MLF Experimental Report	提出日 Date of Report 07 June 2016
課題番号 Project No. 2015A0059 実験課題名 Title of experiment Phonon dynamics of Mg alloys with synchronized long-period stacking ordered structure 実験責任者名 Name of principal investigator Shinya Hosokawa 所属 Affiliation Kumamoto University	装置責任者 Name of responsible person Prof. S. Itoh 装置名 Name of Instrument/（BL No.） HRC/(BL12) 実施日 Date of Experiment 30 March 2016 – 4 April 2016

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.

Mg alloy, $Mg_{97}Zn_1Y_2$, Polycrystal

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.

Recently, a new series of Mg alloys [1] with the microstructure containing a synchronized long-period stacking ordered (LPSO) structure, the so-called KUMADAI Magnesium, has been attracted considerable attention due to the excellent mechanical properties. By adding a small amount of Zn and rare-earth metals (Y or Gd) impurities, light weighted Mg metal of soft and flammable becomes much hardened and un-flammable. By taking such advantages, the new Mg alloys can be used even for body materials of aircrafts.

A scanning transmission electron microscope (STEM) image obtained by Abe et al. [2] showed light and dark atomic image stripes, which represent the impurity-rich and -poor regions, respectively. Changes in stacking lattice order are also observed at the center of the light stripes, and thus, the concentration of the impurities and the modulation of the lattice stacking order are synchronized. Excellent mechanical properties of the LPSO phases were understood due to such interesting microstructures.

Macroscopic elastic properties of these Mg alloys were intensively investigated by several groups [3]. However, the microscopic information on the dynamics of this material is still lacking. Furthermore, element selective dynamical experiments have not been planned so far. Due to the difference of the scattering cross-

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

sections, inelastic neutron scattering (INS) emphasized the dynamics of majority Mg atoms, while inelastic x-ray scattering (IXS) that of impurities, in particular Y atoms. A complementary use of neutron and x-ray sources is necessary for this study. We already performed the IXS experiments at BL35XU/SPring-8 [4,5]. The energy resolution is about 1.6 meV.

A $Mg_{97}Zn_1Y_2$ LPSO polycrystal rod with ~100% LPSO phase (18R) was provided by Kawamura laboratory in Kumamoto University through the joint research program supported by Grant-in-Aid for Scientific Research on Innovative Areas, "Synchronized Long-Period Stacking Ordered Structure". The sample size is 29φ x 70 mm. The measurement was carried out using the INS spectrometer installed at HRC/MLF/J-PARC at room temperature. The incident neutron energy was selected at 200 meV and the energy resolution is about 6 meV.

Figure 1 shows $S(Q,\omega)$ (left) and the sum of the data at Q = 0.85 – 1.00 Å^{-1} (right). In this figure, mainly two phonon dispersion relations are observed and located at about 26 ± 3 and 17 ± 3 meV in the sum of Q = 0.85 – 1.00 Å^{-1}. From the previous IXS experiment in the same Q range, a large excitation peak is observed at about 27 meV, corresponding to the longitudinal acoustic (LA) mode. Besides, small peaks are seen at about 10 and 17 meV, which can be assigned as localized and transverse acoustic (TA) modes, respectively. Note that the localized mode is not observed in pure Mg, indicating that the 10 meV peak is due to the impurity effect of the Zn and Y atoms. In the present INS result, the TA mode is larger and localized mode is very small with respect to the LA mode. By taking into account the scattering cross-sections of Mg and impurities, it is concluded that the TA mode is mainly composed of the vibrational motions of Mg atoms and the localized mode is related to those of the impurity atoms.

This work was supported by JSPS Grant-in-Aid for Scientific Research on Innovative Areas, "Synchronized Long-Period Stacking Ordered Structure".

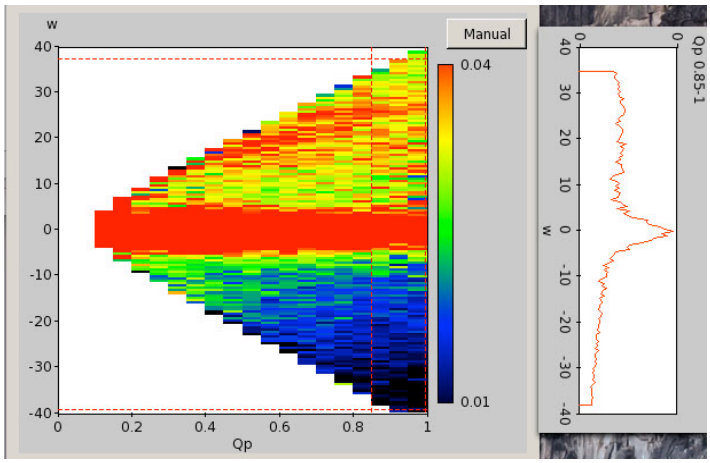

Fig. 1. $S(Q,\omega)$ (left) and the sum of the data at Q = 0.85 – 1.00 Å^{-1} (right) for $Mg_{97}Zn_1Y_2$ polycrystal.

[1] Y. Kawamura et al., *Mater. Trans.* **42**, 1172 (2001).

[2] E. Abe et al., *Philos. Mag. Lett.* **91**, 690 (2011).

[3] For example, M. Tane et al., *Acta Mater.* **61**, 6338 (2013).

[4] S. Hosokawa et al., *Materials Transaction* **56**, 914 (2015).

[5] S. Hosokawa et al., *SPring-8 Experimental Reports* 2014B1159, 2015A1221.