1068 CD
DOI: 10.1017/S1431927606063689
Microsc Microanal 12(Supp 2), 2006

Commensurate intergrowths in titanium monoboride precipitates

Usanee Kitkamthorn and Mark Aindow

Department of Materials Science and Engineering, Institute of Materials Science, University of Connecticut, Storrs, CT 06269-3136, USA

The addition of boron to Ti-based and TiAl-based alloys can refine the grain structure and this is usually accompanied by the formation of boride particles due to the low solid solubility of B. The borides can exhibit a remarkable diversity of morphologies and crystal structures, although most of these are TiB monoborides in the form of plates, needles, and/or ribbons. The equilibrium crystal structure for TiB is B27, but certain alloying additions (e.g. Nb, Ta) can stabilize the B_f structure [1]. Such borides often contain high densities of planar defects and in our work we have studied these defect structures in two alloys: Ti-6-4 and Ti-44Al-4Nb-4Zr (at. %), both modified with 1 at.% B.

The alloys were prepared by transferred-arc plasma melting with B in the form of AlB_{12}. TEM samples were prepared by twin-jet electropolishing using an electrolyte consisting of 6% perchloric acid, 34% butanol and 60% methanol at -15°C and 30 V / 40 mA. The samples were then Ar+ ion milled for 0.5 h at 0.5 kV / 0.2 mA to remove any residual contamination or damage layer on the surfaces. The CTEM experiments were performed in a Philips EM420T operating at 120 kV whereas HRTEM lattice images were acquired using JEOL 2010 FasTEM equipped with a UHR objective lens polepiece ($C_s \approx 0.5$ mm) and operated at 200 kV.

Preliminary SEM observations showed that the borides in B-modified Ti-6-4 were needle-like, whereas those in the B-modified Ti-44Al-4Nb-4Zr were curved ribbons. BF-TEM images (e.g. Fig. 1(a) & 2(a)) revealed that in both cases the borides contained planar faults parallel to the major facet. The needles in the B-modified Ti-6-4 consist of the B27-TiB phase and are oriented with [010] parallel to the needle axis (Fig. 1(a)). HRTEM images such as Fig. 1(b) reveal that the faults lie on (100), and that these correspond to thin coherent intergrowths of the B_f-TiB phase. The ribbons in the B-modified Ti-44Al-4Nb-4Zr are comprised of thin blocks with the B_f-TiB structure and having (010) as the major facet. These blocks contain a wide variety of different defect structures including pockets of metallic B2 phase, and coherent intergrowths of Ti_3B_4 and TiB_2: all of these features lie parallel to $(010)B_f$ and the details of these structures are presented elsewhere [2]. Occasional faults were also observed lying parallel to (110) plane of B_f, and two examples are shown in Fig. 2(b). These latter faults correspond to thin embedded slabs of B27-TiB phase. Interestingly, in both the needles and the ribbons the orientation relationships between the B_f-TiB and B27-TiB phases is:

$$[001]B_f//[010]B27; \text{ with } \{110\}B_f//(100)\ B27.$$

The B_f- and B27-TiB structures are closely related, both comprising regular trigonal prisms with six Ti atoms at the vertices and one B atom at the center [1,2]. Although these prisms are arranged rather differently in the two structures, it is possible to produce the B27-TiB structure by repeated 180˚ rotational twinning of the B_f structure on {110} (Figure 3). Similarly, 180˚ rotational twinning of the B27 structure on (100) would produce B_f. As such, one would expect fully coherent interfaces, which would explain why the faults form on these planes. However, the faults are highly unlikely to form by a shear twinning mechanism in either of the alloy systems considered here: the orientation of the faults parallel to pronounced facets on the boride/metal interfaces suggests that they are instead probably the result of errors in the stacking sequence during growth.

References

[1] M. De Graef, J. P. A. Lofvander and C. G. Levi. Acta Metall Mater 1991; 39: 2238

[2] U.Kitkamthorn, L. C. Zhang and M. Aindow. Intermetallics 2006: In press

[3] Work supported by NSF (Grant # DMR DMR-0072721) and by the Royal Thai Government.

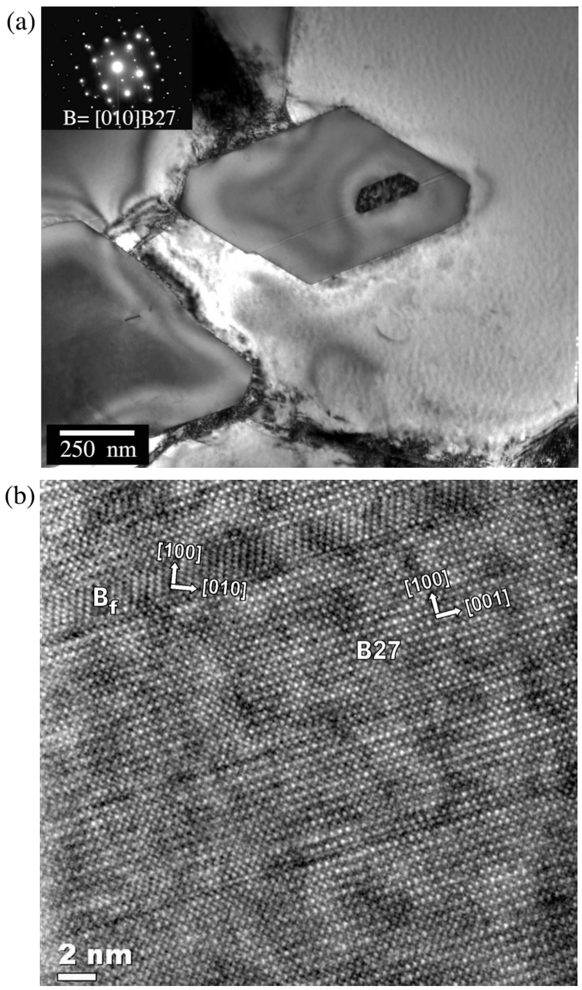

Fig. 1: BF-TEM (a), and HRTEM (b), images from a boride needle in B-modified Ti-6-4.

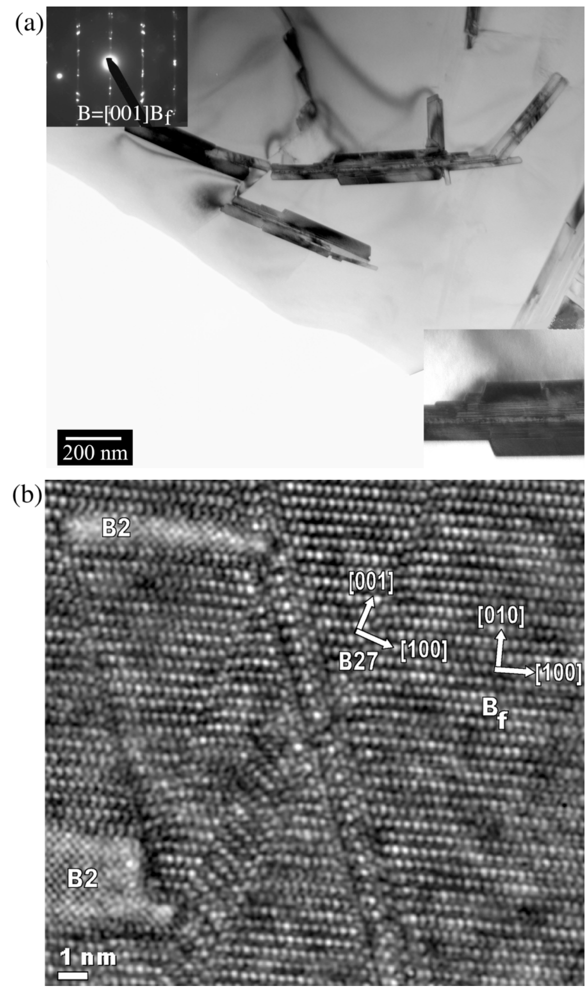

Fig. 2: BF-TEM (a), and HRTEM (b), images of a ribbon in B-modified Ti-44Al-4Nb-4Zr.

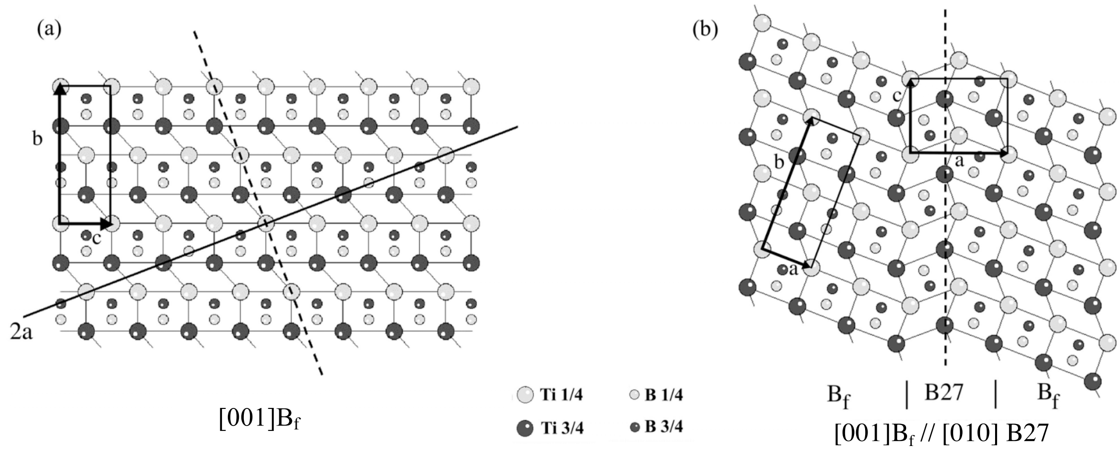

Fig. 3: Creation of a thin B27 layer at a 180˚ twin on (110) in the B_f structure [1]

https://doi.org/10.1017/S1431927606063689 Published online by Cambridge University Press