Precession electron diffraction, high-resolution microscopy and atom probe analysis of nano-size precipitates in Al-Zn-Mg industrial alloys

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Transmission electron microscopy is an excellent tool for characterization of the semi-coherent, metastable hardening precipitates embedded in aluminum alloys. However, structure solution by conventional electron diffraction is complicated, by double scattering via matrix reflections. This is overcome by the precession technique [1]. Composition is analyzed by the atom probe (APFIM) technique. The semi-coherent, disk-shaped ca 3x5nm-size η′-precipitate on the $\{111\}_{Al}$ planes, which determines the strength of Al-Zn-Mg alloys is an intermediate stage in a decomposition sequence: super-saturated solid solution → GP-zones → η′ → η-$MgZn_2$ (stable). The η′- lattice is hexagonal: $c_{\eta'} = 2[111]_{Al} = 1.402$nm, $a_{\eta'} = (1/2)[211]_{Al} = 0.496$nm. High-resolution images revealed that structure proposed earlier from X-ray photographs [2] could not be retained; a model based on a structural unit similar to the stable Laves phase $MgZn_2$ was proposed instead. The composition of the unit cell $Mg_4Zn_{10-x}Al_{4+x}$ was chosen, which is close to the atom-probe result with x ~3-4. Electron diffraction intensity data were collected by the precession technique, on film and imaging plates. Three-dimensional data sets obtained by merging 5 or 7 projections recorded on film or imaging plates covered 85% of allowed reflections inside 1Å. From systematic absences the space group P-6c2 (190) was assigned. Patterson and Fourier analysis confirmed basic features of the HRTEM model. Refinement results will be presented; the relation to other structures along the transformation path will be discussed.

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