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Possible dislocation configurations in slip-plane-aligned boundaries in fcc metals

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The deformation-induced extended planar dislocation boundaries in aluminium and copper deformed to medium strains ($\varepsilon<1$) have preferred crystallographic alignments. The crystallographic planes of these boundaries depend on the grain orientation and the deformation mode [1]. In many cases two sets of low-angle planar boundaries, which align with the active slip planes, are formed. This is, for example, the case for grains belonging to the α-fibre of the rolling texture, spanning from the Goss to the Brass orientation. Slip-plane-aligned boundaries are also typical for other orientations, e.g. the rolled 45° ND-rotated Cube orientation. These grain orientations all have four active slip systems, distributed on two slip planes, which is assumed to be the reason for the characteristic slip-plane-alignment of the boundaries [2].

The planar boundaries have been suggested to be low-energy-dislocation-structures (LEDS) free of long-range stresses, i.e. the Frank equation should apply [3]:

$$\sum \frac{1}{\mathrm{D_i}} \mathbf{b_i} \{(\mathbf{n} \times \boldsymbol{\xi}_\mathbf{i}) \cdot \mathbf{V}\} = 2 \ \sin\theta/2 \ \mathbf{V} \times \mathbf{a}$$

where $\mathbf{b}_i$, $\boldsymbol{\xi}_i$ and D_i are Burgers vector, line direction and spacing of dislocation set i, $\mathbf{n}$ the boundary plane normal, and $\mathbf{V} \perp \mathbf{n}$. The misorientation is the axis/angle pair $\mathbf{a}$ / θ.

Aiming at investigating the origin of the preferred slip-plane-alignment, a theoretical analysis is conducted of the possible Frank boundaries constructed from dislocations gliding on the active systems. In addition, the boundaries are regarded geometrically necessary by accommodating local differences in slip activities so that strain compatibility as well as the lattice misorientation across the boundaries must be considered.

References:

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