Pressure-induced Development of Dislocations at Elastic Discontinuities

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Abstract

The stress fields around spherical elastic discontinuities in an isotropic solid subjected to externally applied hydrostatic pressure have been computed on the basis of a continuum mechanics model. The results have been compared with transmission electron microscopy observations of the pressure-induced development of dislocations in tungsten containing particles (thoria and hafnium carbide) or internal voids and in a model system of copper containing helium bubbles with the principal objective of elucidating the factors controlling the formation of such dislocations.

For the tungsten, no new dislocations were developed up to 25 kilobars, but they were observed at ThO_2 and HfC particles following pressurization to some 40 kilobars. The computed value of the maximum induced shear stress at that pressure is much below that required for dislocation nucleation. These observations of pressure-induced dislocations are interpreted in terms of additional stress concentrations associated with surface irregularities at the particles. In contrast to the tungsten, pressure-induced dislocations were observed around the helium bubbles in copper for a pressure (25 kilobars) in keeping with that predicted from the model.

For both the tungsten and the copper systems, the development of pressure-induced dislocations depends strongly on the size of the elastic discontinuities. This result is shown to be in keeping with the interpretation of the mechanism of the development of pressure-induced dislocations as one of nucleation rather than multiplication of pre-existing dislocations.

§ 1. Introduction

For several polycrystalline metals containing localized elastic discontinuities—iron containing particles of Fe_3C and FeO (Radcliffe and Warlimont 1964), chromium containing Cr_2O (Garrod and Wain 1965) and beryllium containing iron beryllide (Andrews and Radcliffe 1967)—the development of dislocations at the discontinuities as the result of the application of external hydrostatic pressure has been demonstrated from transmission electron microscopy observations. Since the introduction of fresh dislocations in this way at room temperature, as reviewed recently (Radcliffe 1969), can lead to marked changes in the mechanical behaviour of certain metals, it is important to develop a quantitative understanding of the mechanism by which such dislocations are formed.

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