Slip Systems in VC-TiC Alloys

The cubic refractory metal carbides generally deform plastically with a $\{111\}$ $\langle 1\bar{1}0\rangle$ slip system characteristic of their similarity with fcc metals or covalently-bonded cubic crystals, [1-3]. Slip on $\{110\}$ and $\{100\}$ planes has also been reported for ZrC [4] and TaC [5], and as would be expected, the dislocation Burgers vectors, where measured, were parallel to $\langle 110\rangle$.

Single crystals of a number of VC-TiC alloys were compressed in different orientations, namely [001], [012] and [111], to investigate the critical resolved shear stress for slip [6, 7] on the different possible slip systems. In all the compositions studied in this work, a $\{111\}$ slip plane was exhibited. As Burgers vector analysis indicated that the slip direction was $\langle 110\rangle$, the primary slip system was deduced as $\{111\}$ $\langle 1\bar{1}0\rangle$ in common with most of the pure carbides. In addition to the normal $\{111\}$ slip, however, crystals of VC-25% TiC also exhibited surface traces corresponding to slip on $\{110\}$ planes when compressed in the [111] direction. This observation is surprising since, for compression along [111], the Schmid factor for slip on the $\{110\}$ plane in the $\langle 1\bar{1}0\rangle$ slip direction, is zero. If slip then does take place on $\{110\}$ planes, the only likely slip direction is $\langle 001\rangle$.

An unambiguous determination of the slip plane could not be made since surface traces were observed only on one face of the crystals. However, transmission electron metallography suggested that VC-25% TiC crystals when deformed plastically at 1800° C do exhibit dislocations which have Burgers vectors along $\langle 001\rangle$ directions. In fig. 1a the long dislocations are in contrast when the imaging plane is (002), but they are invisible in a $(\bar{2}20)$ reflection (fig. 1b) consistent with the Burgers vector having an $a[001]$ form. All the other dislocations in this sample have the usual $\langle 110\rangle$ vectors as each one is out of contrast either in the $(\bar{1}1\bar{1})$ or the $(\bar{1}11)$ reflections (figs. 1c and 1d respectively).

From these results, it would appear that a secondary slip system $\{110\}$ $\langle 001\rangle$, is activated in VC-25% TiC alloys when deformed at high temperatures. Its occurrence has important implications with respect to toughness and ductility of the carbides, particularly at low temperatures. If dislocations having $a\ \langle 001\rangle$ Burgers vectors are introduced by high temperature deformation as, for example, in some forming process, the intrinsically brittle carbides may be further embrittled, since such dislocations have the highest energy configuration in the cubic lattice and can be considered as crack nuclei lying in $\{100\}$ cleavage planes.

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Figure 1 overleaf

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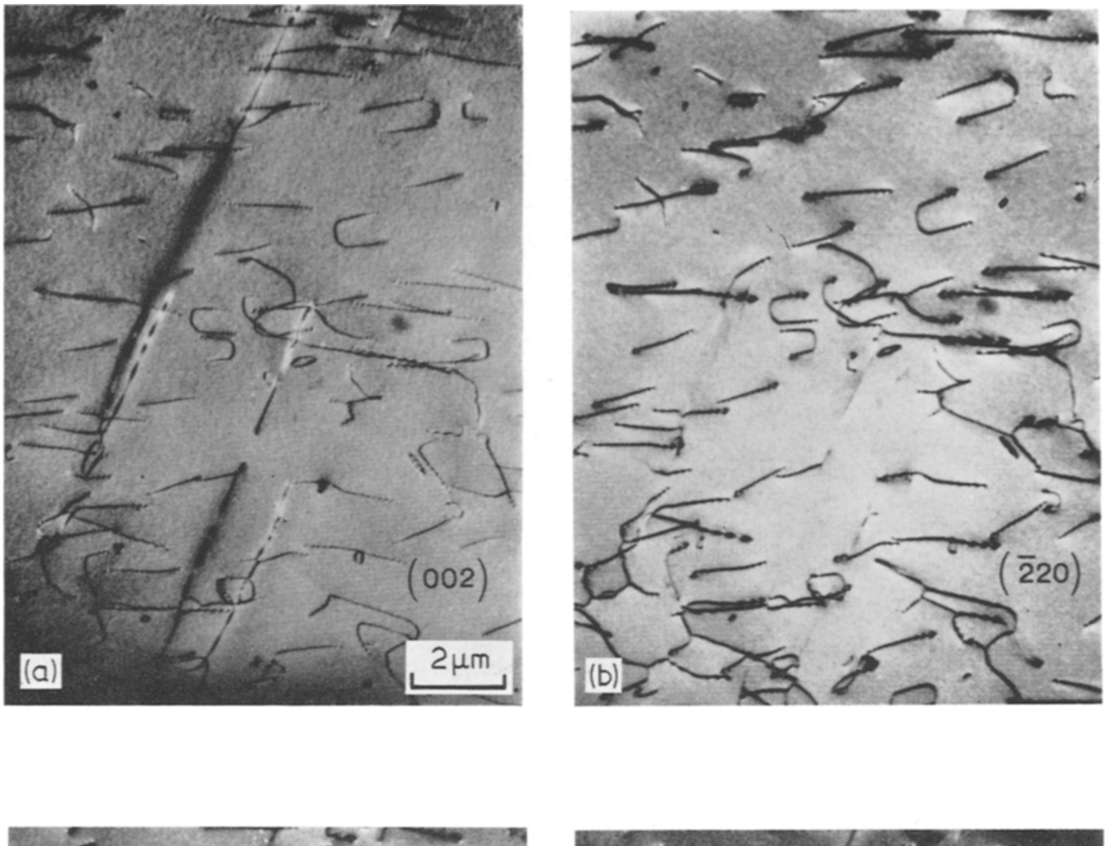

Figure 1 Deformed structure of VC-25% TiC