Title: Study of cooperative dislocation phenomena in solids by the acoustic emission technique

Author: Michal KNAPEK

Department: Department of Physics of Materials

Supervisor: doc. RNDr. František Chmelík, CSc., Department of Physics of Materials

Abstract: Plastic deformation of micron-scale crystalline materials differs considerably from bulk specimens, as it is characterized by random strain bursts. Three categories of metallic samples were investigated in this thesis: micron-scale copper micropillars with varied geometries, submillimeter-scale aluminum microwires, and aluminum and aluminum-magnesium salt-replicated foams. Very precise fabrication methods and sensitive measurement set-ups consisting of uniaxial compression and tensile tests with concurrent acoustic emission (AE) recording were developed. These fine methods allowed for investigations of effects related to plastic deformation at micrometer scales, i.e. the dislocation dynamics associated with the stress drops. Size effects in plastic deformation, as well as clear correlations between the stress drops and the AE events, were found in microsamples, confirming that dislocation avalanches are indeed responsible for the stochastic character of deformation processes also at microscales. Open-cell pure aluminum and aluminum-magnesium foams produced by salt replication with cells between 25 and 400 µm in average diameter and relative densities between 25 and 45 % were also tested as one of the very few materials where, thanks to its structure, the abovementioned effects are manifest also in a bulk form. Size effect in the mechanical properties was evidenced in pure aluminum foams. Moreover, the Portevin-Le Châtelier (PLC) effect was found in the aluminum-magnesium foams. To account for the deformation behavior and the occurrence of PLC effect within such complicated structures, the AE signals accompanying the compression of tested samples were further evaluated using advanced frequency analysis and statistical methods.

Keywords: microsamples; size effect; metal foams; plastic deformation; acoustic emission