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U. Essmann, M. Werner

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DEPENDENCE OF THE CYCLIC STRESS-STRAIN CURVE OF F.C.C. SINGLE CRYSTALS ON TEMPERATURE AND STACKING-FAULT ENERGY

U. Eßmann and M. Werner

MPI für Metallforschung, Institut für Physik, Heisenbergstr. 1, 7000 Stuttgart 80, FRG

The shape of the cyclic stress-strain curve (resolved saturation stress τ_s versus resolved plastic-shear-strain amplitude γ_{pl}) at low to intermediate strain amplitudes reflects macroscopic properties of persistent slip bands (PSBs) [1,2]. After a rather steep increase of τ_s , the curve exhibits a long plateau in the strain-amplitude regime $10^{-4} \leq \gamma_{pl} \leq 10^{-2}$. Within this range only a small increase of τ_s is observed. In other words, τ_s can be considered as a constant in a first approximation. Investigations by optical and electron microscopy have shown that the beginning of the plateau is determined by the first appearance of PSBs, whereas at the end of the plateau the whole specimen surface is covered by PSBs. The PSBs are orientated parallel to the active slip plane. Experiments reveal that with increasing γ_{pl} the pattern of the dislocation arrangement in the plateau range transforms from that of the matrix (which is observed at $\gamma_{pl} < 10^{-4}$) to that observed in PSB lamellae traversing the specimen.

Some of the characteristic features of a PSB lamella are the following: One observes a strong strain concentration. The local strain amplitude in a PSB, $\gamma_{pl,PSB}$, may be more than two orders of magnitude larger than that in the surrounding matrix. The specimen surface becomes severely damaged where a PSB lamella intersects it. PSB lamellae (which have thicknesses of typically 1 μm) exhibit a unique dislocation pattern: It consists of a striking periodic arrangement of thin parallel dislocation walls, which subdivide the bulk of the lamellae into long channels. The walls are orientated perpendicular to the Burgers vector \underline{b} and consist of dislocation dipoles. Screw dislocations linking the walls are observed in the channels.

Considering dislocation glide and dislocation interactions in PSBs a number of authors espouse that the dislocation density is controlled by a dynamical equilibrium between dislocation multiplication and annihilation [2,3,4,5]. It is concluded that dislocation glide in PSBs must be a highly dissipative process. Though many properties of PSBs have been explained in these terms, three items and their mutual relation await a theoretical explanation. These are i) the distance between the periodic dislocation walls, ii) the plateau stress $\tau_s = \tau_{PSB}$, and iii) the density of the screw dislocations in the channels.

In order to promote an explanation we have started a systematic investigation of the dependence of τ_{PSB} on deformation temperature and on stacking fault energy γ .

Our experimental set up allows for push-pull deformation in the temperature interval $80 < T < 450$ K. In order to vary the stacking fault energy γ we use as specimens single crystals of silver, copper, nickel, and aluminum. Values of γ_i and $\gamma_i/G_i b$, where G denotes the shear modulus, have been compiled by Coulomb [6]. Accordingly our choice of materials corresponds to a variation of γ between 0.002 (Ag) and 0.135 J/m² (Al) and of γ/Gb between 2.6 (Ag) and 18.9 (Al). We did not find any correlation between τ_{PSB} and the stacking-fault energy. Tentatively we have plotted in Fig. 1 the value $10^4 \tau_{PSB}/G$ versus $(T/T_m)^{1/3}$, where T_m denotes the melting temperature. We obtain a linear relationship between these variables for copper and nickel in the temperature interval investigated. Preliminary results indicate that in the case of aluminum and silver the observed plateau stresses τ_{PSB} deviate considerably from those obtained by an extrapolation of the relationship in

Fig. 1 for $(T/T_m)^{1/3} \approx 0.63$. Values taken from Mughrabi et al. [2] and from Basinski et al. [7] agree with our results. A difference which may correlate with the stacking fault energies show the cyclic stress strain curves of silver and aluminum for low γ_{pl} at 80 K: The plateau stress is reached in aluminum and silver at $\gamma_{pl} = 2 \cdot 10^{-4}$ and $\gamma_{pl} = 1 \times 10^{-3}$, respectively.

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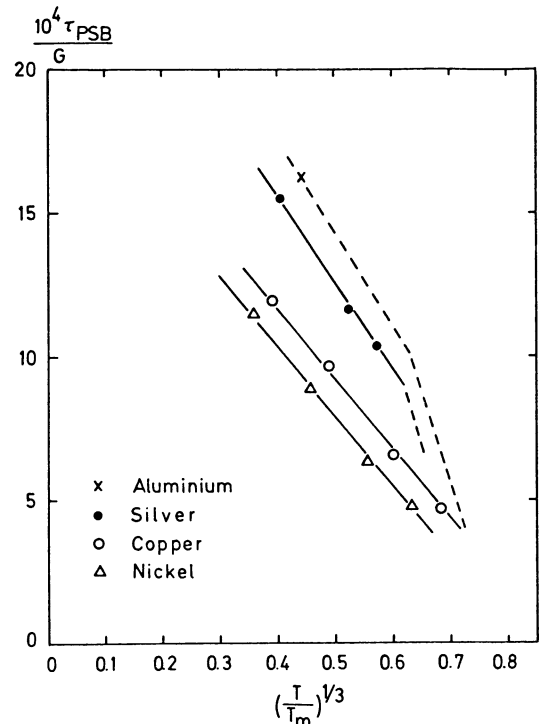


Fig. 1 Plot of the reduced plateau stress versus the cube root of the homologous temperature