Nanoobjects microscopy

Comparative analysis of formation and decomposition processes of Al-TM supersaturated solid solutions obtained by rapid solidification and by severe plastic deformation

A.L. Berezina[1], O.A. Molebnyi[1], T.O. Monastyrska[1], O.A. Davydenko[2]

[1]G.V. Kurdyumov Institute for Metal Physics, Natl. Acad. of Sci. of Ukraine, 36 Vernadsky Blvd., Kyiv-142, 03680, Ukraine.
E-mail: moleb.74@gmail.com

[2]O.O.Galkin Donetsk Institute for Physics and Engineering, Natl. Acad. of Sci. of Ukraine, 46 Prospect Nauky, Kyiv, 03028, Ukraine.

The degree of supersaturation and the kinetics of decomposition of aluminium alloys containing only slightly soluble transition metals (TM) Al0,3%Sc, Al0,6%Sc, Al0,6%Sc(0,1-0,3)%Ti, Al0,6%Sc(0,1-0,6)%Ta has been studied. The transition metals have been chosen to have different diffusive mobility from $10^{-17}m^2s^{-1}$ to $10^{-22}m^2s^{-1}$ and different solubility in the solid aluminum. Supersaturation was achieved by three methods: a) quenching from a homogeneous solid solution after homogenization; b) quenching from the melt at a cooling rate of 10^6 deg/s; c) using the technique of severe plastic deformation (SPD). A combined method of conventional hydroextrusion (HE) and equal-channel angular hydroextrusion (ECAH) was used as the SPD technique. The HE and the ECAH techniques were carried out according a scheme “a billet after a billet”. During the ECAH the sample was turning around the longitudinal axis by 90° before the following deformation (route B_c). The ECAH was implemented through the matrix crossing the channel section at Φ=90°. The value of the accumulated equivalent deformation after 5 cycles of ECAH was e5.8. Deformation was realized at room temperature under the pressure from 677 to 526 MPa for the ECAH to reduce the influence of the thermally activated ascending diffusion.

The kinetics and the morphology of the decomposition were analyzed using durometric, resistometric, electron-microscopy and X-ray methods.

The supersaturated solid solutions are shown to form in all alloys after both melt-spinning and SPD. As that, after melt-spinning process the grain size of the alloys is 1-5 μm that is an order of manitude smaller than the ordinary casting technology. SPD technique leads to the grain size decreases up to ~0.5 μm. A study of the kinetics of decomposition showed an acceleration of coalescence at SPD, both inside the grain and on the grain boundaries. The grain size reduction is the main cause of hardening. It was obtained that Ti and Ta do not slow down the coalescence.