ABSTRACT

Experimental investigations carried out with intrinsically strong crystals show that the critical resolved shear stress (CRSS) τ decreases sharply as temperature T is increased from 0K to a certain value T_o, which is equal to 0.1 – 0.2 T_m in the case of body-centred cubic (BCC) metallic crystals. Reverse is true for the activation volume v associated with the unit activation process of yielding. Several theoretical attempts have been made in the past to account for these observations, which have been critically reviewed in some detail. The common feature of the proposed models is the concept of kink-pair mode of escape of screw dislocations trapped in Peierls valleys (i.e. Peierls mechanism) in intrinsically strong crystals at rather low temperatures. Data available in the literature on the temperature dependence of the CRSS of BCC alkali metals K, Li and Na, and BCC transition metals V, Mo, Ta, Nb, Fe and W have been examined in the light of the model developed by Butt and Feltham. It is found that the temperature dependence of the CRSS τ is in accord with the expression $\sqrt{\tau} = A - BT$, where A and B are positive constants. Peierls mechanism is the rate-controlling process of yielding in Fe, Ta, Mo, Nb, V and K crystals at rather low temperatures. Slip occurs on (110) plane in Ta, Mo and Nb crystals (78 – 300K), on (211) plane in Fe (78–200K) crystals, and on (321) plane in K(1.5– 25K) crystal. However, rate-controlling process of yielding in Li(78 – 250K) and Na (50 – 150K) crystals is not Peierls mechanism but stress-assisted thermally-activated breakaway of a straight edge-dislocation segment from an array of pinning points due to localized defects by cooperative unzipping and at the same time expanding in the shape of shallow bulge to saddle-point.