Age-hardenable aluminium alloys like Al-Mg-Si-Cu, Al-Mg-Zn and Al-Cu are important structural materials for construction and automotive applications due to properties like high strength/weight ratio and good formability, often combined with good corrosion resistance. One overall objective in our research is to improve the understanding of the fundamental physics taking place at the atomic scale in these alloys – which decides nucleation, phase stabilization and precipitation [1]. The size, density and crystal structure of the hardening precipitates are given by the alloy composition and the thermo-mechanical history of the material and will to a large extent decide the material’s properties. In Al-Mg-Si alloys the main hardening precipitates are $\beta''$ needles [2]. In Mg-richer alloys with small additions of Cu, the $\beta''$-phase is often replaced by fine lath-shaped, Cu-containing $L$-phase precipitates. The $L$-phase structure is disordered, often containing sub-units of the periodic Q' and C phases, ordered on an inherently projected hexagonal Si-network [1], which aligns with (100)Al. All the precipitate structures in the Al-Mg-Si system are based on this network. $L$ has high coherence, less strain and strong bonding with the Al matrix and therefore shows a larger resistance toward dissolution and growth [3]. The high thermal stability is supported by in-situ TEM experiments, which indicate that all $L$-phase precipitates form at an early stage and remain after long thermal exposure [4]. In addition to being promoted by increased Cu levels, the formation of $L$-phase precipitates is triggered by increased Mg/Si ratios, likely due to a stabilising effect of Cu enriched interfaces [5]. Due to its disordered nature, the composition of the $L$-phase is varying. An average composition can be estimated by determining the atomic species in each atomic column from aberration-corrected high-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM) images. For heavily deformed alloys, the $L$-phase nucleates both as discrete precipitates on dislocation lines and homogeneously in the undistorted regions of the Al matrix [6]. The incorporation of Cu in precipitates may also make the alloy less prone to intergranular corrosion [7].

This presentation will demonstrate how HAADF-STEM can be used to study precipitate phases like $L$ in aluminium alloys. In combination with the scanning precession electron diffraction (SPED) technique utilizing effective machine learning approaches and digital post-processing [5,6] this is a very useful methodology to get comprehensive information about precipitate morphology and phase compositions, as well as crystallite orientations, also in deformed materials.


This work is supported by the Research Council of Norway and Norwegian light metal industry through several projects and the NORTEM infrastructure at the TEM Gemini Centre in Trondheim (NFR 197405).