Dislocation structure stability of the zinc crystals

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Stability of forest of pyramidal dislocations in the $\{11\bar{2}2\}\langle\bar{1}\bar{1}23\rangle$ system of zinc single crystals has been studied under repeated deformings in the (0001)$[2\bar{1}\bar{1}0]$ sliding system and intermediate anneals. The hardened state stability has been shown to depend heavily on the annealing temperature and plastic straining processes in the basal sliding system. The dislocation density decrease in the set and decreased yield limit are supposed to be associated with a strong elastic basis-pyramid interaction at the forest densities exceeding a critical value ($>4\cdot10^9$ m^{-2}).

Исследовалась устойчивость леса пирамидальных дислокаций в системе $\{11\bar{2}2\}\langle\bar{1}\bar{1}23\rangle$ монокристаллов цинка при воздействии на кристалл многократных деформирований в системе скольжения (0001)$[2\bar{1}\bar{1}0]$ и промежуточных отжигов. Показано, что устойчивость упрочненного состояния существенно зависит от температуры отжига и процессов пластической деформации в базисной системе скольжения. Делается вывод, что уменьшение плотности дислокаций леса и уменьшение предела текучести связаны с сильным упругим базисно-пирамидальным взаимодействием при плотностях леса выше критического значения ($>4\cdot10^9$ м$^{-2}$).

The concept of directional formation of various dislocation structures is today believed to be fruitful without doubt, since many physical properties of crystals depend on distribution of dislocations in the crystal volume [1, 2] and their interaction [3, 4] and are structure- and orientation-sensitive [5, 6]. At the same time, the time stability of the formed structures under thermal-mechanical or other factors is studied unsatisfactorily [7]. In this work, the stability of pyramidal dislocation forest in the $\{11\bar{2}2\}\langle\bar{1}\bar{1}23\rangle$ system of zinc single crystals has been studied under repeated deformings up to yield limit by basal sliding and intermediate anneals.

Single crystals of 99.997 % purity zinc were examined. The crystals were grown in preset shapes and crystallographic orientations using the procedure described in [8]. Six pieces (samples) of $15\times14\times4$ mm^3 were cut out of each grown and annealed (650 K, 8 h) block-free single crystal using electrospark cutting. The block absence in the crystals was proved by selective chemical etching. The studied were performed using three series of samples. By compressive deforming along $[2\bar{1}\bar{1}0]$, a preset density of forest dislocations was formed in the sample in $\{\bar{2}112\}\langle2\bar{1}\bar{1}3\rangle$ and $\{2\bar{1}\bar{1}2\}\langle\bar{2}113\rangle$ systems. The density of formed pyramidal dislocations, N_p, was about $2\cdot10^{10}$ m^{-2}. Then, two 0.8 mm wide and 4.5 mm long slits oriented along $[2\bar{1}\bar{1}0]$ were cut in each sample. The shape and crystallographic orientation of a sample prepared in this manner are shown in Fig. 1. The initial (growth) density of basal dislocations, N_b, as determined by the $(01\bar{1}0)$ plane etching, did not exceed $8\cdot10^9$ m^{-2}, that of pyramidal ones, N_p, as determined by the (0001) plane etching, $6\cdot10^7$ m^{-2}. The etching of $(01\bar{1}0)$ plane provides information on the total density, N, of basal and pyramidal dislocations. This