Selfinduced change of deformation path in Cu-Al single crystals
A. Korbel, M. Szczerba

To cite this version:
Mechanisms governing the mechanical performance of Cu-Al single crystals in tensile at room temperature along <112> direction were studied. Three independent sources of information: tensile characteristics (Fig.1), slip markings on (110) and (111) crystal faces and components of macroscopic deformation tensor provided self consistent data enabling to analyse the bulk features of the crystals in terms of microstructural slip events. The data from Cu-9at.% Al crystals will be used to demonstrate what appears to be a general behaviour of Cu-Al alloys of solid solution structure while tested along <112> direction. A very typical feature especially for concentrated alloys, is presence of four distinct linear stages on tensile characteristic of successively reduced strain hardening rates. The initial hardening caused by simultaneous action of two (symmetrical) primary systems (second stage of deformation) is broken down by entry of cross slip systems and falls to about 50% of its initial value. The transient between the second and third stage is characteristic of unstable flow and manifested by a propagation of deformation band along the sample. The strain rate sensitivity drops down dramatically to low but positive value and after nonhomogeneous transient it follows a negative slope to the end of the third stage. Activation of the critical system appeared to be typical for the very large (about 80% of elongation) transient between the third and fourth stage. In Cu-9at.% Al crystals discontinuous modes of band propagation was observed and deformation showed then typical features of Portevin-Le Chatelier Effect. Nonhomogeneous deformation, although initiated by cross or critical slip systems always utilized alternatively one of primary systems (coarse slip banding). Because of the orientation factor the entry of cross slip (first transient) or critical slip (second transient) systems can be explained only in terms of internal stress argument (self-induced change of deformation path, 1-3). The fact that entry of critical slip promotes avalanche like glide in one of primary system, associated with a very low hardening rate, suggests the mechanism of structural softening. The model is based upon the assumption that replacement of L-C barriers can provide a very efficient relaxation mechanism. The reaction may proceed as follow:

- Primary slip dislocation
  \[ \frac{a}{\sqrt{2}} [101] \rightarrow \frac{a}{\sqrt{2}} [211] + \frac{a}{\sqrt{2}} [\overline{1}12] \text{ or} \]
  \[ \text{CA} \rightarrow \text{CP} + \text{PA} \text{ on (111) plane,} \]
  conjugate slip dislocation

- Conjugate slip dislocation
  \[ \frac{a}{\sqrt{3}} [011] \rightarrow \frac{a}{\sqrt{3}} [121] + \frac{a}{\sqrt{3}} [\overline{1}12] \text{ or} \]
  \[ \text{AB} \rightarrow \text{AX} + \text{YB} \text{ on (\overline{1}11) plane,} \]
  Lomer-Cottrell reaction

- Critical slip dislocation
  \[ \frac{a}{\sqrt{2}} [101] \rightarrow \frac{a}{\sqrt{2}} [112] + \frac{a}{\sqrt{2}} [21] \text{ or} \]
  \[ \text{BD} \rightarrow \text{BX} + \text{YD} \text{ on (111) plane,} \]
  attractive junction forms

- Shockley partial
  \[ \frac{a}{\sqrt{2}} [\overline{1}12] \rightarrow \frac{a}{\sqrt{2}} [121] \text{ or} \]
  \[ \text{BX} + \text{YB} \rightarrow \text{anihilation of Shockley partial.} \]

- Energy release:
  \[ \Delta E = 2E \gamma \text{ at } a. \]

Suggested mechanisms

The first transient and third stage of deformation - relaxation of internal stresses by cross slip. The second transient and fourth stage of deformation - interaction between primary- and conjugate-critical slip system dislocations (replacement of Lomer-Cottrell locks by glissible Shockley partial).

References