SOLID STATE STUDIES IN CERAMIC ALLOYS

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During the first quarter of this contract period a transmission electron microscope study was made of the interaction between dislocations in TiC and trace quantities of boron. TiC single crystals were heated to 2000°C in the presence of small amounts of boron such that the resulting boron concentration in the samples was approximately 100 ppm. Control samples were similarly heat treated in the absence of boron. In the microscope, the undoped samples exhibited features characteristic of a high stacking fault material, i.e. all dislocations were undissociated and of the $\frac{1}{2}\langle 110\rangle$ type. In the doped samples, however, dislocations were associated with large areas of fringe contrast, 0.5 to 1.0 microns wide. Tilting experiments revealed that the dislocations in these samples were Shockley partials of the $\frac{1}{6}\langle 112\rangle$ type, and that the areas of fringe contrast corresponded to intrinsic stacking faults that lie on $\{111\}$ planes. By analogy with fcc metals, it is considered that the partials and faults were formed by a dissociation of unit dislocations by a reaction of the type

$$\frac{1}{2}[1\bar{1}0] \longrightarrow \frac{1}{6}[1\bar{2}1] + \frac{1}{6}[2\bar{1}\bar{1}].$$

Since this reaction occurs only in doped samples it appears that the dissociation and fault formation results from a mechanism similar to that first proposed by Suzuki (Dislocations and Mechanical Properties of Crystals, John Wiley and Sons, New York 1956). Thus it is suggested that boron atoms diffuse to unit dislocations at the heat treatment temperature, leading to a localized reduction in stacking fault energy and concomitant dissociation.

The work of Hren and Thomas (Trans. AIME 227, 308 (1963)) indicates that a similar phenomenon occurs in an Al-20% Ag alloy, but that it is followed by precipitate formation at the fault. In the present work, electron diffraction studies failed to reveal any evidence for the existence of a second phase. However, the low concentration of boron involved might preclude detection even if precipitation had occurred. Nevertheless, it is considered that the faults described may constitute the nuclei of the "Mondrian precipitates" observed by Williams (J. Appl. Phys. 32, 552 (1961)) in TiC, since their distribution, density of occurrence, and crystallographic relationship to the matrix all are similar to those of the precipitates.

The present findings indicate that trace amounts of boron can drastically alter the defect structure of TiC. Because these changes may have important implications with regard to the high temperature properties of this material, further work is planned on this system. In particular the microscope hot stage will be employed to study the dissociation reaction in more detail as well as the interaction between mobile dislocations and the faults. Material having a higher concentration of boron will also be examined to further clarify the relationship between the faults and the "Mondrian precipitates".

A more detailed description of the work outlined here is being submitted to NASA as a RIAS report, and to Physica Status Solidi for consideration for publication.