Bull. Mater. Sci., Vol. 6, No. 4, September 1984, pp. 699–700. © Printed in India.

Grain boundary-dislocation interactions*

S RANGANATHAN

Department of Metallurgy, Indian Institute of Science, Bangalore 560 012, India

Abstract. Our current understanding of the structure of grain boundaries will be described first. The structure of low angle boundaries can be rigorously described in terms of arrays of dislocations. The structure of high angle boundaries continues to defy a complete and rigorous description. A model has been developed based on coincidence site lattices. This model postulates the presence of grain boundary dislocations even at high angles of misorientation to accommodate the deviation from exact coincidence conditions. The Burgers vectors of such grain boundary dislocations can be found by the translation vectors of the DSC lattice. An interesting point is that the Burgers vectors are not lattice translations. Hence the dislocations are confined to the surface of the boundary and cannot move into the grain. Alternative descriptions of the structure of grain boundaries make appeal to the Bernal type of polyhedral voids that occur in metallic glasses. A brief discussion of the strength of this approach will be outlined. Dislocations at grain boundaries can affect both grain boundary migration and sliding. The possible mechanisms for these phenomena will be described. The importance of understanding these mechanisms to explain deformation of metals at high temperatures will be stressed.

Discussion

M Youssuff: Is it possible to include vacancies in the approach you have described?

S Ranganathan: This is an important question; the answer is not known.

P Rodriguez: How do you explain migration with the help of imprisoned grain boundary dislocations?

Ranganathan: It is easy to explain this migration in a framework similar to Aronson's theory of the growth of precipitates. For example, in cases where the ledge mechanism operates, the ledges move along the plane in which the precipitate is growing.

Rodriguez: If we provide energy in the form of stress, is it possible that the smaller grain boundary dislocations combine to form larger mobile lattice dislocations?

Ranganathan: It should be possible, but no clear evidence is available.

S Ray: Can only certain lattice vectors be split into DSC vectors?

Ranganathan: Any lattice vector can be broken into DSC vectors, since the DSC lattice consists of both the lattice positions.

Ray: Are ledges inherited from the energetics of growth? Are these a common feature?

Ranganathan: They need not be inherited from the growth. Yes, they are a reasonably common feature.

* Only a summary is presented.

S Ramaseshan: Why is a polycrystalline material stronger than a real single crystal?

Ranganathan: In a polycrystalline material, the dislocations are stopped at the grain boundaries, thereby impeding their movement.

Ramaseshan: In the Bernal picture, could a polycrystalline material be considered as a composite of grains and grain boundaries?

Ranganathan: One could think of the polycrystalline material as a two phase material—the grain boundaries and the grains. The idea, though found in the literature, has no validity. We have to consider the boundary as a whole.

T V Ramakrishnan: Is there any evidence for the existence of dislocations and their movement?

Ranganathan: We can actually see dislocations by etch, pit techniques, field-ion microscopy, electron microscopy, etc.! There is no doubt about the movement of the boundary of a bicrystal when it is loaded in the form of a cantilever.

G Srinivasan: Should not the energetics contain all sorts of things, including contributions from the electrons?

Ranganathan: I am tempted to agree with this since all existing theories seem to be succeeding only up to a point. There seems to be something basic that is missing.

Srinivasan: Could the unique microscopic properties shown by a metallic glass (*e.g.*, the electronic properties and ductility) be translated to a microscopic description of grain boundary sliding?

Ranganathan: One would indeed like to do that. However we are rather ignorant about both these areas and hence not much progress has been made.

Srinivasan: Is this analogy being used only with reference to structure?

Ranganathan: Right now, for the structure and the geometry.

K R Rao: As the dislocation structure can change owing to a variety of factors, it appears that the structure of the specimen is really transient—how does one ensure reproducible conditions in this sense?

Ranganathan: The underlying structures are not as transient as appears at first sight, but careful investigation of this point is certainly in order.

A P Pathak: Is there a study of the variation of the strength with respect to the orientation of the boundaries?

Ranganathan: I think this has been done for bicrystals, but not for polycrystals.