（ ※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。 ）

MLF Experimental Report

提出日 Date of Report	
課題番号 Project No. 2012B0100	装置責任者 Name of responsible person Kazuya AIZAWA and Stefanus HARJO
実験課題名 Title of experiment In-situ Neutron Diffraction Study on Deformation Behavior of Mg Alloy with Long-Period Stacking Ordered Phase	装置名 Name of Instrument/(BL No.) TAKUMI (BL 19)
実験責任者名 Name of principal investigator Satoshi MOROOKA	実施日 Date of Experiment Dec. 15 2013 – Dec. 17 2013
所属 Affiliation Yokohama National University	

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）

Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

Master ingots with a composition of $Mg_{97}Zn_1Y_2$ (at%) and $Mg_{89}Zn_4Y_7$ (at%) were prepared by induction melting. And then, the as-cast ingots were extruded at 350 and 450 degree C at a reduction rate of 10:1 in air at ram speed of 2.5mm/s, which were named as Mg12E and Mg47E, respectively [1]. The obtained Microstructure is αMg (hcp) + LPSO two-phase structure for all. The volume fraction of LPSO phase was 25 pct. and 85 pct., respectively which was determined by a point counting method. The scattering density of αMg phase is 6.98E+10 (cm^-2) and 7.14E+10 (cm^-2) for the extruding type of Mg12E and Mg47E alloys, respectively.

[1] K. Hagihara et al.; Intermetallics, 18(2010), 1079.

2. 実験方法及び結果 （実験がうまくいかなかった場合、その理由を記述してください。）

Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

【Experimental method】The *in-situ* TOF neutron diffraction during tensile loading was performed by using TAKUMI (BL19). The bar type tensile test specimens for *in-situ* experiments with a gouge length of 15 mm, diameter of Φ5 mm were machined from the extruded Mg alloy. TAKUMI is equipped with 50kN tension tester mounted on the diffractometer, with its loading axis turned 45 degrees with respect to the incident beam. There are two detector banks, which measure time-resolved diffraction patterns at fixed horizontal scattering angles of ±90 degrees. The two detector banks thus measure diffraction patterns from grains oriented in axial and transverse geometry with respect to the applied stress.

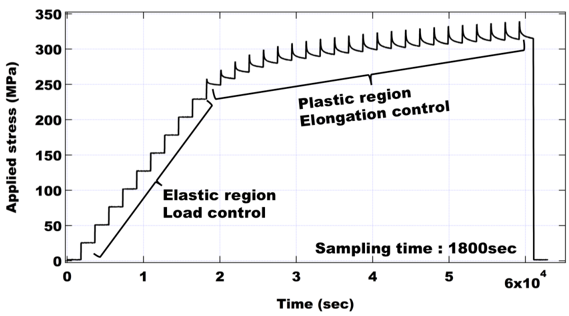

Fig. 1 Time schedule of tensile test for Mg12E.

2. 実験方法及び結果(つづき) Experimental method and results (continued)

The sampling volume for neutron diffraction is wide range at the parallel position of the tensile specimen, so that bulky averaged information is obtained. The *in-situ* diffraction experiments during tensile testing were conducted using load control (elastic region) and elongation control (plastic region), with counting times of approximately 1800 sec (Fig. 1).

【Experimental result】

Figure 2 shows a lattice strain determined from peak shifts of {10−10} $_{Mg}$, {0002} $_{Mg}$, {10−11} $_{Mg}$, {11−22} $_{Mg}$, {4−2−25} $_{LPSO}$ and {4−2−28} $_{LPSO}$ reflection peaks as a function of the applied stress for Mg12E alloy. As is observed in Fig. 2, the lattice strains of them in the axial direction increase linearly with increasing of the applied stress in the beginning of deformation indicating elastic regime. From the diffraction slopes, it is found so called the diffraction young's modulus E_{hkl} for [10−10] $_{Mg}$, [10−11] $_{Mg}$, [11−22] $_{Mg}$ and [4−2−25] $_{LPSO}$ are slightly larger than that for [0002] $_{Mg}$ and [4−2−28] $_{LPSO}$. The obtained values of E_{10-10}, E_{0002}, E_{10-11}, E_{11-22}, E_{4-2-25} and E_{4-2-28} are approximately 46GPa, 51GPa, 47GPa, 47GPa, 48GPa and 51GPa, respectively. Therefore, this means that influence of elastic anisotropy is very small. After yielding (= Macro yielding), in case of the Mg matrix, {10−10} $_{Mg}$ lattice strain increase while {0002} $_{Mg}$, {10−11} $_{Mg}$ and {11−22} $_{Mg}$ decrease with increasing of the applied stress. This implies that the {0002} $_{Mg}$, {10−11} $_{Mg}$ and {11−22} $_{Mg}$ family grains are plastically softer than {10−10} $_{Mg}$ grains, resulting in stress partitioning that is called intergranular stresses. This result was suggested that {0002} $_{Mg}$, {10−11} $_{Mg}$ and {11−22} $_{Mg}$ family grains were occurred the stress relaxation by basal slip, shear deformation and twinning deformation. In case of the LPSO phase, [4−2−25] $_{LPSO}$ and [4−2−28] $_{LPSO}$ lattice strain increase with increasing of the applied stress. This means that LPSO family grains continue the elastic deformation in spite of Mg matrix yielding. After then, this implies that the [4−2−25] $_{LPSO}$ family grains are plastically softer than [4−2−28] $_{LPSO}$ grains, resulting in stress partitioning. Hence, Mg12E alloy was able to estimate that Mg matrix and LPSO phase deformed to the separation due to the dual-phase alloy.

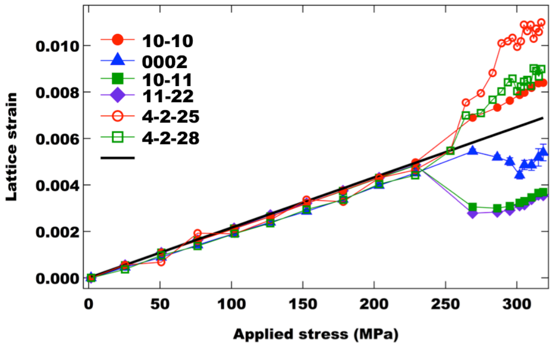

Fig. 2 Change in lattice strain during tensile deformation of the Mg12E alloy in the axial direction.

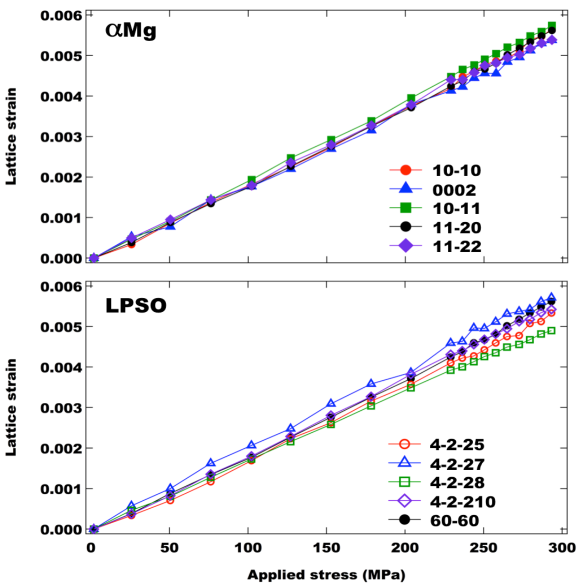

Fig. 3 Change in lattice strain during tensile deformation of the Mg47E alloy in the axial direction.

Figure 3 shows a lattice strain determined from peak shifts of {10−10} $_{Mg}$, {0002} $_{Mg}$, {10−11} $_{Mg}$, {11−22} $_{Mg}$, {4−2−25} $_{LPSO}$, {4−2−27} $_{LPSO}$, {4−2−28} $_{LPSO}$ and {4−2−210} $_{LPSO}$ reflection peaks as a function of the applied stress for Mg47E alloy. As is observed in Fig. 3, the lattice strains of them in the axial direction increase linearly with increasing of the applied stress as well as Fig. 2. The obtained values of E_{10-10}, E_{0002}, E_{10-11}, E_{11-22}, E_{4-2-25}, E_{4-2-27}, E_{4-2-28} and $E_{4-2-210}$ are approximately 53GPa, 54GPa, 51GPa, 54GPa, 54MPa, 50MPa, 58MPa and 53GPa, respectively. Therefore, the influence of elastic anisotropy of Mg matrix is smaller than that of LPSO phase. And then, these values of Mg47E are larger than those of Mg12E. Because, it can be estimated that the atom bonding of Mg47E alloy was strengthening by concentration of Zn and Y.