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THE MORPHOLOGY OF THE TRANSFORMATION INTERFACE IN REACTION SINTERED SILICON CARBIDE

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The mechanisms by which silicon carbide transforms from one of its crystal structures to another remains a central question in understanding its behaviour. This is of importance in elucidating how polytypism occurs and is also of immediate practical concern since the β (cubic) to α (hexagonal) transformation is found to accompany exaggerated grain growth in both sintered and hot-pressed compacts ⁽¹⁾. Examination of partially transformed silicon carbide, for instance the boron sintered material, reveals that the α and β forms co-exist within the same grains and that the α regions are in the form of laths extending completely across the grains. ⁽²⁾. Since the broad faces of the laths are also found to be flat and are formed by a close packed plane in both phases, their morphology provides no evidence on how they propagate across the grains or how they thicken. A similar morphology exists for the polytype blocks in the fully transformed material ⁽²⁾.

In this short note we present detailed observations of the interface morphology separating regions of α (6H) structure and β (3C) crystal structure in a reaction sintered silicon carbide.

The material investigated, REFEL^{*} silicon carbide, is produced by the reaction of molten silicon with compacted α -silicon carbide and graphite powders and is predominately α -silicon carbide ⁽³⁾. Foils for high resolution electron microscopy were prepared from thin polished sections by ion-thinning until regions were electron transparent.

* Made by U.K.A.E.A.

They were examined in a 125kV electron microscope fitted with a high resolution tilting stage using standard techniques of bright and dark field diffraction imaging, selected area diffraction and the technique of lattice fringe imaging.

The majority of grains examined were alpha having the 6H (Ramsdell notation) polytype structure, in agreement with the bulk X ray diffraction patterns. In addition, grains of free silicon were found. However, in a small number of cases, individual silicon carbide grains contained both cubic (β) and hexagonal (α) forms. This is seen in Fig. 1, where the grain is oriented so that $[011]_{\beta}$ and $[\bar{1}1\bar{2}0]_{\alpha}$ are parallel to the incident electron beam direction. In this low magnification micrograph, the interface is clearly seen to be irregular rather than planar. The selected area electron diffraction patterns, Fig. 2a and 2b, indicate that the interface does indeed separate a region of hexagonal (6H) stacking (Fig. 2a) from a region of cubic (3C) stacking (Fig. 2b). This was confirmed by dark field imaging using hexagonal reflections. (The presence of weak hexagonal reflection in the pattern 2b is due to the fact that the selected area diffraction aperture was slightly larger than the size of the cubic region and necessarily included part of the hexagonal region as well).

Details of the interface itself were obtained by using the technique of lattice fringe imaging. By placing the objective aperture in the diffraction pattern as superimposed in Fig. 2a, the cubic and hexagonal regions are imaged simultaneously. In addition however lattice fringes corresponding to the spacing of the spots ($15 \text{ \AA}$) are visible in those regions where the stacking is hexagonal. In this way the interface structure is imaged with a resolution of the 6H unit cell periodicity

as in Fig. 3. The interface is seen to be stepped and consists of unit cell high ledges.

A number of conclusions may be drawn from these observations. Firstly, they suggest that in reaction sintered silicon carbide the phase transformation proceeds by the propagation of unit cell high ledges along a close packed plane. The propagation of such a ledge interface across a grain would result in a transformed region that is lath shaped and bounded by a close packed plane, as is observed in other partially transformed silicon carbides indicating that the same mechanism may well operate in these forms too. Secondly, the fact that the α and β phases do not extend completely across the grains in this material whereas they do in the boron sintered and hot pressed materials implies that the transformation is retarded in some way, perhaps by an impurity or solute mechanism. Thirdly, the additional observation that the interface steps all lie on only one of the two close packed planes in the $[011]_{\beta}$ section would suggest that the growth is the result of a cooperative phenomenon.

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Figure Captions

1. Low magnification bright field lattice fringe image electron micrograph of the transformation interface between α and β SiC. The fine fringe spacing is 15.2 Å.
2. Selected area electron diffraction patterns taken from a) the hexagonal (α) region, and b) from the region of cubic stacking (β) of figure 1.
3. Lattice fringe image of part of the interface, revealing that it consists of unit cell high steps or ledges. The diffraction condition used is that shown in figure 2a by the superimposed outline of the objective aperture.

FIG. 1

0 0 0 0 4 4 0 0 8 1 6

XBB 775-4962

FIG. 2

0 0 0 0 4 4 0 0 8 1 7

Fig. 3

XBB 773-2083

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