THE INFLUENCE OF DEFORMATION ON THE TEMPERATURE DEPENDENCE OF FRACTURE TOUGHNESS OF CHROMIUM ALLOY

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The influence of structure formed by plastic deformation on fracture toughness of chromium by cleavage was studied. It was found that dependence of fracture toughness on degree of deformation is nonmonotonous as well as for molybdenum and for iron. Maximum of fracture toughness corresponding with deformation 20-30% has grown due to test temperature increase. Formation of highangle cells results in the growth of fracture toughness due to increasing number of highangle boundaries.

INTRODUCTION

A lot of publications have been devoted to investigation of regularities of structure formation under plastic deformation. In /1,2/ results obtained for bcc metals have been presented in generalized schemes which characterize structure evolution during plastic deformation within wide interval of test temperatures and deformation rates. Analysis of such diagrams for various bcc metals permits to conclude that there are some general mechanisms of structure transformation under deformation.

In /3/ it was shown that for certain state of structure deformation curve in terms "$\sigma-\varepsilon^{1/2}$" (here σ - true deformation stress, ε - true strain) consisted of straight lines sections, whereas bends were corresponded to structure state changes.

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In /4/ monotoneous dependence of yield stress on previous strain and non-monotonous dependence of D.-B.-T.- temperature on previous strain were observed side by side. It was discovered that peculiarities of last dependence were caused by structure state changes.

Present work has been devoted to investigation of structure influence on fracture toughness of deformed chromium alloy. The character of structure evolution under deformation was founded to be absolutely adequate to common structure diagrams.

MATERIALS AND METHODS

Chromium alloy was deformed by rolling temperature of 700^{0}C.

Fine structure of deformed chromium was observed by transmission electron microscope JEM100-CXII /JEOL).

Fracture toughness was measured under three-point bending of specimens with electrospark cracks.

Failure mechanism were investigated by scanning electron microscope Superprobe-733 /JEOL).

RESULTS AND DISCUSSION

The change from chaotic distribution of dislocation to low disoriented cells took place for strains about 20%. Formation of disoriented cells was observed for strains above 60%.

Dependence of toughness on previous strain for alloy under test temperatures -196, +20, +70, +100^{0}C are presented in Fig. 1a.

Maxima on the curves correspond with the deformation for which formation of low disoriented cells structure was observed. This effect has been revealed also for Fe and Mo, hence we might expect that it is general physical process which manifested itself when crack interacts with deformation structure.

Increase of toughness under deformation above 60% is stipulated by increasing number of highangle boundaries.

Discussing physical nature of non-monotonous dependence of fracture toughness on value of previous deformation it is necessary to record following:

Maximum of fracture toughness corresponding to deformation of 20-30% is stipulated by interaction of dislocations being emitted from the crack tip with boundaries of low disoriented cells. This interaction would be characterized as thermoactivated. Attempts have been undertaken to evaluate deformation substructure contribution to the process of fracture toughness formation under certain test temperature. In this connection values of fracture toughness of deformed materials have been reduced by values of fracture toughness of the undeformed material for respective test temperature (Fig. 1b). It was found that maximum corresponding to deformation 20-30% has grown due to test temperature increase.

Fracture toughness increase being observed for high deformed materials is only stipulated by increasing of number of highangle boundaries.

CONCLUSIONS

Thus, results presented enable us to advance in understanding of mechanism of crack's interaction with substructure of metals and to determine links between these processes and general principles of deformation structure formation for bcc metals.

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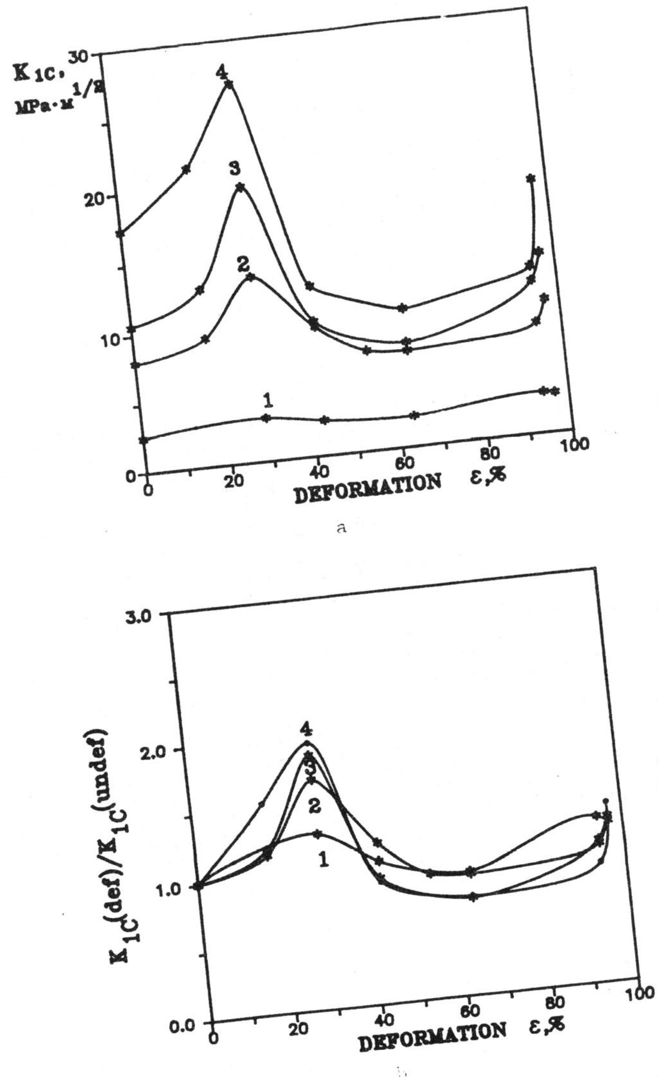

Figure 1. Fracture toughness of chromium vs degree of deformation (a). Normalized values of fracture toughness (b). Test temperature, ^{0}C: 1 - -196; 2 - +20; 3 - +70; 4 - +100.