

## Aging precipitation sequence of Mg-Y-Sc alloy by HRTEM

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Magnesium (Mg) has been widely used as structural materials, for example, frame of electrical devices, parts of automobile, due to its light weight. Several reports are available about addition of rare-earth element (RE) on Mg, and Mg alloys show precipitation hardening by aging treatment of super saturated solid solutions (S.S.S.S.). Lorimer et. al. reported the precipitation sequence in Mg-Y alloys aged at 473K as S.S.S.S.  $\rightarrow \beta''$  (D019)  $\rightarrow \beta'$ (cbco)  $\rightarrow \beta$ (Fm $\bar{3}$ m). Scandium (Sc) addition on Mg alloy is known that it enhances a heat resistance. In this study, 3 kinds of Mg alloys (Mg-Y, Mg-Y-Sc alloys) containing the same total amount of solute elements, have been investigated to clarify the effect of the Sc on age-hardening and precipitation using High Resolution Transmission Electron Microscopy (HRTEM), Selected Area Electron Diffraction (SAED) technique and HRTEM simulation.

Mg-3.6at.%Y and Mg-3.5at.%Y-0.9at.%Sc used in this study were prepared by casting using 99.9% Mg ingot, Y and Sc chips. The obtained alloy was homogenized at 773K for 43.2ks and then hot rolled at 773K. The rolled sample were subjected to solution heat-treated at 773K for 3.6ks in an argon gas atmosphere. After that quenched in water at 293K, and aged in a silicone oil bath at 473K. TEM samples were thinned by the twin-jet electro polishing technique using an electrolyte of 10% perchloric acid-ethanol solution at 253K. For HRTEM observation, TOPCON EM-002B operated at 120kV. HRTEM simulation images were calculated using the multi-slice method. Simulation images are obtained for each defocus and TEM sample thickness. The model used for the HRTEM simulation using a rectangular cell of 1.92nm x 2.22nm x 0.52nm including 96 atoms based on the hcp structure of Mg by MacTempasX. HRTEM images and HRTEM simulation images contrast were measured using Gatan Digital Micrograph software.

In HRTEM observation, zig-zag structure and pre- $\beta''$  were observed. Also, both precipitates were confirmed in SAED pattern as diffuse spot in the early stage of aging. In peak-aged and over-aged conditions,  $\beta'$  phase was observed. It is considered that beta prime formed from zig-zag structure and pre- $\beta''$ . In this study, the variation of the lattice constant of the b-axis in over-aged Mg-Y-Sc alloy was confirmed by SAED pattern and HRTEM analysis. First principle calculation was conducted using DV-Xa method to understand the bonding energies between Mg and alloying elements. Further analysis was carried out by multi-slice method and line profile.