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On the low temperature deformation of α-iron

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Plastic deformation of body-centered cubic α-iron at low temperatures differs significantly from the behavior of other transition metals. In particular, anomalous slip has never been observed in iron, although it is a common feature of other (non-magnetic) transition metals. Moreover, twins in iron form exclusively on {112} planes sheared in the twinning sense, whereas recent experiments on niobium, chromium and tungsten reveal also the presence of fine misoriented lamellae on {112} planes subjected to antitwinning shear. While these differences are often attributed to the presence of ferromagnetism, the underlying mechanism has never been elucidated. Our objective here is to investigate the plastic deformation of coarse iron polycrystals of high purity subjected to slow compression at 77 K. A single experiment in conjunction with electron backscattered diffraction is used to obtain full information about the variation of slip activity with the orientation of applied load. We have found no signature of anomalous slip or twinning on {112} planes sheared in the antitwinning sense. These findings are further supported by molecular statics simulations with and without the presence of magnetism. They show that the differences in plastic deformation of iron are not caused by ferromagnetism. Instead, the differences in the plastic behavior of bcc metals correlate with the magnitudes of edge displacements around 1/2<111> screw dislocations.

Keywords: twinning, α-iron, molecular statistics, 77K