Nucleation of Dislocation Around Inclusions in Iron Crystals

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Abstract

Nucleation of dislocations around inclusions, small particles of FeO, Al_2O_3 or ZrO_2, in iron was investigated by means of transmission electron microscopy. Dislocation loops produced around inclusions by the prismatic punching were observed in iron containing FeO or ZrO_2 particles when annealed for 100 min at 800°C and furnace cooled. These loops seem to be produced by thermal stresses arising, during cooling, from the difference in the thermal expansion coefficient between the inclusion and the matrix. Generation of dislocations was also observed around inclutions and precipitates in iron deformed by 2% at room temperature.

The nucleation mechanism of dislocation loops around inclusions in iron was discussed. The nucleation stress of the dislocation loop calculated from the present model is $\mu/22 \sim \mu/47$ at room temperature where μ is the shear modulus of the matrix, which is compatible with the experimental observation of dislocation around the ZrO_2 inclusion. The elastic shear stress distribution around a spherical inclusion in an isotropic elastic medium during the application of tension was considered. In this case, the stress concentration around the inclusion was too small to nucleate a dislocation loop. It is deduced that the residual stress around the inclusion thermally induced during cooling, for example, plays a major role in the nucleation of dislocations by mechanical deformation.

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