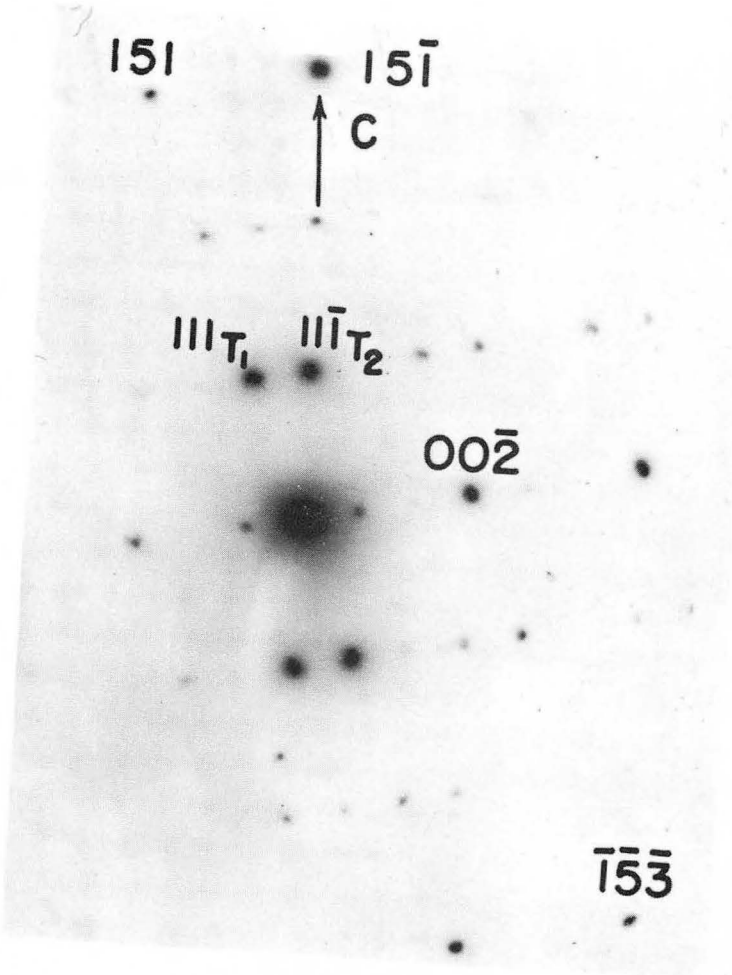

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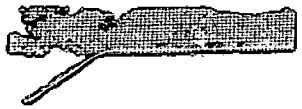
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