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3DAP/TEM Study of Precipitation Hardened Magnesium Alloys

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Recent intense interest in developing lighter wrought alloys revived researches on precipitation hardenable magnesium alloys. Since the age-hardening responses of magnesium alloys without rare earth elements are poor, precipitation hardening has not been used in conventional wrought magnesium alloys. However, optimizations of alloy compositions often lead to the formation of metastable nano-sized precipitates during artificial aging, which substantially enhances the yield strength. In order to understand the mechanism of age-hardening behaviors of recently developed magnesium alloys, the demand for analyzing solute clusters and nano-scale precipitates in magnesium alloys is increasing. Since three-dimensional atom probe (3DAP) can visualize solute clustering processes, it is the ideal tool to investigate the pre-precipitation stages of age-hardening magnesium alloys to complement transmission electron microscopy.

3DAP analysis of magnesium alloy has been difficult because of low yield strength that causes frequent specimen rupture under a high electric field and low evaporation field. However, the use of UV-laser to assist field evaporation reduces the chance of specimen rupture, enabling reliable dataset acquisitions from magnesium alloys.

In this presentation, we show examples of the applications of UV laser assisted 3DAP to various precipitation hardenable magnesium alloys that have been carried out to understand the effect of trace elements on age hardening. Mg-5.4Sn-4.3Zn-2.0Al-0.1Na (wt%) alloy exhibits significant enhancement of age hardening from 50 to 100 VHN upon aging at 160 ^{o}C. This is because Sn-Na clusters form in the early stage of aging (Fig. 1), which provide heterogeneous nucleation sites for refining Mg_2Sn precipitates (Fig. 2). While the Na-microalloyed extruded Mg-Sn alloy exhibited the high strength of ~ 350 MPa, Na leads to a significant embrittlement. To eliminate Na, we have substituted the Sn-Na co-clusters with the Zn-enriched ones by adding more Zn. The developed Mg-5.4Sn-5.8Zn-2.0Al-0.1Mn alloy exhibited the high strength over 370 MPa with large ductility of ~14% [1]. The role of alloying elements on the age hardening behavior and microstructure evolution in Mg-Zn and Mg-Ca based alloys will also be discussed [2-4].

References:

[1] T. T. Sasaki *et al*, Acta Mateialia, **99** (2015), p. 176.
[2] T. Bhattacharjee *et al*, Scripta Materialia, **99** (2012), p. 967.
[3] C.L. Mendis *et al*, Acta Mateialia, **57** (2009), p. 5593.
[4] T. Nakata *et al*, Scripta Materialia, **101** (2015), p. 28

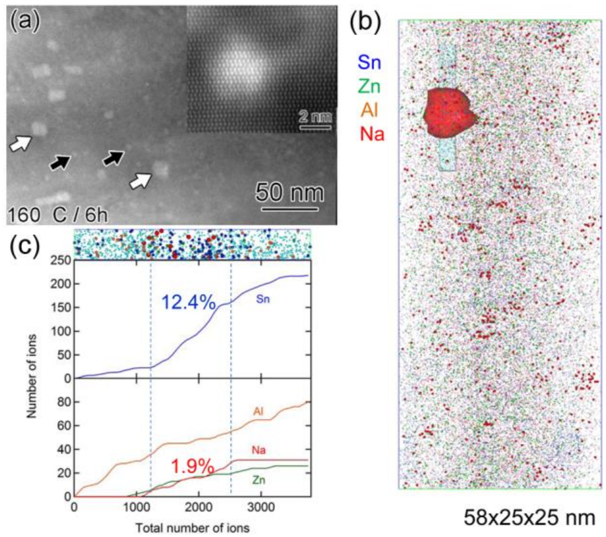

Figure 1. (a) HAADF-STEM image and (b) 3D atom map obtained from the Mg-5.4Sn-4.3Zn-2.0Al-0.1Na (wt%) alloy aged at 160°C for 6h. (c) is the ladder diagram analyzed from the volume (blue) in (b) [1].

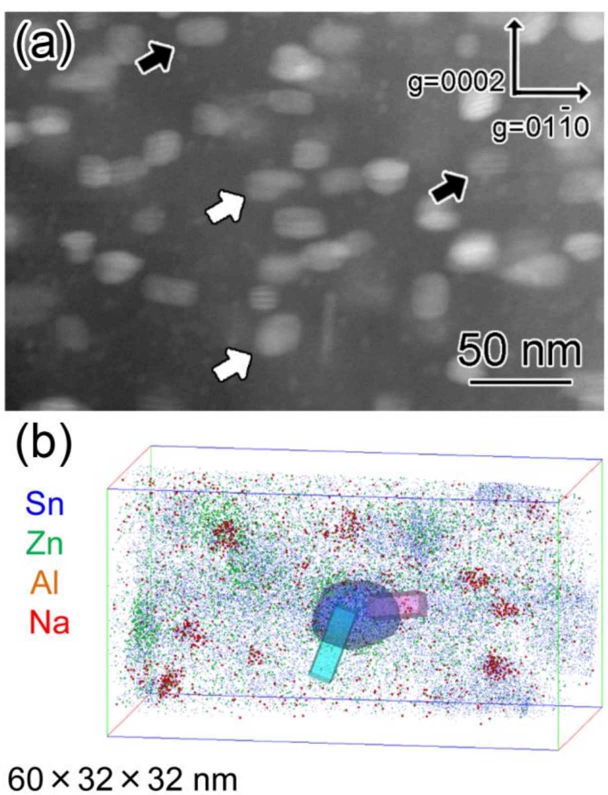

Figure 2. (a) HAADF-STEM image and (b) 3D atom map obtained from the Mg-5.4Sn-4.3Zn-2.0Al-0.1Na (wt%) alloy aged at 160°C for 16h showing heterogeneous nucleation of precipitates at Sn-Na co-clusters [1].

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