Co-precipitation in a Si-containing 7xxx type Aluminium alloy

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Age-hardenable Al-Mg-Zn alloys are of great interest in automotive and aerospace structural products, particularly due to their high strength/weight ratio. The strength is mainly attributed to formation of the η' phase as platelets on the $\{111\}_{Al}$ planes, during artificial aging. In the present work, a 7003 alloy containing Zn-Mg-Si-Cu (5.56-0.68-0.11-0.01 wt%) is studied using scanning transmission electron microscopy (STEM). The alloy was extruded, homogenized and water quenched before artificial aging to the T79 condition. In the T6 condition the alloy is susceptible to stress-corrosion cracking (SCC), while overaging reduces the susceptibility significantly. The purpose of the study is to find the microstructural differences causing this effect.

Figure 1 shows STEM images of the different phases. The main hardening phase η' with habit plane $\{111\}_{Al}$ along the $<112>_{Al}$ direction was found in agreement with previous work [1], see figure 1b). Other precipitates with ~$MgZn_2$ composition could be determined from energy dispersive x-ray spectroscopy (EDS). These were found to be the η_1-phase with habit plane $\{100\}_{Al,}$ and the atomic structure was resolved when observing along the $<110>_{Al}$ direction [2,3]. This phase is structurally identical to the equilibrium $MgZn_2$ phase and appears as two "different" structures, since both the [0001] and [-12-10] directions are parallel to the $<110>_{Al}$, as shown in figure 1c). Combining STEM images with density functional theory (DFT) calculations, the structure of the interface between the precipitate and the aluminium matrix could be determined.

EDS mapping found clusters of Mg-Si when viewed along a $<100>_{Al}$ direction and high resolution STEM reveled these as hardening hybrid-phases similar to those belonging to the 6xxx alloy series [4]. These were observed as free-standing precipitates in the bulk, as in figure 1d), but also nucleated onto η-type precipitates and other heterogonous sites. These phases were not found in the T6 condition, and we believe this to be relevant to the SCC properties, as the electrochemical properties will be changed when solutes are locked into precipitates rather than in solid solution. Furthermore, this finding is relevant to any Si containing 7xxx alloy, as this phase should be included in models in order to predict correct mechanical and functional properties.

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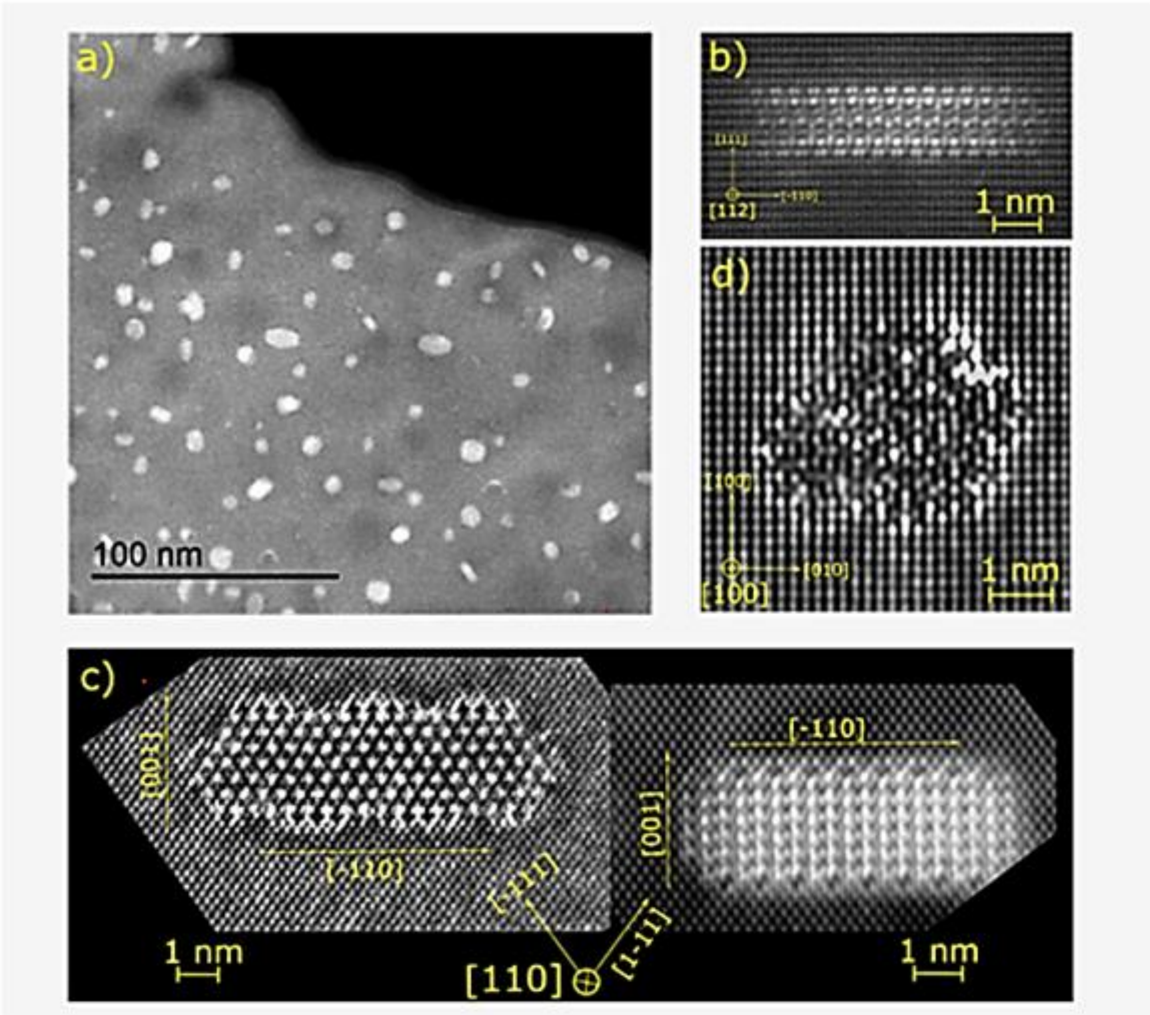

Figure 1: High Angle Annular Dark Field (HAADF) images of precipitates in a 7003 alloy. a) Overview STEM image showing the general microstructure along a <100> Al direction. b) The conventional η' hardening precipitate observed along a <112> Al direction. c) η_1 precipitate observed in a <110> Al direction showing structure of the phase 90° to one another and d) MgSi-type precipitate observed in a <100> Al direction.