MLF Experimental Report	提出日 Date of Report 15 November 2017
課題番号 Project No. 2017A0008 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 31.03.2017-19.04.2017

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.

$Mg_{97}Zn_1Y_2$, Polycrystal
$Mg_{85}Zn_6Y_9$, 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 non-flammable. By taking such excellent natures, the new Mg alloys can be used for body materials of subways or even 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 to be originated from 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-sections, inelastic neutron scattering (INS) emphasizes the dynamics of majority Mg atoms, while inelastic

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

scattering (IXS) enhances 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 [4-6]. The energy resolution is about 1.6 meV.

In the last INS experiment at J-PARC [5], we used incident neutrons with a high energy E_i of 200 meV to observe the overall spectral features of the INS spectra. In turn, however, the energy resolution was about 6 meV, a large difference from the IXS one of about 1.6 meV. In this project, we carried out the INS experiments on the $Mg_{97}Zn_1Y_2$ and $Mg_{85}Zn_6Y_9$ polycrystals using E_i = 100 meV. Owing to the improvement of the spectrometer, the resolution width rose to be about 2 meV, similar to that of IXS. In this experimental round, we concentrate to precisely measure the transverse acoustic (TA) modes in combined with the longitudinal acoustic (LA) modes at the large Q values.

Figure 1 shows the $S(Q,\omega)$ spectra in the ω-Q plane on (a) $Mg_{97}Zn_1Y_2$ and (b) $Mg_{85}Zn_6Y_9$ polycrystals. As seen in the figures, the dispersion relations of the TA and LA modes are seen in the first and second Brillouin zone below Q < ~2.4 Å^{-1} as observed in the IXS spectra [4-6]. Moreover, the dispersion-less excitation modes are observed at about 10 and 17 meV in the spectrum of (b) $Mg_{85}Zn_6Y_9$ polycrystal, which were again detected in the IXS spectra [4-6].

In our previous combined INS and IXS experiments, we expected that the TA modes are mainly composed of the vibrational motions of host Mg atoms, and the dispersion-less modes are highly related to those of the impurity atoms. We will confirm the above speculation by using newly obtained INS data in this project.

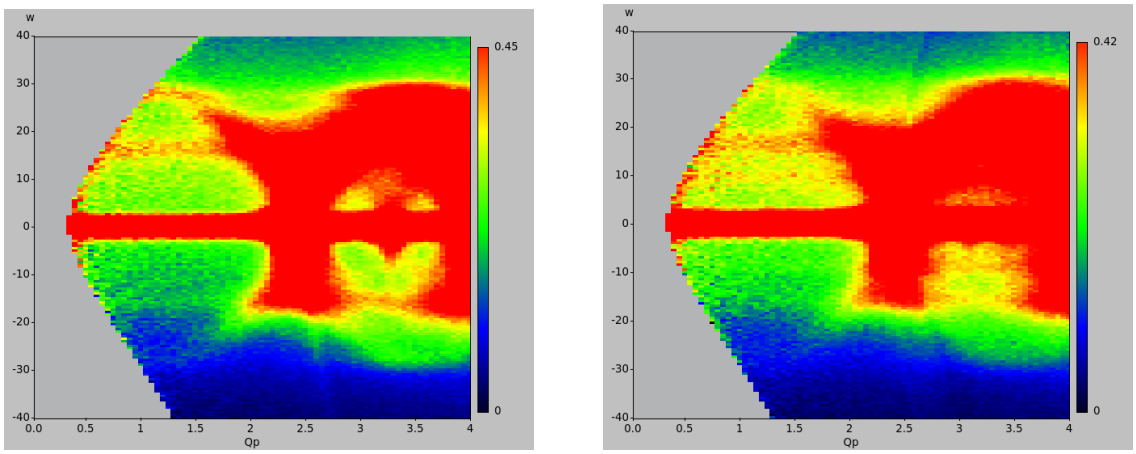

Fig. 1 The $S(Q,\omega)$ spectra in the ω-Q plane on polycrystalline (a) $Mg_{97}Zn_1Y_2$ and (b) $Mg_{85}Zn_6Y_9$ at E_i = 100 meV.

[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., *J. Alloys Compd.* **695**, 426 (2017).

[6] S. Hosokawa et al., *Acta Mater.*, submitted.