Aluminium alloys belong to the most widely used metallic materials in many industrial applications. Final properties of the alloy are highly dependant on the thermo-mechanical treatment during manufacturing and the resulting microstructure. Thus detailed knowledge of the microstructure evolution during processing is required for tailoring the final product.

Aluminium alloy from AA3003 series with main alloying elements Mn, Fe and Si was prepared by twin-roll casting in industrial conditions. This material was further subjected to severe plastic deformation by equal channel angular pressing (ECAP). During ECAP the billet is pressed through two channels of equal cross-section, which intersect at an angle of 90°. The equivalent strain imposed to the material after one pass is ε~1. Such deformation leads to fragmentation of the grains and ultimately to formation of ultra-fine grained structure [1].

The objective of the present work was to evaluate the role of ECAP on the precipitation kinetics during isochronal annealing. Three materials were compared – as-cast material, material after one ECAP pass and material after four ECAP passes. Measurements of relative electrical resistivity changes were combined with in-situ heating in transmission electron microscope JEOL 200FX working at 200 kV. The in-situ observation enabled detailed study of the precipitates evolution during the whole temperature range.

At lower annealing temperatures the recovery of dislocation substructure took place. During annealing up to 300 °C the first precipitates of α-AlMnFeSi phase [2] started to form. Their size increased with further annealing but above 450 °C the smaller ones dissolved back to the solid solution. The precipitation started first in the material after four ECAP passes, last in the as-cast material, which was not subjected to deformation. It is known that in this type of alloy the precipitates form preferentially on grain boundaries [3]. As the number of the grain boundaries increases with the imposed deformation, the precipitation was facilitated in the materials subjected to ECAP.


Acknowledgement: The authors gratefully acknowledge the financial supports of grants GAUK 1428213, GACR P107-12-0921 and SVV-2014-269303.
Fig. 1: The evolution of electrical resistivity during isochronal annealing (derivation of relative changes). The peaks in positive values correspond to precipitation, the negative ones correlate with particles dissolution. "Init" denotes material after twin-roll casting, "1P" and "4P" materials after one and four passes in ECAP, respectively.

Fig. 2: Micrographs from in-situ TEM heating with a rate 50 °C/50 min. The evolution of microstructure of the alloy after four ECAP passes - recovery of dislocation substructure, grain growth, precipitation of α-AlMnFeSi phase and its dissolution back to solid solution.