GRAIN BOUNDARY RESISTANCE TO CLEAVAGE FRACTURE IN Fe-3% SI ALLOY AND FE POLYCRYSTALS: EXPERIMENTS AND MODELING*

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ABSTRACT

Experiments on grain boundaries in bi-crystals of Fe-3%Si alloy have shown that cleavage cracks can break through high angle grain boundaries by entering from one grain into a neighboring one at a number of relatively evenly spaced places in a tiered form, depending primarily on the angle of twist misorientation, with the tilt misorientation being of relatively minor importance. At very low temperatures the specific resistance of grain boundaries to cleavage penetration in most cases can be assessed by a crack trapping model of penetration of the cleavage crack across the boundary and a well defined geometrical penalty of a crack deflection toughening effect as the tiered separate cleavage planes are bridged by additional cleavage cracking of the connecting ligaments in the adjoining grain. There is a definite transition between pure cleavage and mixed cleavage above –5C where the ligaments between the tiered cleavage cracks in the adjoining grain undergo sigmoidal plastic bending followed by ductile tearing, resulting in a definite increase of the overall specific fracture work by a factor of 2-3 above the level of pure cleavage.

In the propagation of a cleavage crack through a field of grains with random misorientations the above form of penetration of cleavage cracking across grain boundaries becomes considerably modified, first, through more irregularly shaped crack fronts probing grain boundaries no longer monolithically and, second, through large scale simple shear type separations of boundaries that are left behind as the cleavage cracking goes around the more difficult grains requiring some boundaries of such grains to be sheared off.

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