実験報告書様式（一般利用課題・成果公開利用）

（ ※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. 2014A0094 実験課題名 Title of experiment In-situ Neutron Diffraction Study on Tensile-Compression Deformation Behavior of 18R-LPSO Mg alloy 実験責任者名 Name of principal investigator Satoshi MOROOKA 所属 Affiliation Tokyo Metropolitan University	装置責任者 Name of responsible person Kazya AIZAWA and Stefanus HARJO 装置名 Name of Instrument/（BL No.） TAKUMI (BL 19) 実施日 Date of Experiment May/18/2014-May/21/2014

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.

The nominal composition of the Mg–Zn–RE alloy used in the present study is $Mg_{85}Zn_6Y_9$ (at.%). Master alloy ingot was prepared either by high frequency induction melting of pure metals in an argon atmosphere or by furnace melting of pure metals in a steel tube under a CO_2 atmosphere, followed by casting into a water-cooled copper mold. The obtained microstructure is almost 18R-Long Period Stacking Order (LPSO) phase structure and a few casting defect.

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 tension-compression cyclic loading was performed at room temperature by using TAKUMI (BL19). The bar type testing specimens for *in-situ* experiments with a gauge length of 6 mm, diameter of Φ5 mm were machined from the Mg casting alloy. TAKUMI is equipped with tension-compression 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. The sampling volume for neutron diffraction is wide range at the parallel position of the tensile specimen, so that bulky averaged information is obtained. An event mode of data acquisition system employed at MLF enable us to analyze the obtained data by changing data slicing time interval after testing. Taking statistic sufficiency into consideration, the time interval can be decreased with increasing of neutron beam intensity.

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

At room temperature, cyclic testing was performed using high-precision extensometer under fully-reversed cyclic loading conditions at constant maximum and minimum strain amplitudes of +0.5 % and -0.5 %. The cyclic strain increasing rate was 2 × 10^{-4} %/sec. The initial loading was tensile. Cyclic data were collected at N= 1, 2, 3, 4, 5, 10, 30, 50, 75, 100, 150, 175 cycles. During the tension-compression cycles above, four points along the hysteresis loop were studied, as shown in Fig. 1. These points coincide with the maximum tensile (Pts 1 and 5) and the maximum compressive strain (Pt 3), the two zero-stress points (Pts 2 and 4). The applied stress at the maximum tension (Pt 5) and the maximum compression (Pt 3) as a function of number of cycles (Fig. 2) demonstrate almost the hardening region of tension-compression cycles. The failure-life time of this alloy was 218 cycles.

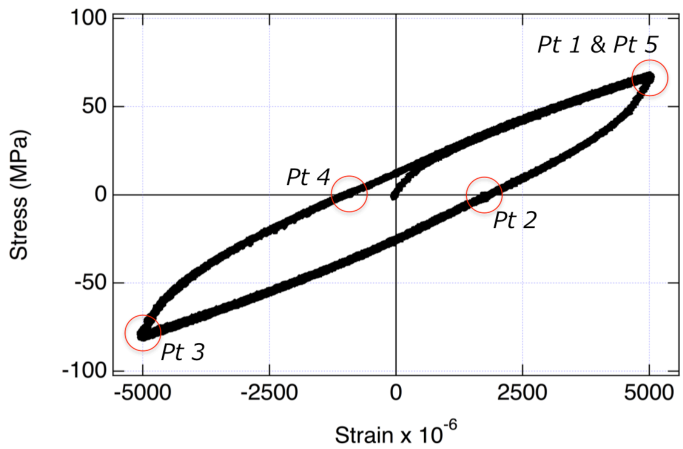

Fig. 1 The stress-strain curves of the initial tensile loading and the four measurement points within the first tension-compression cycle. Pts 2 and 4 are at 0 MPa; Pt 3 is at -0.5 %; Pts 1 and 5 are at +0.5 % strain, respectively.

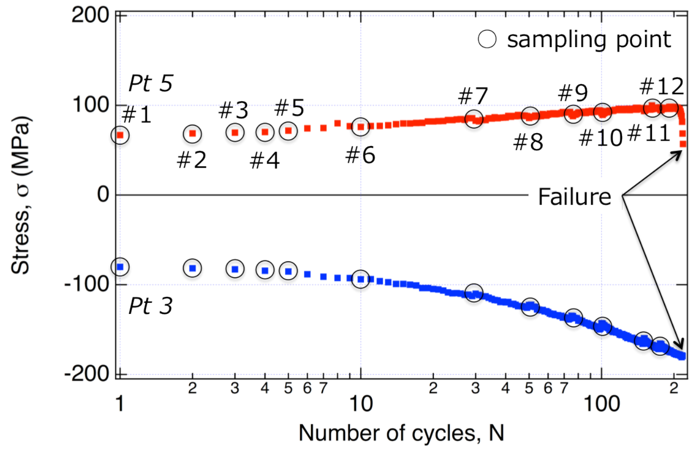

Fig. 2 The stress evolution at the maximum tension (Pt 5) and compression (Pt 3) as a function of number of cycles.

【Experimental result】

The tension-compression regime with strain amplitude control is considered in this work. Fig.1 illustrates a stress-strain loop under strain-controlled cycling. During initial loading, yielding is observed in the stress-

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

strain curve before the 1st-tension-compression cycle (Fig. 1).On unloading, plastic strain is seen at 0 MPa (Pt 2). The compression to a -0.5 % strain (Pt 3) shows a nonlinear stress-strain response. In reloading in tension through 0 MPa (Pt 4) and +0.5 % strain (Pt5), the hysteresis loop develops. Fig. 2 shows an increase of peak stresses in both tension and compression with increasing number of cycles resulting in cyclic hardening up to the 200th cycle. At the 200th tension-compression cycle, tension and compression peak stresses are approximately +97.4 and –176.7 MPa, respectively. The both peak stresses are different. Because, it suggests that kinking (quasi-twinning) was occurred by compression deformation.

The flow curves of tension-compression continuous loading are presented in Fig. 3 for $Mg_{85}Zn_6Y_9$ casting alloy with fully 18R-LPSO phase structure. During the initial tensile loading, all of the internal lattice strains evolve linearly, indicating that all grains are elastic up to a stress 30 MPa, at which point the diffraction peaks diverge from linearity. The nonlinearity in the internal strain development occurs at a significantly lower stress than the 0.2% proof stress identified by the applied stress-strain curve and signifies microyielding; the initiation of plasticity within some of the grains. Post yield, family grains with a {60.0} plane normal parallel to the loading direction start accommodating a greater portion of the strain elastically while family grains with a {00.18} plane normal parallel to the loading direction start accommodating less elastic strain. This indicates that the latter are yielding as they now accommodate some of their deformation by plastic strain rather than elastic strain and that the former must, thus carry more of the applied load.

Therefore, the hysteresis loop of 18R-LPSO phase structure {60.0} strain is much different from that of {00.18}, showing that the intergranular stress built up during the forward deformation accelerates the backward plastic flow resulting in an increase of the Bauschinger stress and Bauschinger strain.

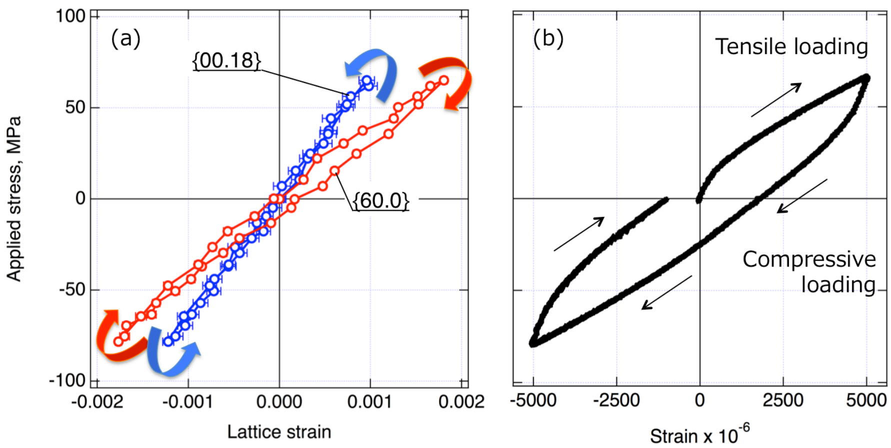

Fig. 3 Results of tension-compression test for $Mg_{85}Zn_6Y_9$ casting alloy: (a) changes in {00.18} and {60.0} lattice strains during the test shown in (b) and (b) Applied stress-strain curve (beam power: 300 kW).