Characterization of precipitates in Mg alloy QE22 using advanced imaging, diffraction and spectroscopy techniques of electron microscopy

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As the lightest structural metal, magnesium and its alloys have received considerable attention in the past two decades. Age hardening is an important strengthening method for many Mg alloys and an in-depth understanding of the structure, composition, morphology and distribution of precipitates is required for any further improvement in the age hardening response of existing Mg alloys. QE22 (Mg-2Nd-2.5Ag-0.7Zr, wt.%) is an age hardenable commercial Mg alloy which exhibits superior tensile properties and creep resistance over many other Mg alloys. However, the precipitate phases related to its ageing process have not been clearly established, although two metastable phases and an equilibrium phase have been reported [1]. For the metastable phases, their exact atomic structures still remain unclear. For the equilibrium phase, there has been controversy views on whether it has a complex hexagonal structure [2] or a tetragonal structure [3]. In this work, the precipitate phases formed during isothermal ageing at 300°C were characterized using selected area electron diffraction (SAED), convergent-beam electron diffraction (CBED), high-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM) and atomic-resolution energy-dispersive X-ray spectroscopy (EDS) mapping in an aberration-corrected STEM. The atomic structures of the metastable phases and the equilibrium phase established from these combined imaging and diffraction techniques, also verified by HAADF-STEM image simulation, will be presented in this talk. The transformation mechanism between them will also be discussed.

References:

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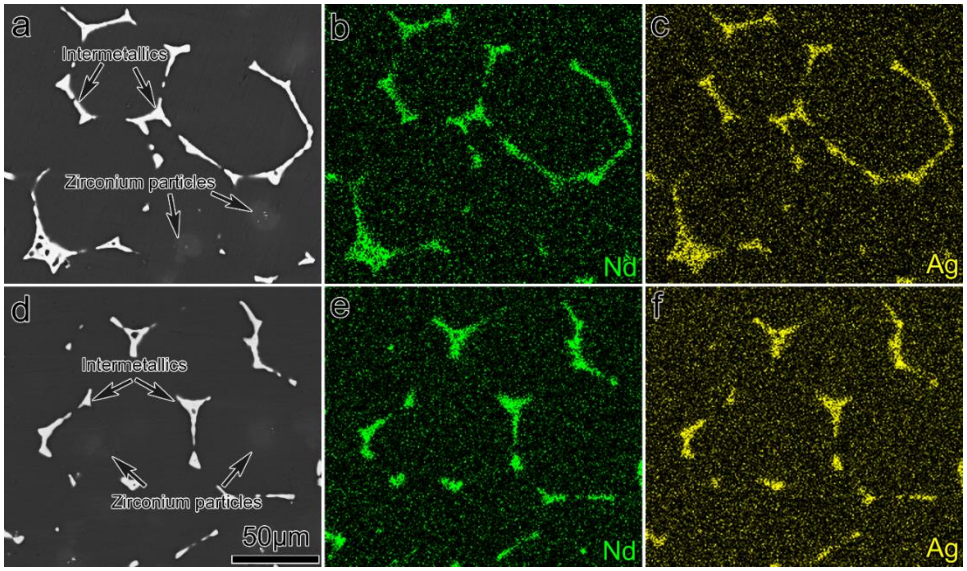

Figure 1. BSE images showing equilibrium intermetallic phase in (a) as-cast, and (b) solution treated samples. (c-f) SEM-EDS mapping analysis of the equilibrium intermetallic phase: (b, e) Nd maps, (c, f) Ag maps.

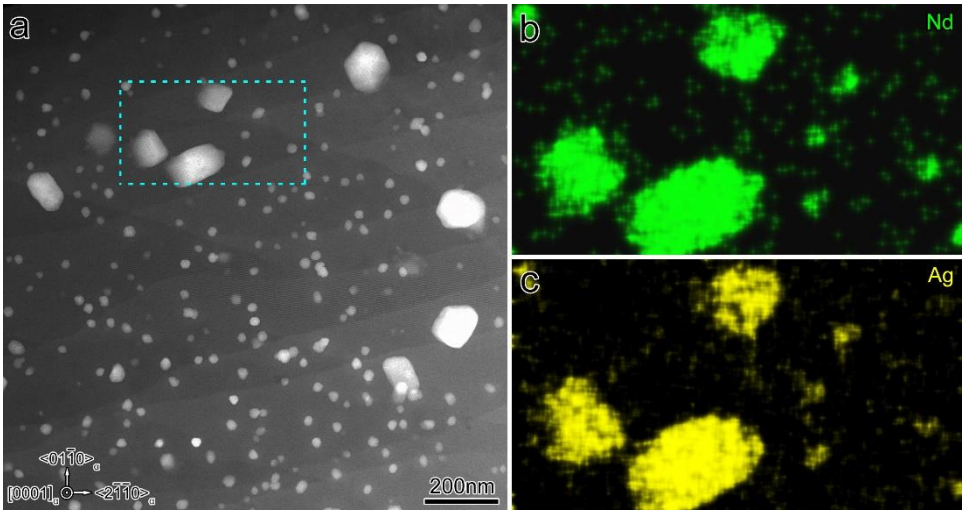

Figure 2. (a) HAADF-STEM image showing the equilibrium precipitate phase and (b, c) STEM-EDS maps of the equilibrium phase particles outlined in the blue frame in (a): (b) Nd map, (c) Ag map.